MARCH 17, 1977

CCDS: ARE THEY READY FOR VOLUME APPLICATIONS?/74

Expanding a minicomputer's input/output capacity/100

So you want to be a consultant?/105

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RT22	C2	L,P,W,X	½″ square
RT24	C2	L,P,W,X	⅜″ square
RT26	C2	W,X	¼″ square
MIL-R-39015			
RTR12	D	L,P,Y	1¼″ long
RTR22	D	L,P,W,X	½″ square
RTR24	D	P,W,X	⅜″ square

CERMET

Style	Characteristics	Qualified Terminals	Description
MIL-R-22097			
RJ12	C,F	L,P,Y	1¼″ long
RJ22	C,F	L,P,W,X	½″ square
RJ24	C,F	L,P,W,X	⅜″ square
RJ26	C,F	P,W,X	¼″ square
RJ50	C,F	P	¼″ round
MIL-R-39035			
RJR12	C,F	L,Y	1¼″ long
RJR24	C,F	P,W,X	⅜″ square
RJR26	F	P,W,X	¼″ square
RJR28	C,F	P	½″ long
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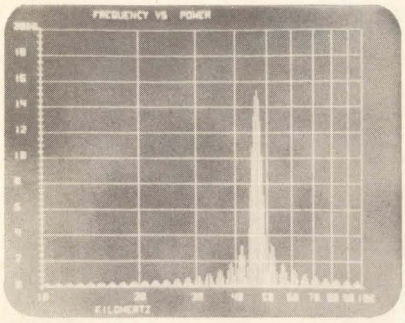

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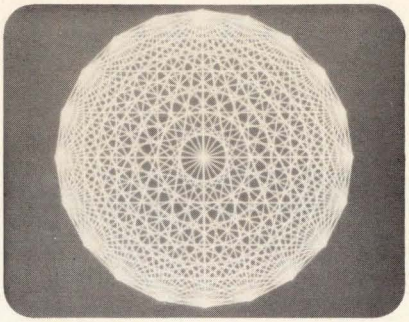
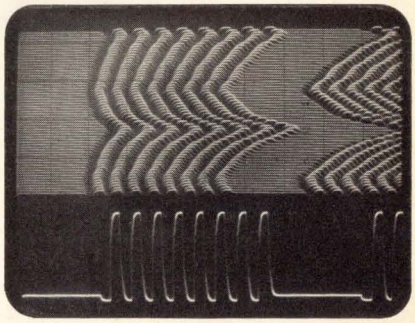
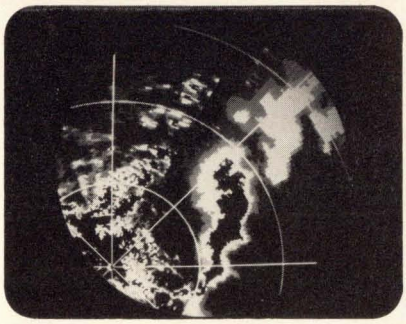


☐ *Computer Graphics*



☐ *Vibration Analysis*



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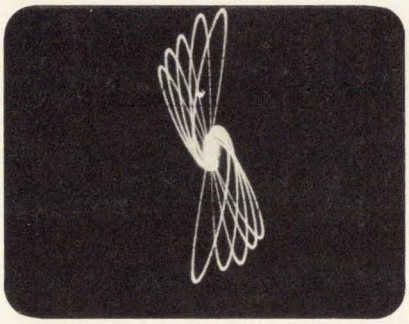

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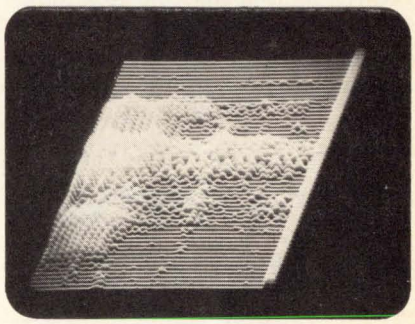

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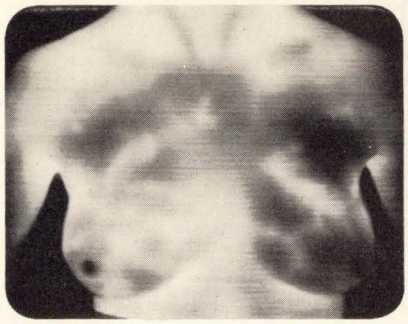

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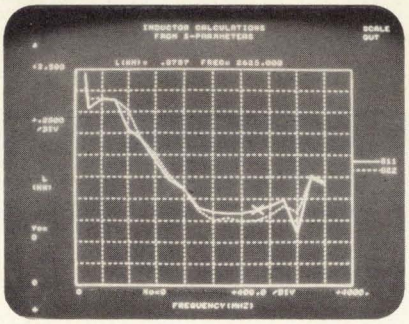

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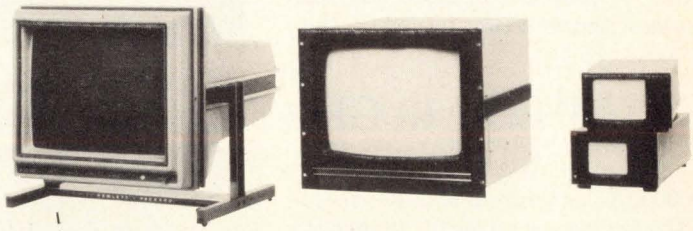

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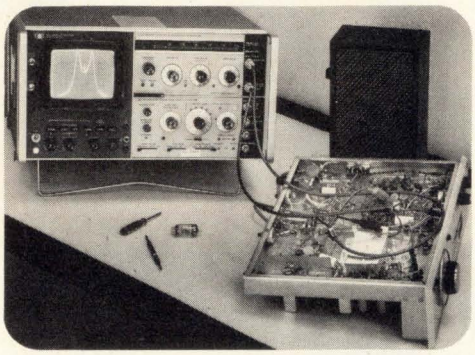
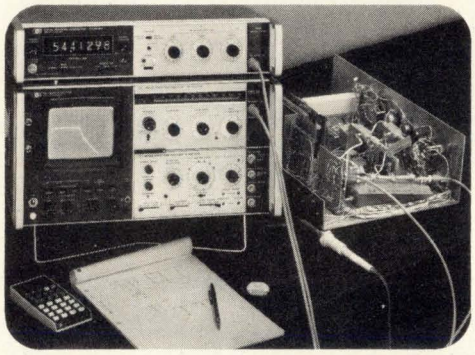


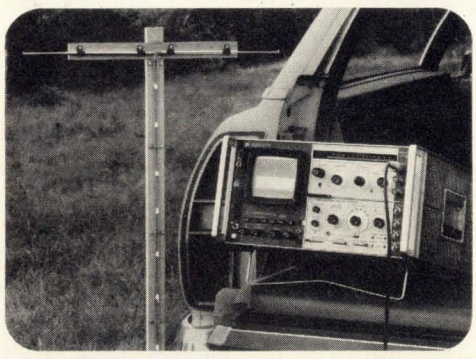
20 Hz to 300 kHz

The 8556A tuner covers 20 Hz to 300 kHz and comes with a built-in tracking generator. It's calibrated for measurements in both 50 and 600 ohm systems, with accuracies better than ±1 dB.



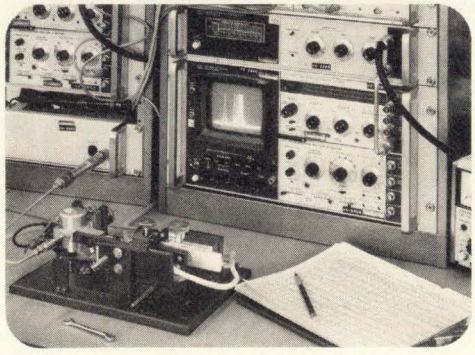
1 kHz to 110 MHz

The 8553B takes you from 1 kHz to 110 MHz with −140 dBm sensitivity. Signals can be measured with ±1¼ dB accuracy. Choose the companion tracking generator/counter for wide dynamic range swept frequency measurements and precise frequency counting.



100 kHz to 1250 MHz

Use the 8554B tuning section to cover the 100 kHz to 1250 MHz range. Measure with ±1¾ dB accuracy. Its companion tracking generator (500 kHz to 1300 MHz) also works with the 8555A tuning section.



10 MHz to 40 GHz

For 10 MHz to 40 GHz, choose the 8555A. Its internal mixer covers to 18 GHz, accessory mixer for 18-40 GHz. Maximum resolution is 100 Hz. Measure with ±1¾ dB accuracy to 6 GHz, ±2¾ dB to 18 GHz. For wide scans free from unwanted response between 10 MHz and 18 GHz, add the automatic preselector.

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Electronics

The International Magazine of Electronics Technology

Vol. 50, No. 6 • March 17, 1977

Highlights

Cover: DIPs face competition, 81

Dual in-line packages, chip-carriers, and film-carriers can all hold large-scale integrated chips, but the high pin count of newer LSI devices favors the latter two. Still, each type of package has distinct advantages, as this special report details.

Cover construction is by Bob Strimban.

Caution is Paris show's watchword, 65

The marketing outlook among exhibitors at the Paris components show generally is cautious. The microprocessor boom is helping boost sales, but other sectors, notably industrial, have not shown the expected recovery.

Unified architecture eases I/O expansion, 100

A unified input/output architecture for minicomputers permits the addition of new peripherals without extensive changes in hardware or difficult reprogramming. Called automatic I/O, the approach draws upon the best features of older techniques. Even direct-memory-access capability can be added inexpensively.

Considering the pros and cons of consulting, 105

Electrical engineers setting out to become consultants should consider the minuses before becoming beguiled by the pluses. On balance, says a successful consultant, the pluses have it.

And in the next issue . . .

The flourishing world of personal computers; a special report . . . the easy way to interprocessor data transfer in distributed systems . . . a monolithic circuit eases design of switching-regulator supplies.

Electronics

Publisher's letter

For three straight years now, editors from *Electronics* have been honored by the judges in the Jesse Neal Award competition, which was set up to encourage and reward editorial achievements in the business press. We are proud to report that our winner this year is our communications editor, Richard Gundlach, for a series of articles on optical communications. The first and largest installment in the series, "Fiber-optic developments spark worldwide interest," was in the Aug. 5, 1976 issue. Follow-up articles were published in the Sept. 2, Sept. 16, and Oct. 14 issues.

The route to becoming an engineering consultant is one of those things that comes under the category of "everything you've always wanted to know, but were afraid to ask," according to James Williams, who wrote the article on consulting that appears on page 105. A consultant since 1969, he has taken on assignments from organizations ranging from major electronic-equipment manufacturers to university R&D labs to city hospitals in both the United States and Europe. With all that experience behind him, he is ready to pass on the kind of information he wishes he had at the start.

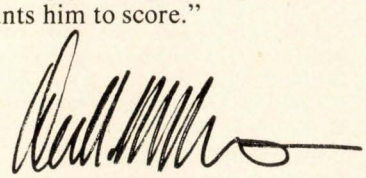
How did he get into consulting? "Almost by default," reports Williams. "I worked for a year in industry, but always wanted to start my own company. Then I realized that consulting is a very good way to get experience in starting a manufacturing company, because consulting is the ultimate education."

Actually, Williams started engineering consulting well before he decided to call himself a consultant. After dropping out of Wayne State University, an unhappy psychology major, he traveled around the country on a motorcycle and, to make ends meet, took part-time jobs at TV and ham-radio repair shops.

"After nine months, I decided it was time to settle down and get serious about a career. Living hand-to-mouth that way taught me a lot." Then, eight years ago he got a job at the Massachusetts Institute of Technology by walking into the research lab off the street. It took six months of persistent effort, but MIT finally "gave me one year to produce or I'd be kicked out." A self-taught designer, he has been involved in R&D projects ever since.

As a consultant, Williams has specialized in test-instrument design. "At MIT, I have been working on biomedical electronics and have become fascinated by instruments for measuring things," he explains. "It got me interested in test equipment and process-control problems."

The biggest misconception about consulting, Williams says, is the "superman image consultants get. Companies call consultants like people call medical doctors—only when they're in need—so a client does not want to think that a consultant will not be able to solve his problem. When he's boxed in a corner, the client wants a fast solution. That's a lot of pressure, but the consultant has a psychological edge; his client wants him to score."



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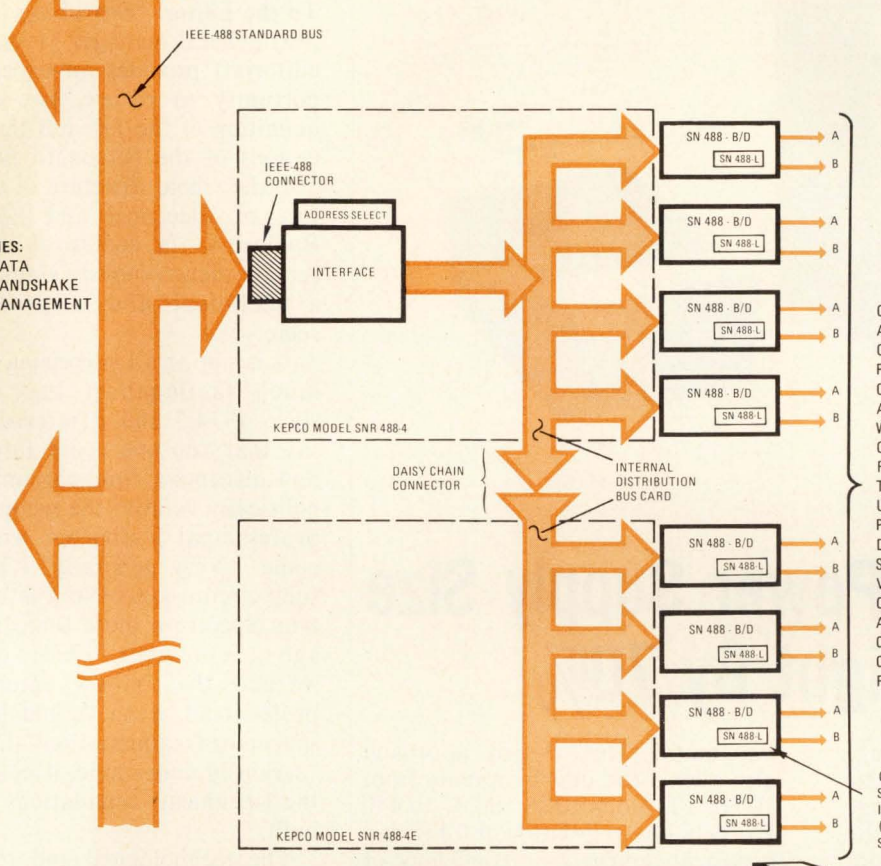

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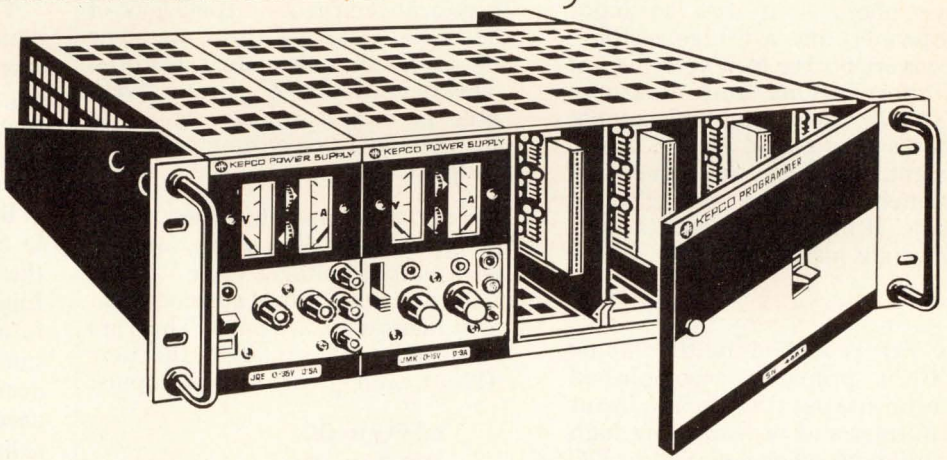

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Readers' comments

Let's review the IEEE structure

To the Editor: "Searching for IEEE's next general manager" (your Feb. 3 editorial) provides an excellent opportunity to review, not only the definition of the job and the qualifications of the person to fill it, but also the whole structure of the Institute of Electrical and Electronics Engineers—[a necessity] if it is to remain dichotomously viable as both a technical and a professional society.

It is not at all surprising that "so much factionalism has emerged since 1974," and it is erroneous to say that "no one could foresee just how disruptive, time-consuming, and politically volatile the whole area of professional activities would become." Very generally, I predicted such circumstances in a letter in the IEEE Spectrum more than five years ago (September 1971, p. 13). I warned that IEEE's entering the professional arena "could lead to a schism or fragmentation" that would "seriously undermine, if not destroy, the (technical) foundations we have built."

The technological and socioeconomic aspects of engineering are not wholly distinct, but overlap to some degree. I do not suggest that the IEEE should be as aloof to professional matters as was its predecessor, the Institute of Radio Engineers.

But if a majority of the IEEE's U. S. members were also members of the National Society of Professional Engineers, their influence on the future of the engineering profession—combined with that of engineers of other disciplines but similar needs in a society structured specifically to give every member a voice in the resolution of inevitably "disruptive, time-consuming, and politically volatile" professional issues—would be an order of magnitude stronger than it can ever be in the IEEE as it is now structured.

Clearly the foremost requirement of a new IEEE general manager is that he be superhumanly capable of compromising its dual objectives without displeasing anyone.

Keith W. Henderson
Mountain View, Calif.

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News update

■ A laser radar-sensor system to detect wind shear and wake turbulence around airports is to be shipped this week to the Transportation Systems Center in Cambridge, Mass., after passing final acceptance tests at Lockheed Aircraft Corp.'s Research and Engineering Center in Huntsville, Ala. The system will go out to Boston's Logan Airport for shakedown tests as part of the Federal Aviation Administration's program to detect troublesome windshear and wake-vortex activity [*Electronics*, April 1, 1976, p. 25].

Wind shear is the sudden shift in wind direction that can cause landing aircraft to drop suddenly or overshoot the runway. Wake turbulence is the trail of disturbed air created by an aircraft that can affect following planes, as well as create landing hazards. The FAA is confident it can detect both at ranges of 1,000 feet using a Honeywell Inc. carbon-dioxide laser operating at 10.6 micrometers. The laser is part of a Lockheed-designed mobile laser doppler velocimeter and associated display terminal.

It differs from an earlier unit from Lockheed by offering onboard real-time data-processing. This permits a faster data rate and more accurate wind and wake-vortex readings.

■ The picture is still blank at Bell Telephone Laboratories Inc. in Holmdel, N.J., for researchers attempting to develop a Picturephone terminal around an 8-bit microcomputer. The terminal, designed to send and receive local and computer-generated alphanumeric and graphic data [*Electronics*, April 1, 1976, p. 36], is still in the experimental stages and shows no signs of coming out of the laboratory.

"There has been progress on the program, but the work doesn't differ all that much from where we were a year ago," says a Bell Labs spokesman. While researchers have made some headway, so far "there have been no findings that we can state with security" and "there's no timetable for completing the development effort." **Bruce LeBoss**

What's new in High-Rel circuits ...

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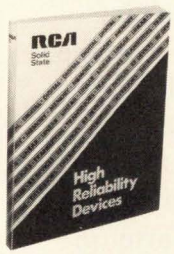
Meanwhile, back on Earth, we qualified 23 COS/MOS devices to QPL Part I of MIL-M-38510. Here again, zero functional rejects. MTTF was 75,000,000 hrs. Failure rate, 0.0013%/1000 hrs.



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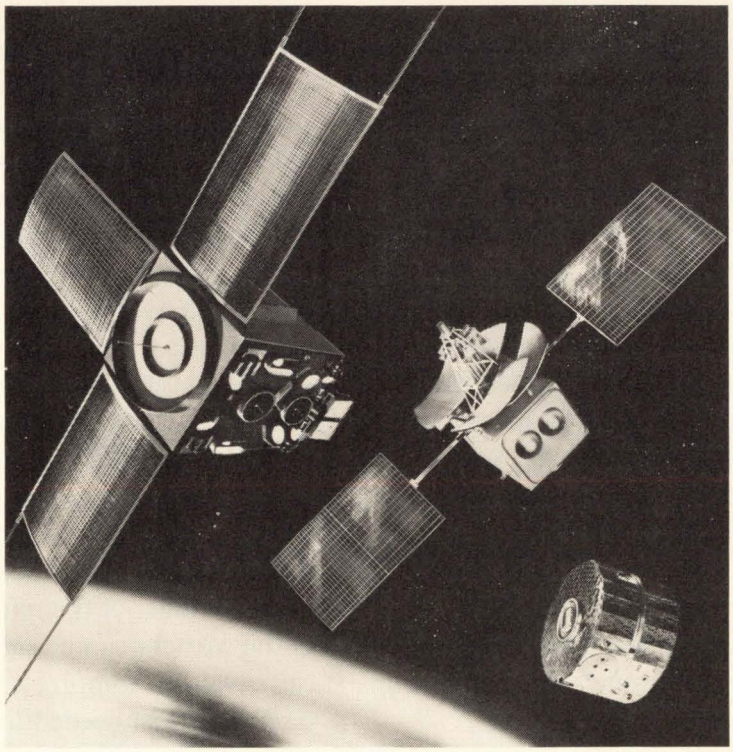
The COS/MOS devices in this table were of the CD4000 Series, processed to Class A requirements of MIL-M-38510 or MIL-STD 883.

Satellite	OSCAR-6	ITOS Series D; F; G; H	Atmospheric Explorer Series C; D; E	SATCOM Series F1; F2
Time in orbit (mo.)	32	85.5	49.5	16.5
Number of COS/MOS devices	90	168	7,200	1,652
Device-hours	2,073,600	2,585,520	85,536,000	9,812,880
Number of failures	0	0	0	0
Failure rate (%/1000 hours)	0.045	0.035	0.001	0.0092
MTTF (hours)	2,360,000	29,000,000	96,000,000	10,750,000

Total device hours: 100,000,000 (Data at 60% confidence, usage thru Nov. 1, 1976)
Failure rate: 0.00092%/1000 hrs. MTTF: 108,000,000 hrs.



Write: RCA Solid State. Box 3200, Somerville, NJ 08876; Sunbury-on-Thames, Middlesex TW16 7HW, England; Ste.-Anne-de-Bellevue, Quebec, Canada; Fuji Bldg., Tokyo, Japan.

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Editorial

Solar cells still seek a place in the sun

It's hard to believe that four years have passed since the energy crisis really hit home, forcing alternate-day gasoline rationing on motorists all across the nation and sending the price of fuels skyrocketing.

But it's even harder to believe that, despite all the talk of the need to return the United States to energy self-sufficiency, just about nothing has been done to refocus the nation's energy priorities. The much-publicized Project Independence, which was aimed at reducing imports of petroleum, for example, has never moved beyond words. Indeed, we are importing an even greater share of our annual petroleum needs now than we were when Project Independence was announced.

And, what is hardest of all to believe is that only token Government support has been given to that singularly untapped source of power—the sun. Even now, with the changing of the guard in Washington, there is little evidence that the harnessing of solar energy has moved ahead much in the race for Government funds.

As a technology, electronics has a stake in solar energy. Some visionaries can see a day when roof-mounted arrays of solar cells will supply the energy needs of the nation's homes. But a more realistic view would be that some percentage of a home's electrical needs could be supplied by direct conversion of the sun's radiation into electricity, with bulk energy-gathering for space heating handled by the scores of solar panels now on the market.

The question now really seems to be what percentage of the nation's electrical needs could be supplied by electronic solar-conversion devices—and supplied at a cost that is commensurate with other energy sources. Of course, the cost equation here is the critical factor, and it must still be determined what sort of premium would be acceptable if a higher price meant a significantly greater degree of national energy independence. Another part of the equation is the tradeoff between initial cost and day-to-day operating costs. Thus, solar cells with their nearly prohibitive start-up cost look poor as an investment, compared with other energy sources, despite their very low long-run costs.

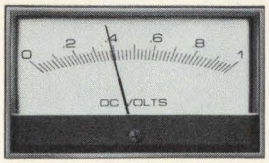
What's needed, and has been needed for a long time now, is for the Federal Government to give solar power research a much higher priority in its research and development efforts than it has in the past. That's the only way that the numbers in the equation are going to change quickly. President Carter in his campaign included solar energy as an area that should have greater emphasis, and we hope this will be translated into something more than the token-support approach of previous administrations. Some of President Carter's recent energy proposals have been criticized as being "short-term"—aimed at achieving some immediate energy-conservation steps, with no real long-term restructuring of priorities. His April 20 energy statement to the Congress should indicate whether that criticism is valid—and whether solar-cell efforts will remain in the shade.

Solar-cell technology is viable today and can be a cost-effective one before too many tomorrows go by. Its contribution to the energy budget of the nation—to say nothing of the world—can be significant. But we can't wait till tomorrow to crank up the research effort needed to bring costs down.

What this country needs is a good $39 DPM.

And we've got it.

The AD2026 from Analog Devices. Priced at $39 in hundreds*, it's the first real alternative to the measurement grade analog panel meter. And the first to give you all the advantages of a DPM at a practical price. Advantages like visual appeal, accuracy, resolution, small size and reliability.



The AD2026 is a three digit, logic powered DPM that measures and displays voltages from −99mV to +999mV on 0.5" LEDs. It consumes only ¾ Watts of 5V power. And because the AD2026 can be scaled with a simple resistive divider on its input pins, you can get direct readout in any engineering unit with equal or better resolution than APMs.

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When it comes to reliability, the AD2026 is unsurpassed. Its I²L technology combines most of the active analog and digital circuitry on *one* chip. The AD2026 has only 14 components and a MTBF of 250,000 hours at 25°C. In a 24-hour-a-day application, you shouldn't expect a failure for 28 years.

A new commercial tester automatically tests all AD2026's for defects such as bad components and solder shorts. It also fully tests both the LSI chip and the complete DPM. Following 168 hours of failure free burn-in, the units are again 100% tested.

The AD2026. Its low price ($39/100s), small size, superior performance, and remarkable reliability make it the only sensible alternative to APMs. Which is just what this country needed.

Check it out. Return the coupon with your check or money order today to order an evaluation sample at the low 1-9 quantity price of $62. And when you receive your evaluation samples you will also receive a Credit Certificate for $23 redeemable when you place your order for the first hundred or more AD2026's.

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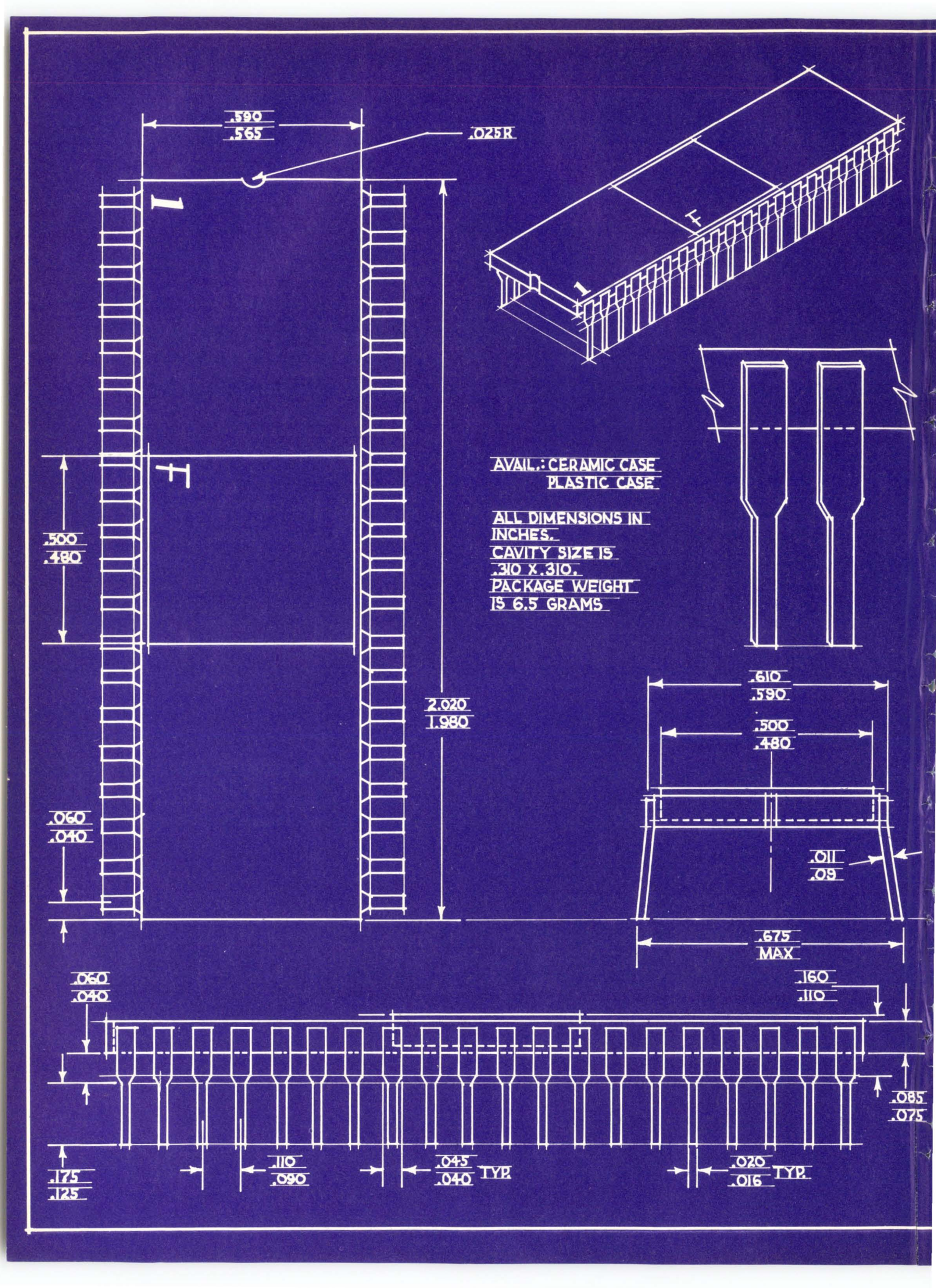
Circle 11 on reader service card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Circle 13 on reader service card

People

Tailor microcomputers for high volume, Stephens says

General Instrument Corp. is going after the 8-bit microcomputer market much as it went after calculators and game chips—by concentrating on high-volume, custom designs, says Ron Stephens. He is the new head of microprocessor operations at GI's Microelectronics group in Hicksville, N.Y.

"We're going to produce 'tailored' microcomputers, devices optimized for the application they serve," says the 34-year-old former president of a West Coast peripherals manufacturer, Xebec Systems Inc. "In this way we'll be able to minimize the circuits needed to interface the microcomputer with the customer's equipment."

Stephens, who relies on device-engineering experience gained previously at Signetics Corp., hopes this approach will squeeze out every extra cent of unnecesary cost in the high-volume end of the marketplace, where orders are for 100,000 pieces and up.

Heavy overhead. "Standard microprocessors—even single-chip designs—could never really survive in such a high-volume environment," he continues, referring to parts in families like Intel Corp.'s 8080 and Motorola's 6800. These tend to carry too much overhead hardware, no matter what general area they are designed for, because they must be applicable to a range of users, Stephens says.

He believes he already has the vehicle for making an impact—a new single-chip microcomputer, the PIC 1650, that GI will begin shipping next month [*Electronics*, Feb. 17, p. 26]. As a standard device, it is suited for control applications in gas pumps, vending machines, fast-food cash registers, telephones, and appliances.

"Where the quantities are 50,000 and below, the 1650 is our desired approach," he says. "But for really large quantities, we expect most users will benefit from custom, dedicated microcomputers that are designed with anything from slight to significant modifications to the basic 1650."

Chip man. Custom designs can be cheaper, says Ron Stephens at General Instrument.

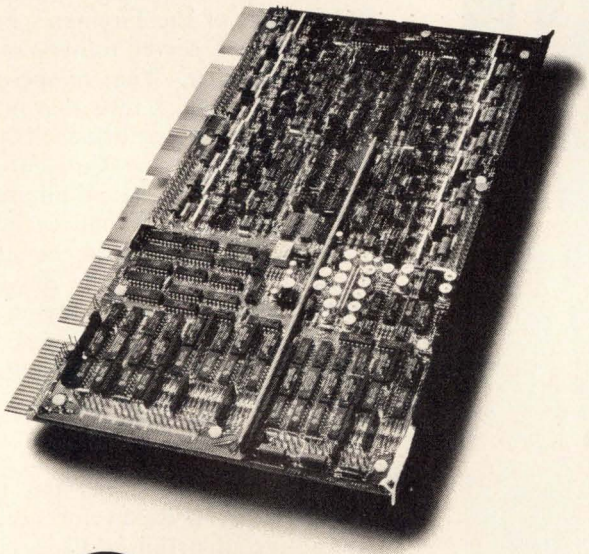
Until now, GI has given only token service to the 8-bit microprocessor field with the Alps microprocessors it builds under license from a West German business equipment maker, Olympia Werke AG.

Overshadow. Single-chip microcomputers will come to dominate the 8-bit market simply because multichip sets will cost too much, Stephens believes. Moreover, high-volume applications "will generate a requirement for custom devices that will completely overshadow that for standard microprocessors."

Ivan Socher sees explosion in distributed data processing

With the first eight of perhaps the largest ever distributed data-processing system ready to go out the door, Ivan D. Socher sees 1977 as "a dramatic year, an explosive year" for

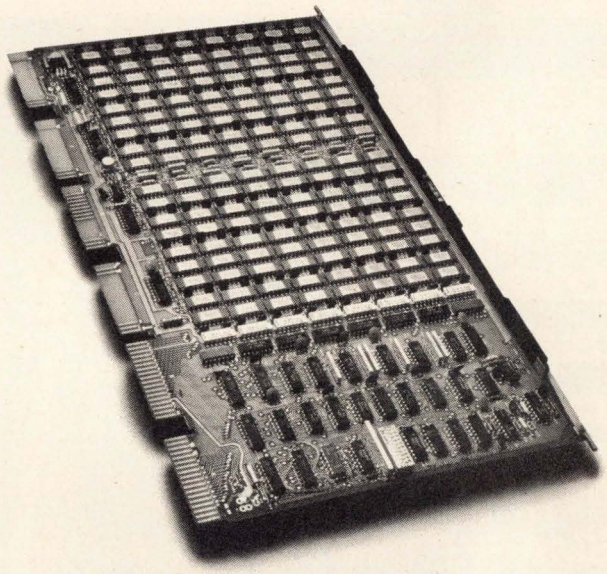
One way or the other, you're going to profit from plugging a Plessey 32K memory card into your PDP-11.



One way

The Plessey PM-1132.

32K words of non-volatile core memory on a single plug-compatible card that occupies just two slots in your PDP-11 mainframe. Compatible with either the standard or the new modified UNIBUS backplane. Available with and without parity.



The other

The Plessey PM-S1132.

Up to 32K words of high-speed NMOS semiconductor memory on a single plug-compatible card that occupies only a single slot in your PDP-11 mainframe. Choose a full-complement 32K word card, or one of 7 depopulated versions, then expand in 4K increments as your data storage needs increase. Available with and without parity.

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the technique. "Mainframes in use now are running out of steam—the IBM 370 is six years old—and users don't want to wait" for the expensive next generation, says the general manager of the Commercial Systems division of Computer Automation Co. They want better performance at a good price now.

Perhaps just as important, he continues, is a shift in management philosophy. Executives more readily accept decentralization of computer power and put less favor on centralized data processing facilities.

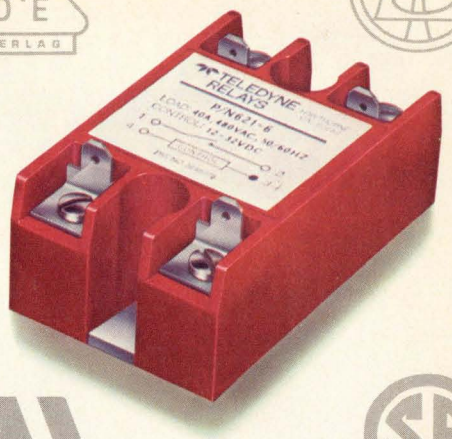
More interest. Socher also figures the $5-million contract his Irvine, Calif., company won to supply distributed data-processing systems to 50 locations of the Fireman's Fund Insurance Cos. served to hypo interest still further. The competition involved benchmark tests that pitted computer systems against each other in actual operation. Competitors, including IBM, Digital Equipment, and Microdata, put out such an effort that they advanced the state-of-the-art by months, the 35-year-old Socher says. After studying the results, other potential buyers are readying their own benchmarks, a development he sees signaling a big boost in business.

Computer Automation is a relative newcomer to the end-user field with its SYFA (systems for access) interactive distributed-processing network. Priced at from $55,000 to $200,000, depending on peripherals, the systems are competitive with units such as DEC's PDP-11 family and IBM's Series/1. The firm's current sales rate of $40 million a year is primarily based on selling board-mounted minicomputers to original-equipment makers.

Two-year lead. An IBM employee in his native South Africa, Socher, like most in his field, likes to avoid competing head on with the industry's giant. He feels he has a two-year lead over IBM and its Series/1, because SYFA has a "more sophisticated operating system, high-level language and support." Given a decent lead, he says, an agile, smaller firm has a good chance of continuing to stay ahead.

SSR UPDATE

Our International Connection



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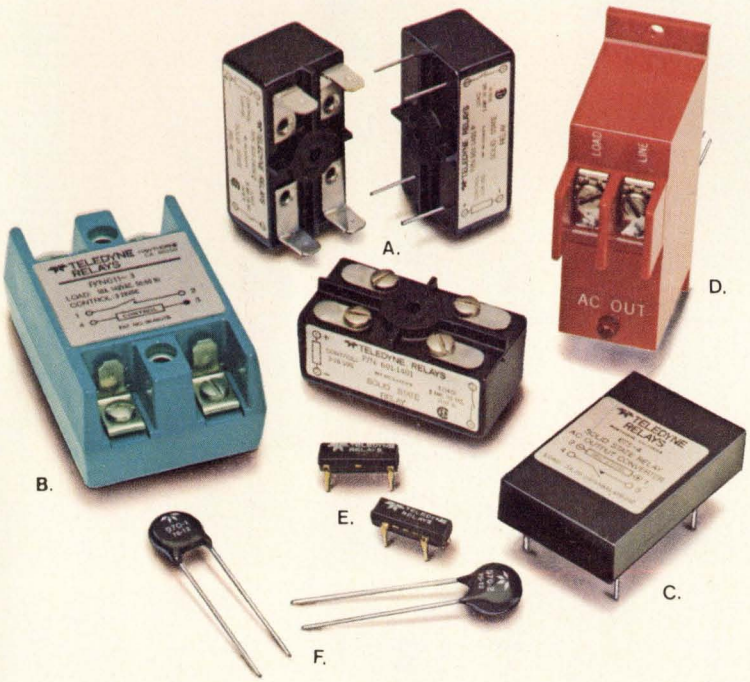

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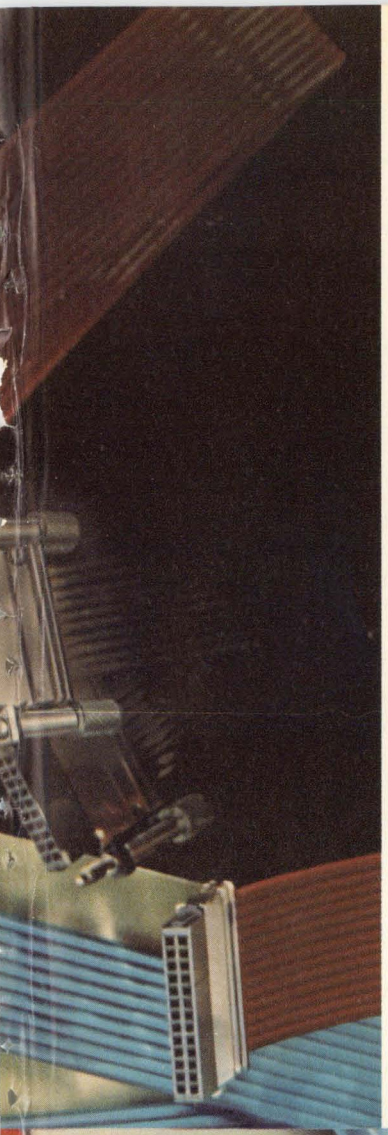

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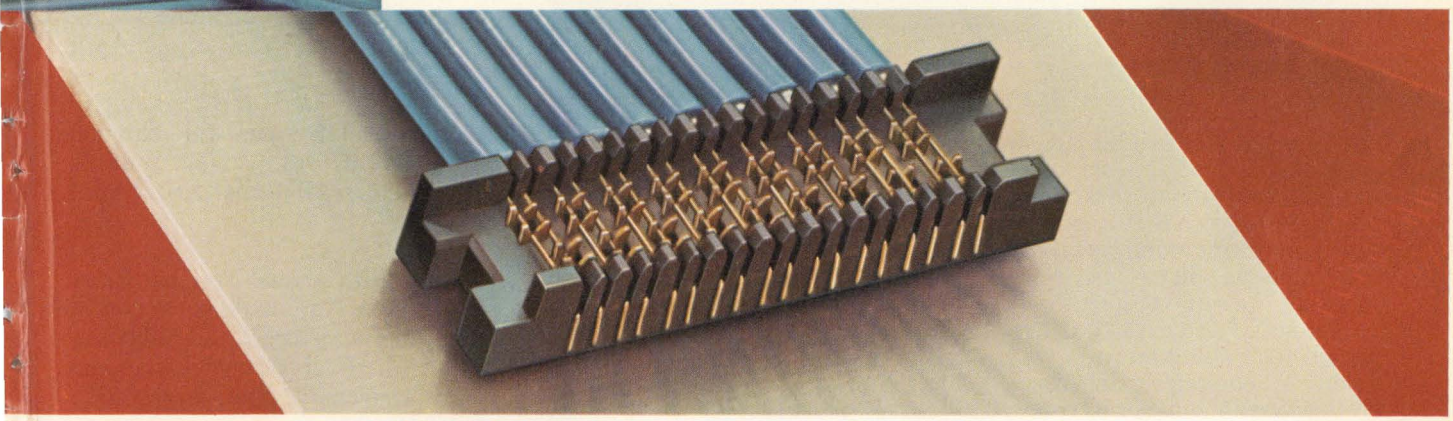

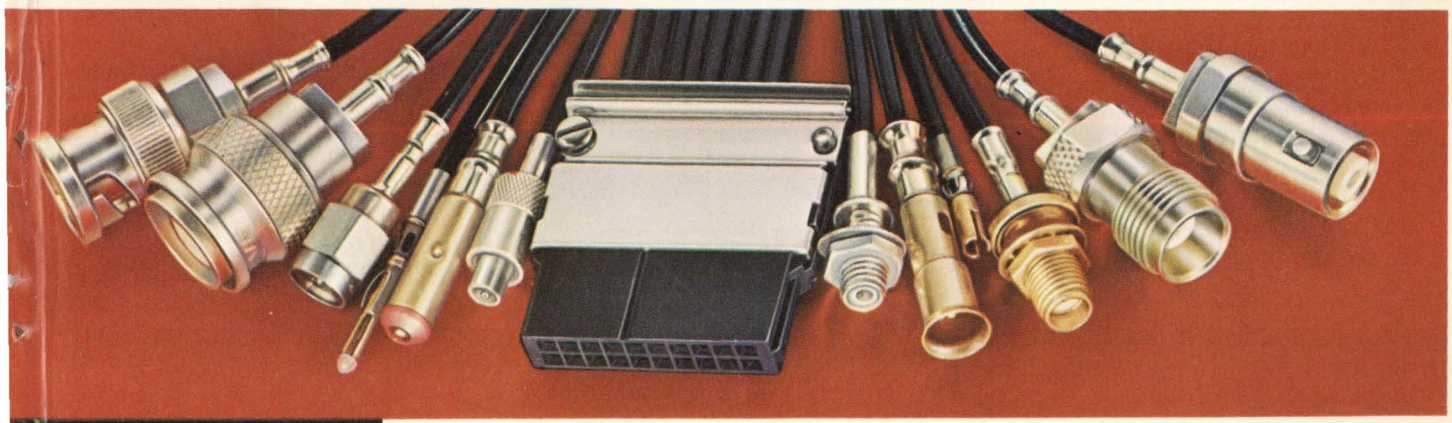

Meetings

Fifteenth Annual International Reliability Physics Symposium, IEEE, Caesars Palace, Las Vegas, April 12–14.

Fifth Annual New England Bioengineering Conference, University of New Hampshire, New England Center, Durham, N.H., April 14–15.

National Information Conference and Exposition, Information Industry Association (Bethesda, Md.), Shoreham Americana Hotel, Washington, D.C. April 18–21.

Electro 77, IEEE, New York Coliseum and Americana Hotel, New York, April 19–21.

Society for Information Display International Symposium, SID (Los Angeles), Sheraton Boston Hotel, Boston, April 19–21.

Eighth Annual Pittsburgh Conference on Modeling and Simulation, IEEE, University of Pittsburgh, *et al.*, Pittsburgh, Pa., April 21–22.

Annual Meeting and Exposition of the Electronics Division of American Ceramic Society, (Columbus, Ohio), Conrad Hilton Hotel, Chicago, April 23–28.

Circuits and Systems International Symposium, IEEE, Del Webb's Towne House, Phoenix, Ariz., April 25–27.

Twenty-Fifth Annual National Relay Conference, National Association of Relay Manufacturers and School of Electrical Engineering, Oklahoma State University, Stillwater, Okla., April 26–27.

International Electric Vehicle Exposition and Conference, Electric Vehicle Council of the Edison Electric Institute, (Charles Snitow Organization Inc., New York), McCormick Place, Chicago, April 26–29.

Eurocon 77—Communications (European Conference on Electrotechnics) IEEE et al., Venice, Italy, May 3-6.

What You Need Is What You Get.

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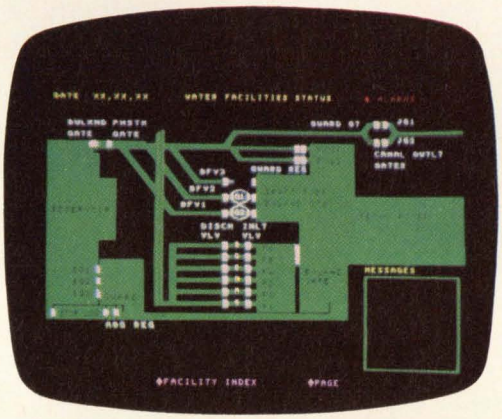
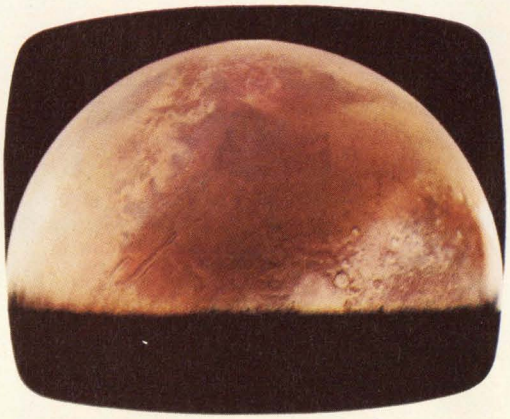


Process Control: Water facilities plant.



Imaging: Viking I Orbiter.

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The RM9000's total modularity lets you select the exact performance you need to fill your particular application. You pay only for the performance you need. Nothing more. And that's like money in the bank.

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Mostek SDB-80. Z80 Power and

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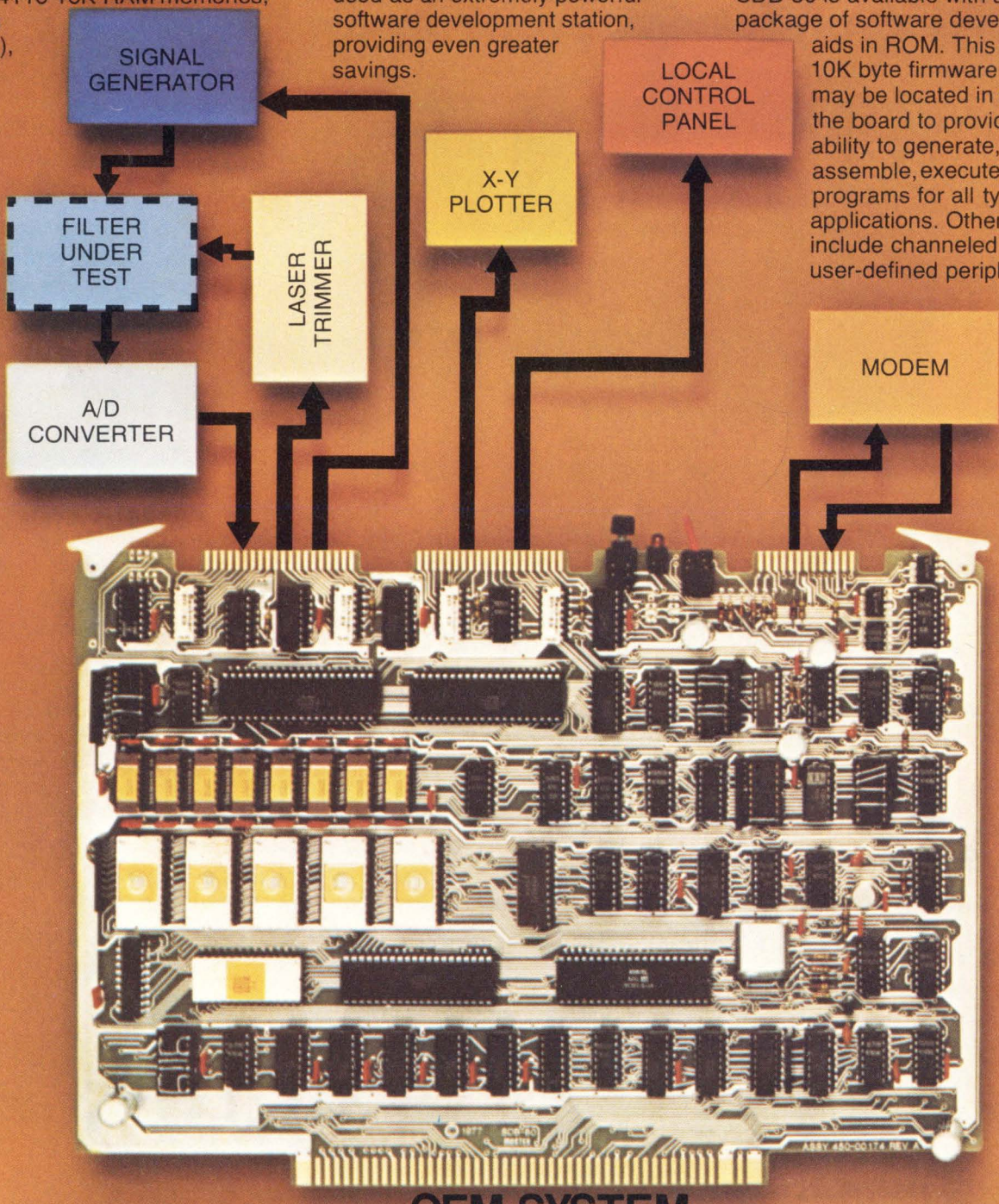
For OEM applications the SDB-80 is one of the most powerful, yet low cost microcomputers available in the industry today. For $995 (single unit quantities) the SDB-80 single board microcomputer includes Mostek's Z80 CPU (MK 3880), eight MK4116 16K RAM memories, two PIO's (MK 3881), one CTC (MK3882), serial ASCII interface (110—9600 baud) sockets for up to 5K bytes of PROM or 20K bytes of ROM, plus a fully buffered and highly sophisticated system bus for complete expandability (including multi-processor applications).

These features are not only important in the user's final system, but also permit the SDB-80 to be used as an extremely powerful software development station, providing even greater savings.

High level languages such as BASIC are also easily supported with the SDB-80 by loading either Z80 or 8080A based interpreters/compilers into the 16K bytes of on-board RAM.

The solution for software development.

For software development, the SDB-80 is available with a complete package of software development aids in ROM. This optional 10K byte firmware package may be located in sockets on the board to provide the ability to generate, edit, assemble, execute, and debug programs for all types of Z80 applications. Other features include channeled I/O for user-defined peripheral



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For more information on the SDB-80 and the complete range of optional support boards, software, and boxes, contact your local Mostek sales office or representative.

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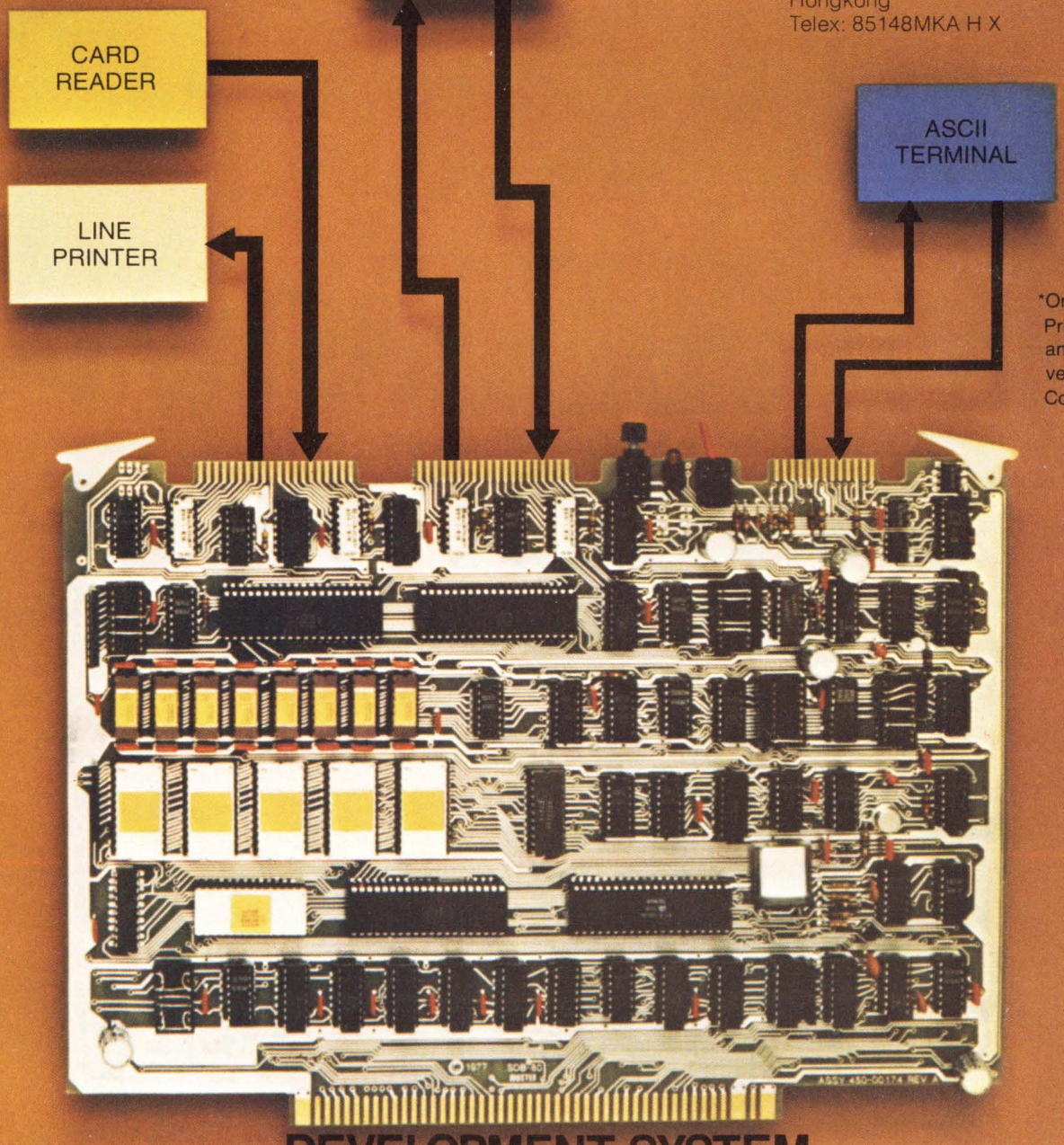

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Electronics newsletter

Ultra-fast 4-k static readied at AMD . . .

The 5-volt 4,096-bit static RAM market, which promises to be one of the most competitive arenas, will get a formidable entry from Advanced Micro Devices. Next month the Sunnyvale, Calif., IC supplier will have samples of a fully static, standard 18-pin, 5-V part **that will be specified down to 80 nanoseconds.** It is easily the fastest 2102-type MOS 4-k static RAM to be aimed at the peripheral and microcomputer market. It should not be confused with the 1,024-bit and 4-k statics with under-50-ns speeds coming up from Intel and AMD. They use more expensive advanced MOS processing and are aimed at the high-speed buffer-memory market [*Electronics,* March 3, p. 32].

Also impressive is the size of the new AMD chips, the 9135 and 9145: 25,000 mil^2, thanks to the firm's oxide-isolated MOS process and a tight-substrate biasing-circuit technique. Worst-case power dissipation is 675 mW, quite respectable for this speed.

. . . as 8048 goes on the drawing board

Action has hardly begun in the one-chip low-end microcomputer market, **but semiconductor suppliers already are forming sides.** AMD, a major supplier of Intel's 8080 family, "will definitely build and manufacture the Intel 8048 one-chip family," says Benjamin N. Anixter, MOS marketing manager. Like many microcomputer manufacturers, the company had evaluated Mostek's 3870 one-chip version of the F8 as a possible alternate, "but we've definitely going with the Intel chip," he said.

GE to demonstrate 1,000-line TV projector model

General Electric Co. is about to show a 1,000-line color-television projector for wall-size pictures in industrial and military applications. It incorporates **a newly designed light valve and electronics and includes features** from the existing 525-line PJ-5000, such as a single electron gun and color-selection diffraction grating without need for registration. The new PJ-5100 is designed to work up to the 1,023-line 60-hertz standard in visual flight simulators and command and control centers, as well as in computer-generated graphics and images. Also at the initial demonstration, scheduled for March 24 at GE's Electronics Park in Syracuse, N.Y., an engineering breadboard that more than doubles the light output of the present line of projectors will be shown.

National, PMI to move into high-spec bi-FETs

The bi-FET business is taking off, says James Solomon, linear R&D manager at National Semiconductor—which developed the bipolar-FET mixed process 18 months ago. Bi-FET operational amplifiers **could grab 30% of the 741 op amp business and could reach $50 million annually by 1980,** he predicts. To maintain National's lead, Solomon not only slashed bi-FET op-amp prices by two thirds, but soon will introduce high-performance versions of the firm's standard bi-FET op-amp line. These parts, which are laser trimmed using a process National calls bi-FET II, features offset voltages as low as 0.5 millivolt. The parts, 155T, 156T, and 157T, will also be supplied in duals and quads, "at very aggressive prices," promises Solomon.

Strong competition for National in the precision bi-FET area will come from Precision Monolithics Inc., which will add a series of high-performing proprietary versions to its recently announced bi-FET second-sourced parts. Donn Soderquist, marketing manager, says these new devices (designated OP-15, 16, and 17) are scheduled for the second

quarter. They employ a new circuit design and zener trimming to achieve the considerably higher slew rate, lower power dissipation, and lower offset voltages (below 0.5 mv), than the "A" versions of the standard line.

Siliconix ready with 2-chip companding codec

Unlike the National and Intel one-chip approach, Siliconix Inc. has chosen a two-chip complementary-MOS companding design for its codec. The coder/decoder function represents **one of the biggest new areas for semiconductors in the growing telecommunications business.** Siliconix' device—one chip for the encoder, the other for the decoder—requires no external components except for input and output filters. Each chip works independently and can function at either an 8-kilohertz or 16-kHz sampling rate.

SMC floppy to offer double density

Since Standard Microsystems Corp. is too late to be first on the market with a floppy-disk controller chip, "the next best thing is to be last, but with the first of a second generation of chips," says Gerry Gollub, senior vice president. The Hauppauge, N.Y., firm, whose specialty is communications and computer peripheral MOS LSI circuits, plans late this year to introduce a standard floppy-disk controller chip **with some of the latest features, such as double density.**

Since SMC does not believe the floppy-disk will totally displace cassettes, it is also readying a cassette controller chip, the COM2601, for later this year. Other standard peripheral chips slated for late 1977 availability are a keyboard encoder without a ROM, a keyboard encoder for capacitance-coupled switches, and additions to its new cathode-ray-tube controller chip family [*Electronics,* Feb. 17, p. 119].

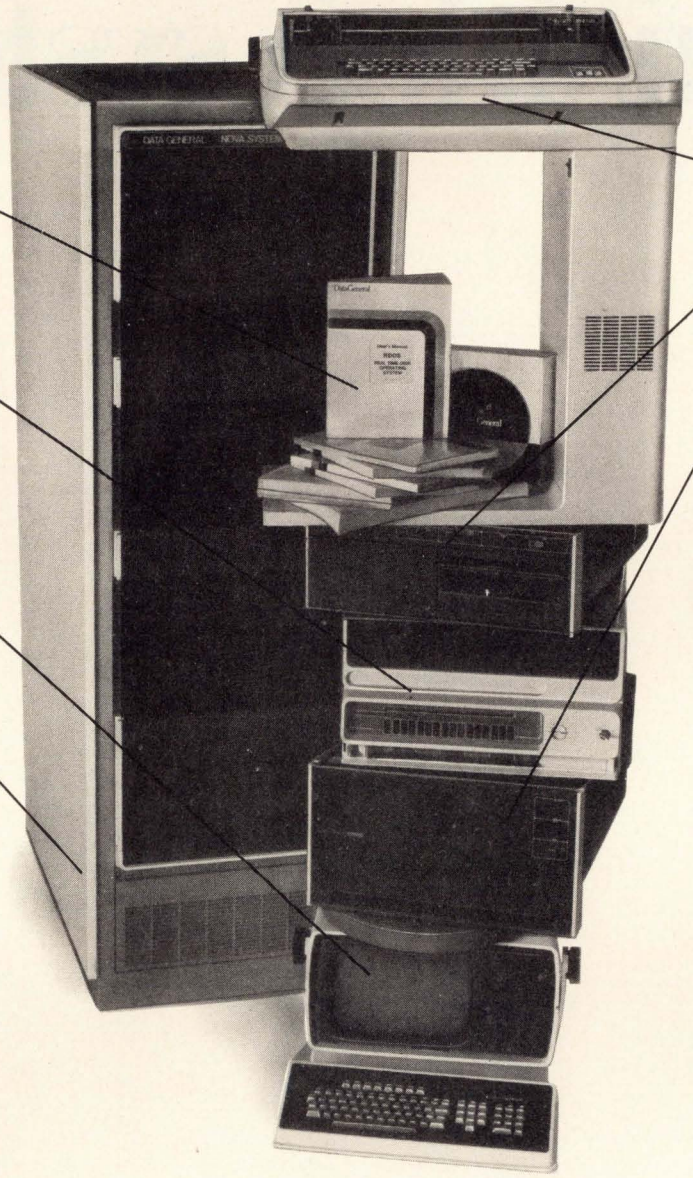
TI memory development work paying off

The payoff has arrived on Texas Instruments' multimillion-dollar memory-development programs of the past few years. The action ranges over several technologies. TI is introducing a 65-kilobit charge-coupled-device memory, its first device, that leapfrogs the industry by a factor of four (see p. 38). The company is now also turning out its 92-kilobit magnetic-bubble memory [*Electronics*, Sept. 30, 1976, p. 39], as well as introducing all the peripheral and interface chips needed to build a microprocessor-controlled magnetic-disk replacement system. In n-channel technology, TI is sampling four static RAMs—two 4-k by 1 bit and two 1-k by 4 bits—that are as fast as 150 ns. Now in production is the fast 4-k, 16-pin dynamic RAM, which, while specified down to the industry-standard 150-ns level, according to John Hewkin, strategy manager, will be selected for super-fast 125-ns applications.

Adjustable-voltage regulators due from National

Look for National Semiconductor to bolster its line of 3-A fixed-output voltage regulators with adjustable units that users can vary between 1.2 and 35 V. **Not only is the voltage capability expanded,** says Robert Dobkin, design manager on these industrial products. **but the LM 150's regulation has been improved.** Load regulation is 0.1% and line regulation is 0.005% per V, both 20 times better than fixed-voltage regulators. The price, at $3, will be about the same as fixed units. Sample parts are due in four to six weeks, production quantities in 10 weeks, and 5-to-10-A programmable devices will be forthcoming in a year.

Here's how Data General's NOVA 3/D system stacks up against the competition.



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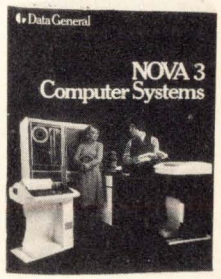

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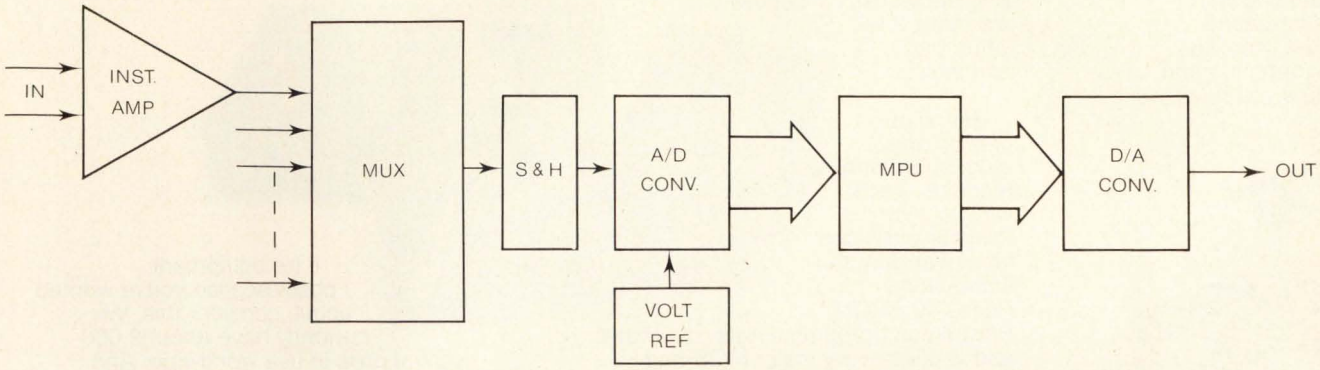

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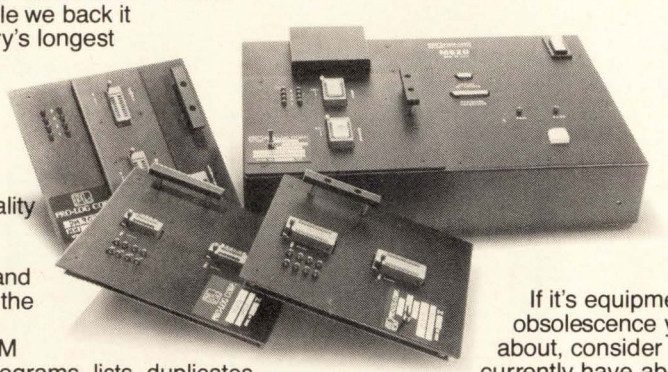

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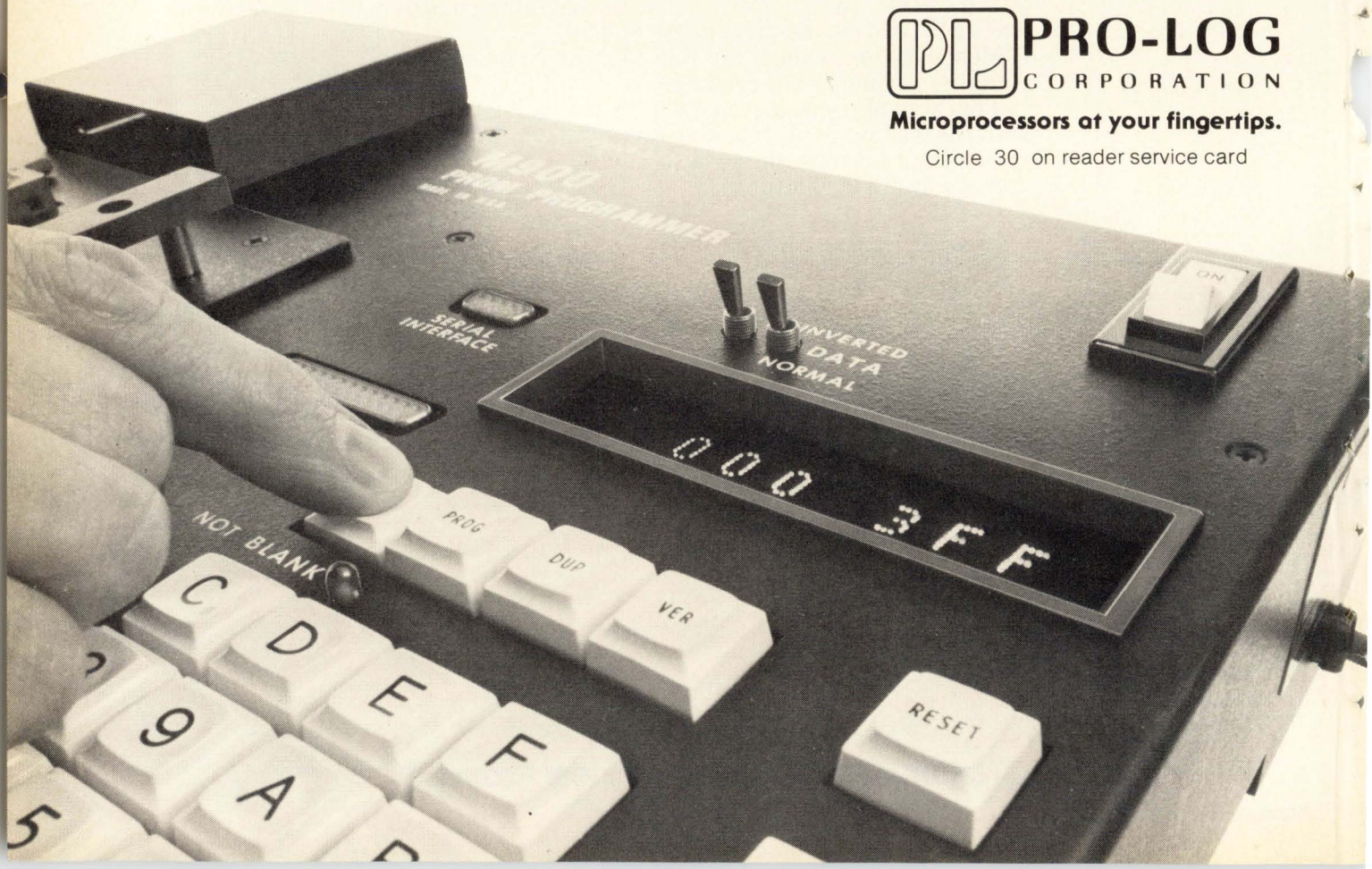


LSI technique combines linear, digital functions

Blocking diode applied by Signetics boosts breakdown; standard low-voltage process builds combination devices

Signetics Corp. has developed a technique with which high-performance linear and digital functions can be combined on the same LSI chip in an inexpensive and relatively simple manner. The company does it by applying a blocking diode to raise the analog breakdown voltage of selected linear transistors while fabricating the other analog devices with standard low-voltage linear processing. The new technique allows high-performance analog devices to be built alongside dense digital circuitry without compromising either, says David Kleitman, vice president of research and development for the Sunnyvale, Calif., subsidiary of U.S. Philips Corp.

"Our approach, we believe, will make the 'system on a chip' a reality, cost-competitive with present multichip approaches," he says.

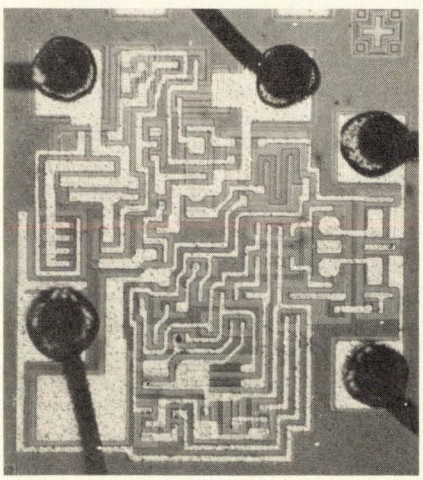
Products coming. Anywhere from 8 to 12 months away from finished devices, Signetics is applying the diode technique to a wide range of products. These include a Codec coder/decoder used in digital pulse-code-modulation equipment, programmable instrument amplifiers, and television deflection circuits—all circuits where high-performance linear functions must be combined with digital data processing.

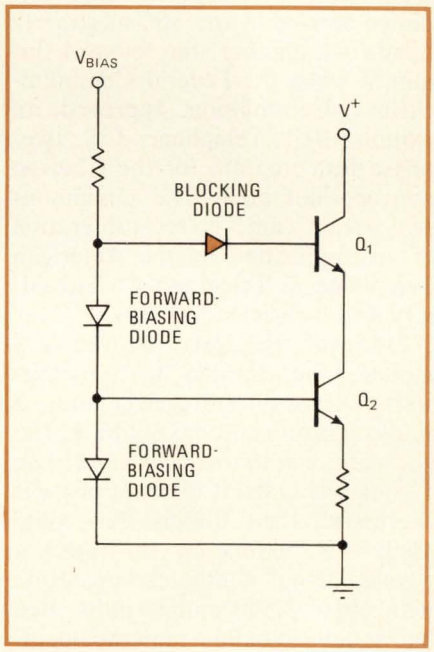
Based on what the company calls the Blauschild blocking diode and using standard low-voltage processes, Signetics has built linear devices with 36-to-40-volt breakdown. For many standard linear functions, chip area has been reduced 30% to 85%, bandwidth improved 2 to 4 times, and slew rate increased almost five times.

How it's done. Even though only a few transistors must withstand large collector-emitter breakdown voltages in most linear circuits, the IC fabrication process is usually designed to meet these requirements. This leads to large dies with wasted space and increased parasitics. Such problems can be avoided, says Robert Blauschild, Signetics' 28-year-old manager of analog-circuit research and the developer of the technique. The secret is to design for low-voltage, high-density circuits but designing only the critical linear circuits to handle the high-voltage breakdowns.

In a standard npn transistor, breakdown usually occurs when the reverse collector-saturation current is avalanche-multiplied, causing enough of a voltage drop to forward-bias the device. Cascode circuits, with two transistors connected as a series-diode bias string, are used so that the devices, in essence, share the load. But the breakdown voltage is not doubled because avalanche multiplication induces the common-emitter current gain to reverse. Blauschild says the upshot is that "current flows out of the common base instead of in, setting up a positive feedback loop that rapidly increases the output current and accelerates breakdown."

Blauschild diode. Blauschild's solution is to add a blocking diode at the base of the first transistor in the cascode to break the loop before the





Extra boost. Blocking diode in cascode circuit raises breakdown voltage to 40 V. The diode also reduces the active die area of devices—by 85% for the high-performance 741-type op amp at left.

onset of negative base current and the positive feedback. The diode clamps off at just below breakdown, which is between 12 and 15 V for digital structures. Any additional increase in output voltage now appears across the second transistor.

Blauschild says 741-type operational amplifiers with 38-to-45-V breakdowns have been built using standard bipolar digital processing. Die size of the op amp is only 28 by 28 mils, about 25% to 65% smaller than devices built with standard linear techniques. Active die area, excluding the bonding pads, is 85% less than present devices, he says.

Slew rate is 2.4 volts per microsecond (vs a standard 0.5 V/μs) and unity-gain bandwidth is 2.5 megahertz (vs 1 MHz). For functions requiring fewer high-voltage breakdown transistors, such as 565-type phase-lock loops, the savings is 50%.

The impact will be greatest in LSI systems combining linear and digital functions, says Blauschild. Using an integrated-injection-logic low-voltage process, engineers did a preliminary design on a 3½-digit panel-meter circuit using the Blauschild concept. Where the present approaches would require two to three chips, Blauschild says the complete analog-to-digital converter with auto zero, decoding, and light-emitting-diode drivers can be put on a single 80-by-80-mil die.

A bonus of the technique is that it can be used to enhance any bipolar process. "By starting with the standard 36-to-40-V linear process, the same 741 design is operational up past 100 V with no increase in chip size or degradation in slew rate and unity-gain bandwidth," he says. □

Communications

FCC approves 800-MHz system proposed by Illinois Bell Telephone for Chicago test

Development of mobile radio-telephone service in the 800-megahertz band took another step forward this month when the Federal Communications Commission approved an Illinois Bell Telephone Co. two-phase test program for the Chicago metropolitan area. The unanimous FCC action came in reconsideration of an application by the American Telephone & Telegraph Co. subsidiary that it rejected last July.

However, the test approved is a modest one, limited to 10 base-station transmitter/receiver sites, a single control point in Oak Park, Ill., and service tests with no more than 135 mobile units. If this first phase is successful, then Illinois Bell could apply for permission to install a developmental commercial operation with up to 2,500 mobile units. Bell had sought to build a start-up operational system with 5,000 mobile units from the very beginning.

But before it can proceed with its tests, Illinois Bell must submit a modified frequency plan to the FCC, one that would confine its system to 12.5 MHz of spectrum spread in two blocks of 6.25 MHz each. This setup, approved in 1974 by the FCC, is the key to a cellular approach to 800-MHz systems. Baltimore's American Radio-Telephone Service Inc. used the cellular approach in its recent proposal to develop a $2.5 million test system with Motorola Dynatac technology in the Baltimore-Washington area [*Electronics*, March 3, p. 38]. Illinois Bell had proposed using 11.88 MHz of spectrum spread over 21 MHz. It is now likely to use 838.74 – 844.98 MHz for mobile units, 883.74 – 889.98 MHz for base stations.

The commission had expected the phone company to use 4-mile-wide cells in its system, but approved the 8-mile-wide cells and taller omnidirectional antennas Bell proposed. It also permits frequency reuse at a distance of 48 miles from the antennas in only two of the cells. Moreover, it says Bell System feasibility tests of its technology in the Newark, N.J., area must be coordinated with work in Chicago.

The FCC also wants a comprehensive financial report from the Bell company that would explain the need for the $23.5 million it proposes to invest in its system. Approval of a commercial operation would depend on its favorable review of current and accumulated costs and proposed charges. It also warned that it offered no guarantees that a successful commercial operation in Chicago would mean automatic approval of AT&T systems for other areas. □

Automatic test equipment

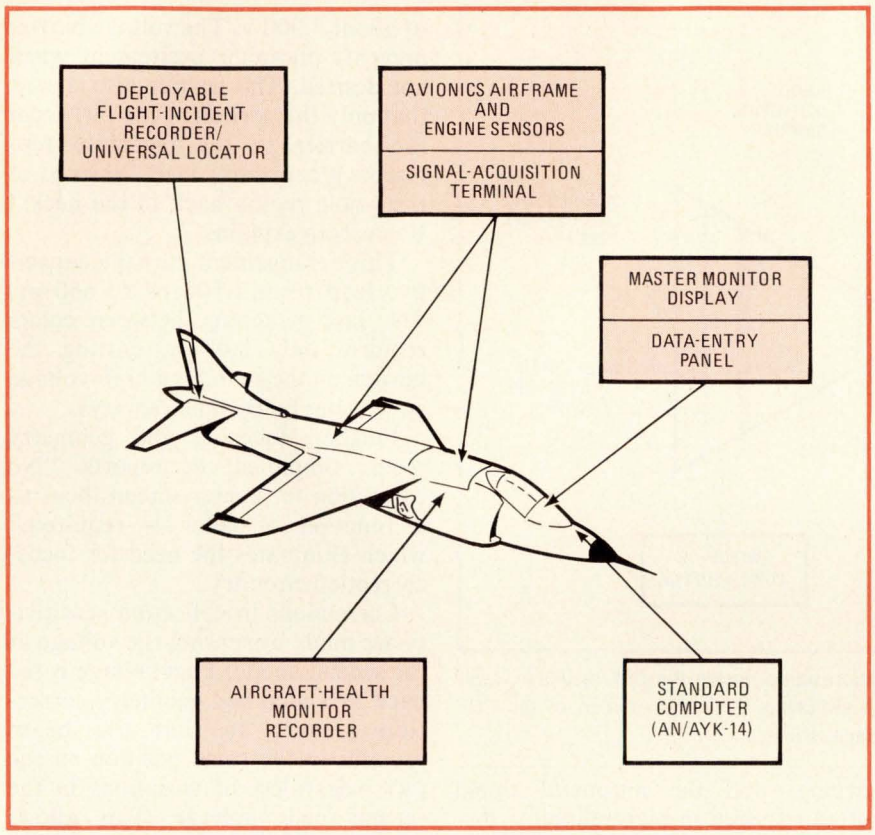
System monitors plane's 'health'

On modern military planes, equipment failures are quickly signaled by fault-monitoring equipment. But "there's presently nothing that monitors the avionics and the aircraft itself to tell you when something is starting to go bad or is just somewhat out of tolerance," points out the program manager for a firm developing a new kind of monitor.

The equipment he is working on, now in engineering development at Conrac Corp.'s Systems-East division in West Caldwell, N.J., is the U.S. Navy's Universal Locator Airborne Integrated Data System. Ulaids uses a multiplexed data bus to tie together four or more microprocessor-based subsystems that monitor the airframe, engine and avionics while the plane is in flight. It can present a view of each system's health on a central display in the cockpit.

Most functions. "It will be a complete monitoring system, providing trend and fault data for almost all functions of the aircraft," according to Henry Kaplan, Conrac's program manager. It can be programmed to command pilots to take corrective actions in an emergency, as well as to instruct the ground crew on maintenance procedures.

Being developed under an $840,000 contract awarded to Con-



Health monitor. Besides pinpointing faults, Conrac's airborne integrated data system evaluates the on-going performance of a plane's engines, avionics, and airframe.

rac last fall, Ulaids "is intended for aircraft of the 1980s," says Jim Martin, deputy program manager at the Naval Air Test Center, Patuxent River, Md. It "integrates several on-going developments to improve flight safety, decrease aircraft turnaround time, and make maintenance easier through diagnostics," he adds.

Among the programs from which he says Ulaids has gleaned technology are: a microprocessor-controlled engine-condition monitoring system for the A-7E attack plane; an integrated cockpit display system, in exploratory development, that indicates the health of several aircraft subsystems on a heads-up display, and a crash-position locator/flight-data recorder for the E-2C early warning and P-3C patrol aircraft.

Ulaids has four major types of subsystems: one for acquiring sensor signals from aircraft equipment, another for selecting and displaying sensor data, and two for recording data. Each has its own 8-bit microprocessor, Intel Corp.'s 8080, and communicates with the other three types to gather data via a redundant multiplexed data bus. The system can operate independently of the central computer on the aircraft, although tests will be carried out to see how it may tie in with a computer such as the Navy's standard AN/AYK-14 airborne system.

Number varies. There can be more than one of the signal-acquisition subsystems. The number depends on the location of the sensors, their number and the susceptibility of their signals to noise. Altogether, then, Ulaids typically will have five or six processing systems working in parallel.

The signal-acquisition terminals, as they are called, monitor the input signals from the aircraft, engine, and avionics sensors. They sample and format the sensor signals and check and evaluate whether the equipment has failed or is out of tolerance. They also perform self tests.

Data goes from the terminals to the master monitor display in the cockpit where it is shown on a 4.8-by-4.8-inch cathode-ray tube. The pilot may use a keyboard data-entry panel at the display to call up information. The keyboard may also be used to put new program instructions into the system.

The data also goes to an aircraft health-monitor recorder where it is put on magnetic-tape cassettes for further processing on the ground. "This processing generates data for maintenance planning, diagnostics and degradation trend analysis," Kaplan says.

The second data-recording subsystem to which the data goes is a flight-incident recorder and locator system that is ejected from the aircraft with the last 30 minutes of flight data in the event of a crash. This unit has a battery-powered omnidirectional beacon that will transmit for 100 hours.

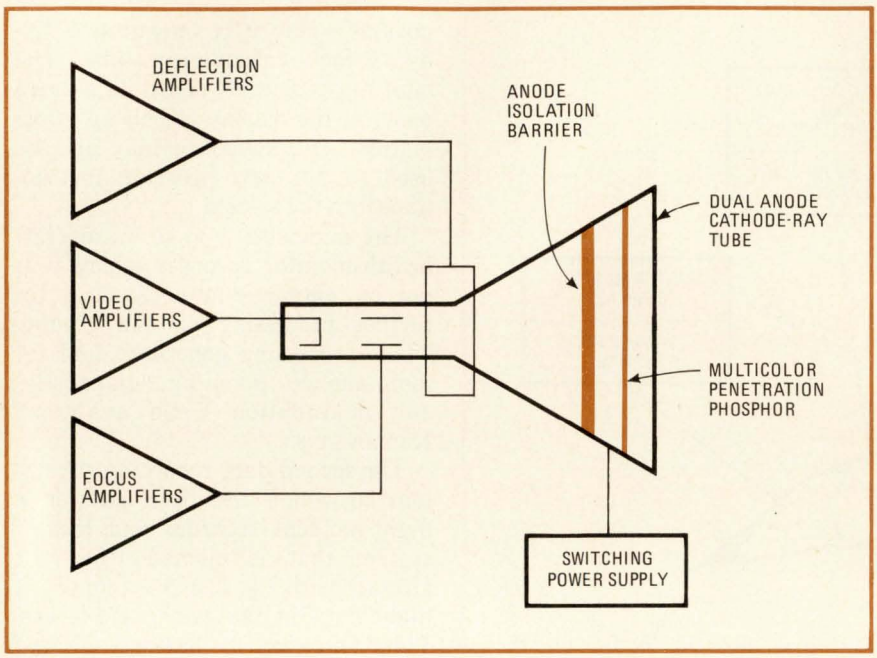
The prototype Ulaids is scheduled to be installed on an A-7E this fall. A preproduction contract could be awarded in early fiscal 1978, says Martin. Several types of aircraft are candidates for the complete system, although parts of it could be used separately. □

Displays

Reduced capacitance simplifies color CRT

Military users of command and control systems increasingly want to display information on cathode-ray tubes in color—especially so that operators may distinguish quickly among graphic symbols representing hostile as well as friendly forces. Engineers at Raytheon Co.'s Equipment division, Sudbury, Mass., believe they have a better CRT for this, one that gets by with less power and simpler circuitry than would usually be the case. They have accomplished this, basically, by reducing by more than eight times the capacitance through which the voltage that changes colors on the screen must be switched.

Raytheon is aiming in particular



Fast switch. Raytheon's use of an anode isolation barrier inside the CRT results in lower capacitive loads than with conventional anode switching. Only that portion of the CRT between the barrier and faceplate presents a capacitive load.

at applications such as the Navy's AN/UYQ-21 standard shipboard display, which will replace the present display in the Navy Tactical Data System. The Navy recently stipulated that the new display must offer four colors; the present one is monochromatic. There are other programs that could use such a display, according to Raytheon, including ones for air traffic control, sonar, and radar fire control. The company calculates that a system built around its new 23-in.-diameter multicolor penetration tube would add only 8% to 15% to the cost of a complete monochromatic system.

Big capacitor. David Bloomstran, manager of the console design section in the division's Computer and Displays Laboratory, points out that a conventional CRT using anode switching of the cathode-to-anode voltage to change colors on the screen has the anode acting as a huge capacitor. That's because the anode consists of the entire internal surface of the tube—from the second grid up to the faceplate and aluminization layer.

Capacitance is increased further by the external aquadag—a conductive coating grounded to prevent arcing—and the mu-metal shield often required in high-reliability displays. That all adds up to a capacitance of 5,500 picofarads, Bloomstran says.

To switch quickly in that kind of system from the voltage required for writing red (18,000 volts) to that for writing green (10,000 V) and settle enough to begin writing again requires about 16 microseconds, 4 μs of which is settling time. With those requirements, and the 5,500-pf capacitive load, the current required is 3.66 amperes, a big demand on the high-voltage power supply.

The company overcomes this by using two anodes. One is created by connecting the aluminization layer and the phosphor to a switching high-voltage power supply and isolating that anode from the main body of the CRT. The main body, or cone, is connected to a fixed high-voltage power supply. Between them, and a little behind the aluminization layer, is a ring of nonconductive material that acts as a voltage barrier to cut the capacitive load.

Raytheon uses conventional phosphor and barrier arrangements, but the dual anodes allow the first (cone) anode to remain at a fixed potential of about 3,000 V. The voltage barrier prevents phosphor excitement when not desired. The barrier also means that only the portion of the CRT from the barrier to the faceplate represents a capacitive load, "instead of the whole region back to the neck," Boomstran explains.

This arrangement cuts the capacitive load from 5,500 pF to 650 pF. The fast switching between colors requires only 0.43 A, cutting the burden on the switching high-voltage power supply, Bloomstran says.

Further, focusing and geometry seems simplified, he reports. "No correction for center-screen focus as a function of color is required," which eliminates the need for focus-correction circuitry.

Corrections in deflection sensitivity are made by sensing the voltage at the second anode. That voltage is fed back to a modified geometry-correction module so that the beam remains in the same position on the CRT, regardless of variations in the second-anode voltage. This allows the beam to be unblanked and begin writing sooner than could be achieved in a system requiring full high-voltage settling. Another feature of the system is that the voltage potential for each of the red, orange, yellow, and green colors can be varied to adjust the hues to the liking of the operator. □

Industrial

New tubes cut cost of infrared imaging

By and large, infrared imaging systems have met with a chilly reception because their sensing element—a pyroelectric vidicon—requires cooling to cryogenic temperatures. The cryogenic hardware has meant outlandishly high systems costs, ranging anywhere from $25,000 to ten times that amount, so IR imaging has been used primarily in military applications such as surveillance.

However, infrared is beginning to heat up around the world for many commercial and industrial imaging

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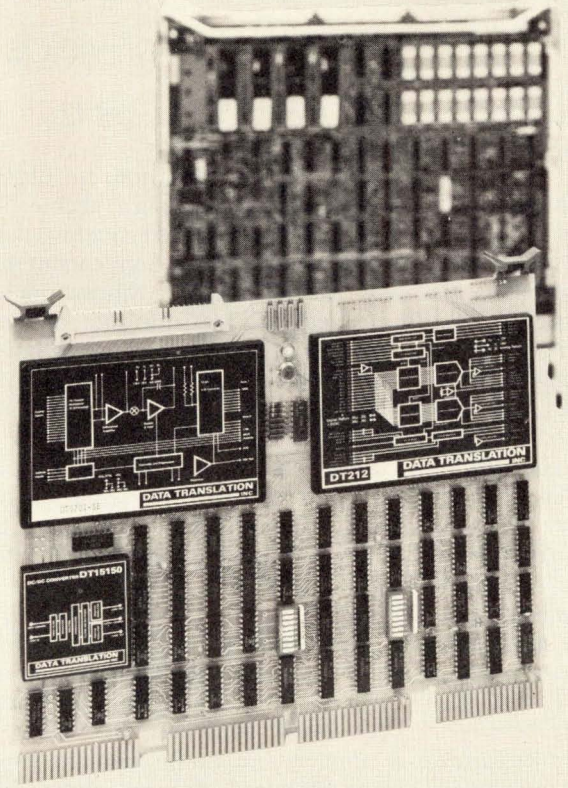

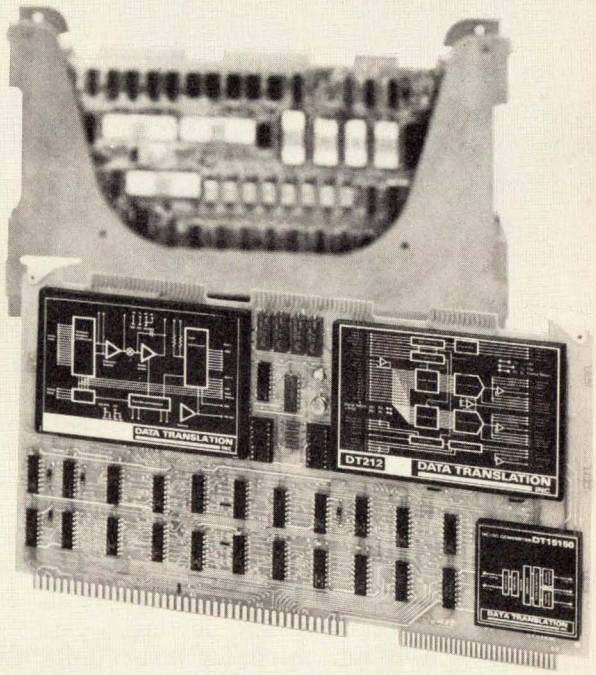

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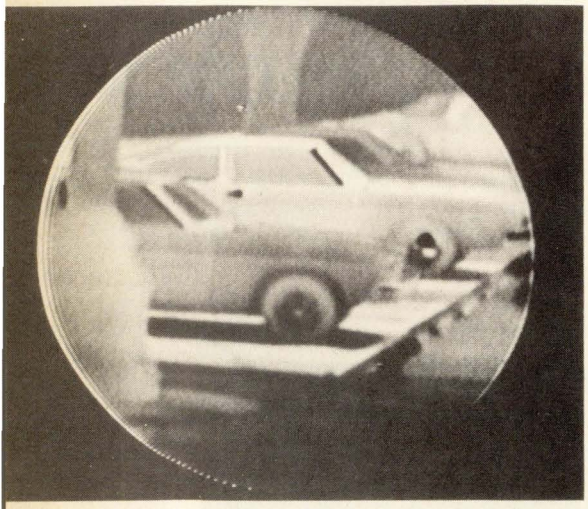

Pretty sharp. Philips' high-resolution room-temperature pyroelectric vidicon yields a picture that is quite detailed for an IR image.

applications. Separate efforts at Philips Laboratories in Briarcliff Manor, N.Y., English Electric Valve Ltd., Chelmsford, Essex, England, and Thomson-CSF, Versailles, France, have produced pyroelectric vidicons that can operate at room temperature, yet provide fairly tight resolutions.

No cooling. Since these tubes have no need for cryogenic cooling, systems costs can be cut by many thousands of dollars—enough to open up many new applications for infrared imaging. Among potential uses are: body scanners and other diagnostic equipment for medical electronics, industrial process controllers such as temperature monitors for foundry furnaces, instrumentation for locating hot spots on circuit boards and detecting defective parts in engines, finding smoldering forest fires, and even monitoring thermal losses from buildings.

Philips' new vidicon has a 1-inch diameter and is about 6 in. long, reports Edward H. Stupp, senior program leader for electronic devices. Inside the tube, the pyroelectric target materials are triglycine fluoroberyllate and deuterated triglycine fluoroberyllate, which permit temperature resolution to within 0.5°C for a picture height of 250 TV lines.

In earlier tubes, Philips employed target materials of triglycine sulfate, but the best panning-mode resolution was 1°C for 250 picture lines. Conventional cryogenically cooled vidicons use completely different target materials—usually mercury cadmium telluride or lead selenide.

The high 0.5°C resolution of the new vidicon makes the performance of an imaging system built around it comparable to that of cryogenic systems, Stupp says. Yet the tube, to be commercially available this spring, will be the $3,500 sensor in a system that could cost about $10,000 complete, he asserts.

The vidicon will be manufactured by another Philips unit, the Electro-Optics division in Slatersville, R.I. The company was supported in its work by the U.S. Army Night Vision Laboratory in Fort Belvoir, Va.

England's EEV is making its room-temperature vidicon with target materials of triglycine sulfate, obtaining a resolution of 0.2°C for 100 lines of picture height (equivalent to the resolution reported for the new Philips tube). Once the image strikes the target through a standard infrared lens, "the image is scanned using the same principle as a standard vidicon camera," says marketing manager Walter Turk. This means that the signal can be mixed with ordinary TV camera circuitry, he explains. The firm is pricing its tube low—at only about $2,300—and is also selling a complete camera for around $8,500.

Off the shelf. The room-temperature IR vidicon from Thomson-CSF has been available off the shelf for a little over a year, notes Walter Sobotka, product-line manager for thermal-TV systems at the Electron Tube division. Inside the tube are target materials of triglycine sulfide, and resolution is 0.4°C for 100 picture lines.

Thomson is putting its vidicon into a new camera that operates without panning—it delivers a flicker-free TV image of a fixed scene without the need for mechanically scanning the field of view. "In the future," Sobotka projects, "we'll have thermographic systems selling for less than $20,000." The Thomson tube, as well as the camera, is available from Dumont Electronics Corp. in Clifton, N.J. Price of the tube, which depends on the quality of the target and the size of the order, is approximately $2,900 singly, says William Adikes, marketing manager. □

Microwaves

TRW transistor yields 40 watts at 2 GHz

Using ion implantation to obtain tiny yet uniform device geometries and tightly controlled shallow doping profiles, TRW Semiconductors Inc. has fabricated a silicon microwave power transistor that delivers just about twice as much continuous-wave power as previous units. At 2 gigahertz, the device produces 40 watts cw with 9 decibels of gain. Under pulsed operation, output jumps to 90 W at a 10% duty cycle for a 10-microsecond pulse width. When operating at 28 volts, collector efficiency of the power device is a high 50%.

Most bipolar microwave power transistors are interdigitated structures; that is, many tiny transistor cells connected in parallel operate as a single-stage amplifier. However, since standard diffused processing does not yield identical cells, nonuniformities can cause power losses and inefficient matching.

Look alikes. But by applying ion implantation, however, TRW in Lawndale, Calif., has achieved such uniformity that "each die looks like all the rest of them," according to Jim Steenbergen, rf-device development manager. The doping depths and profiles in the collector-base regions, where ion implantation is used, are held to tolerances often tighter than 2,500 angstroms. This permits "very tight control of such key cell parameters as output capacitance, transistor gain, and emitter resistance.

The transistor, shown in the photo at the top of page 38, consists of four chips, each containing four separate cells, so there are 16 cells in all, Steenbergen explains. Each chip

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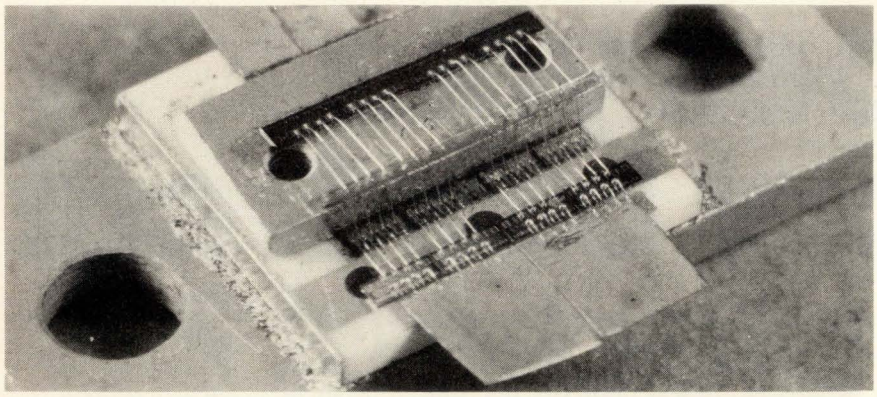

Powerhouse. Bipolar microwave power transistor from TRW includes its own input (bottom) and output (top) matching networks. In the middle are its 16 stacked transistor cells, four to a chip. The device delivers 40 watts continuously at 2 gigahertz.

operating alone can produce 4 W. But stacked as they are, their power output declines.

Because of exceptional cell uniformity, input and output matching networks, which are internal to the device, can be simple symmetrical circuits that are perfectly matched, thereby also increasing performance in the 1-to-2-GHz band, Steenbergen says. Moreover, transmission losses are cut because input and output circuits can be physically much closer to the cells than in discrete designs. Input-output circuits in the TRW device are, for instance, 17 to 20 mils away from the cells, compared with as far away as 1/4 in. for discretes, he says.

The TRW power transistor uses individual shunt inductors for each cell to resonate in parallel with each collector-base junction capacitance, rather than conventional shunts that resonate groups of cells. "This ensures the advantage of uniformity in circuit tuning, further contributing to attaining higher power levels," Steenbergen notes.

Developed partly under contract to the U.S. Army Electronics Command, the transistor has gold metalization and diffused ballast resistors to prevent metal migration. TRW plans to have the 40-W device ready for production later this year. Steenbergen says its higher power levels should make it ideal for replacing several power devices at a time, reducing circuit complexity. The transistor now "actually saturates at 48 to 50 W, but could be improved to hit up to 60 W, with 120 to 130 W pulsed power," he surmises. Contemplated cost of the transistor is about $200 in quantities of 1,000. TRW's present 2-GHz devices, sell for slightly more than $100.

Competitors comment. Mike Mallinger, director of microwave products for Transistor Corp., comments that the TRW development is a "good step forward." But he believes his firm can achieve equal performance with standard diffusion, although it is not yet working with devices at the 40-W level. "I'm glad to see them charging forward."

But ion implantation for such types of transistors is being applied by another company, Microwave Semiconductor Corp., Somerset, N. J. Its research has led to devices capable of 70 W of pulsed output power at 2 GHz and 7 dB of gain, says president Ronald Rosenzweig. The devices are already being supplied in prototype quantities for a major military system, he says. □

Memories

TI's 65-k CCD coming next month

Memory-system designers, wondering where charge-coupled devices might fit into the memory hierarchy, will soon be able to get their hands on the industry's first 65,536-bit CCD memories: Texas Instruments is to sell prototypes next month.

These samples of the big serial-memory part will cost $195 each. But John Hewkin, director of strategy for the MOS memory group at TI's Memory division in Houston, says the devices will sell for about $13 in 1978—less than 0.02 cent per bit, or about half the expected bit cost of 16,384-bit dynamic memories in the same time frame. That is also the entry price most observers feel CCDs must meet to get an evaluation by system specialists for bulk and auxiliary memory applications.

CCD memories fill the gap between the high-capacity, slow magnetic memories and the fast, expensive semiconductor random-access memories. "They are ideal as refresh memories for video displays," Hewkin says, "because they are organized serially and, as the price comes down, we expect to see them replace moving-head magnetic media."

Of other major semiconductor builders working on CCD memories, Fairchild Semiconductor Corp., Mountain View, Calif., appears to be the closest to a 65-k device. It is already shipping serially-organized 9,216-bit and line-addressable 16,384-bit parts; a 65-k chip, probably organized like TI's, is expected by the end of summer. Intel Corp., in nearby Santa Clara makes a 16-k serial CCD memory.

Organization. TI's TMS3064 memory is organized as 65,536 by 1 bit, in 16 line-addressable loops of 4,096 bits. Worst-case time for accessing a single bit in any loop is 800 microseconds at the device's maximum 5-megahertz operation; best case is typically 150 nanoseconds. Typical power for reading or writing is 300 milliwatts; standby, or recirculate, power is 100 mW. At the memory's minimum frequency of 1 MHz, active power is 100 mW and standby power drops to 50 mW. Refresh rate is 4 milliseconds.

TI's CCD device requires only three power supplies: ±5 volts, and +12 V. The part is compatible with transistor-transistor logic—200-millivolt noise immunity on the inputs alleviates the need for pull-up resistors—except for the two MOS-level clocks and a chip-enable pin. "The

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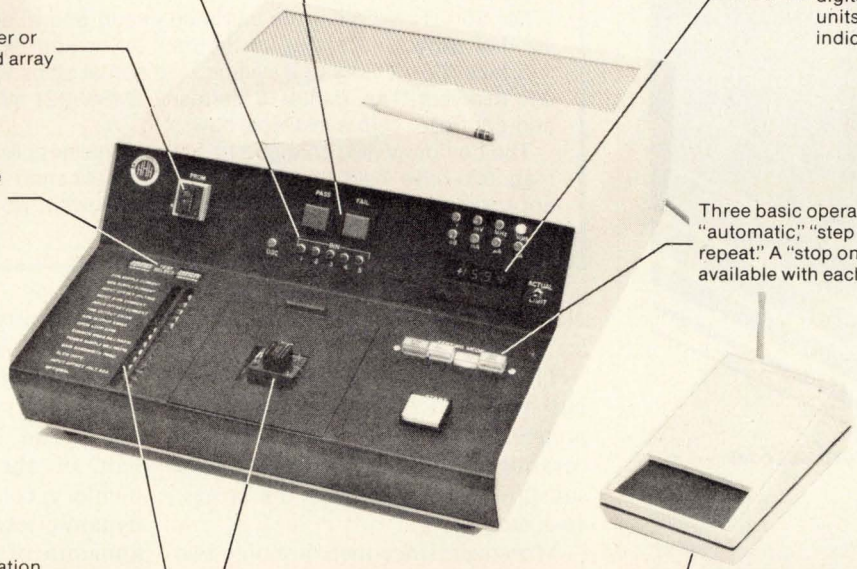

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92,304-bit bubble memory to join TI CCD

While Texas Instruments readies samples of its new CCD memory, it is also announcing production and price details for the bubble memory available in sample quantities since October. Dubbed the TBM0103, the new 92,304-bit bubble memory [*Electronics*, Sept. 30, p. 29] costs $200 each in single units. Moreover, the company says it will make available by the end of the year a bubble memory with 256,000 bits.

According to the company, volume prices when the 92,304-bit device goes into production in the fourth quarter will be in the 0.04 to 0.05 cent/bit range—about $37 to $46 for the 14-pin dual in-line package, which includes bubble-memory chip, permanent magnets, wire coils, and magnetic shield. Within two years, the price will be about 0.005 cent/bit, indicates Michael H. Valek, bubble-memory manager at TI's Linear and Special Products division in Dallas.

For $50, TI will sell users a printed-circuit board, schematics, and a parts list that allow prototyping of the four driver and clock chips necessary to interface the memory to a system. The actual chips will not be available until late this year. The TMS9916 (formerly TMS5502) microprocessor-interface-and-controller chip is available now.

The company also changed to slightly smaller coils to provide the rotating magnetic-drive field to the chip. The modification pares 0.1 in. from the approximately 1-in.-square package and lowers power consumption from 0.7 to 0.5 W.

clocks are non-overlapping, non-critical clocks," Hewkin adds.

The firm will not divulge chip size, but the device is packaged in a nonstandard 16-pin, 400-mil-wide ceramic package that implies a chip substantially larger than the largest 16-k MOS RAM.

Moreover, since there are only two electrodes per bit of storage compared to three for random-access memories, the CCD cells make more efficient use of silicon. In addition, by ion-implanting the storage wells, TI designers are able to contain the stored charge without resorting to implanted barriers between wells. This simplifies the peripheral support circuitry, since non-overlapping clocks can be used. Indeed, a full half of the chip is reserved for memory, compared to about 30% for dynamic RAMs, which require large amounts of on-chip overhead support. Finally, a potential yield killer has been eliminated: shorts between top-level polysilicon electrodes do not cause failure, because of the fact that the electrodes are electrically connected anyway. □

Digital panel instrument from Analogic hits $39 price with C-MOS circuit chip

When it comes to digital panel instrumentation, $39 appears to be a special target. Last year, Analog Devices Inc., Norwood, Mass., hit that mark with a 3-digit panel meter that cut the former DPM price by some $30. Now, Analogic Corp, Wakefield, Mass., is aiming at the same $39 mark, but with a digital panel instrument.

The distinction is important, the company says. Although a DPM simply replaces an analog meter and its two input and two power terminals, a digital panel instrument (DPI), is much more systems-oriented. Through a multicontact connector in the back, Analogic's 3½-digit AN2570 offers differential inputs and external controls like "test," "blank display," and "hold last reading," as well as end-of-

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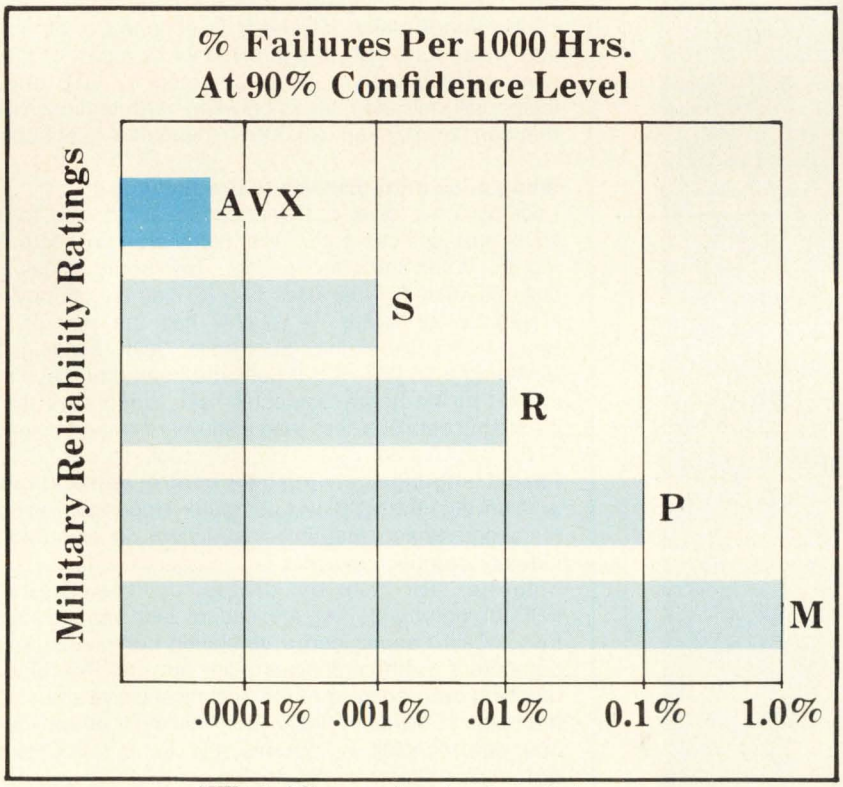

AVX is building capacitors, in volume, that are more than ten times more reliable than the highest military standard.

conversion and over-range-signal outputs. As a $15 option, it also has a binary-coded-decimal output for printing out readings.

At $39 in quantities of 100, the DPI is nearly half the price of its predecessor, Analogic's two-year-old $72 type 2538. At the lower price,

News briefs

RCA turns consumer and commercial electronics upward

Pruning marginal and unprofitable electronics activities and instituting tighter cost controls paid off last year at RCA Corp. In the firm's annual report to shareholders, issued March 7, president and chief executive Edgar H. Griffiths says RCA's electronics operations made a "remarkable comeback" in 1976. Most notable was the transformation from a 1975 loss of $48.3 million in commercial electronics to a 1976 profit of $7.5 million. Leading in gains were solid-state operations, which turned profitable, and color picture tubes. The firm's consumer-electronics business showed a 65% profit jump to $41.8 million so that the consumer- and commercial-electronics segments represent a swing of $72.3 million in profit on a $280 million revenue hike. Consumer-electronics sales totaled $1.371 billion and commercial-electronics, $0.689 billion. Company sales totaled $5.36 billion.

Racal, RCA team for U.S. Army radio system

Racal Electronics Ltd., fresh from its successful battle to acquire Milgo Electronics Corp., Miami, is now teaming with RCA to bid on the U.S. Army's Sincgars-V, a single-channel ground and airborne radio system for the late 1980s. Racal, in Bracknell, England, will serve as lead company, and RCA Government Communications Systems in Camden, N.J., will add expertise in electronic counter-countermeasures.

GT&E sets up third earth station

General Telephone & Electronics Corp. will formally dedicate its third earth station on March 24. The terminal, located about 70 miles north of Tampa, Fla., has been integrated into the nationwide telephone network through connecting facilities of General Telephone Co. of Florida. Transmitting interstate telephone calls, the terminal forms a part of the domestic communications satellite system jointly operated by GTE and AT&T. Long-distance telephone calls are relayed between earth stations via two Comstar satellites that can handle nearly 29,000 simultaneous telephone conversations.

Wang adds mini-diskette to product line

Looking for a lower-cost random-access device to include among 20 new small-business-computer and peripheral products introduced earlier this month, Wang Laboratories Inc., Tewksbury, Mass., hit upon a dual mini-diskette memory that uses 5¼-in.-diameter floppy disks. The disk, which stores 89,600 bytes, is roughly half the size of conventional diskettes. Shugart Associates Inc., Sunnyvale, Calif., building the mini-diskette drives for Wang's $6,200 PCS II Deskette computer, says it's supplying a growing market in the hobby-computer field. Wang says the mini-diskette memory package costs 60% less than a standard diskette system.

Pascal language gets push for control applications

A relatively new high-level computer language, Pascal, is gaining popularity for programming real-time instructions in electronic control applications. Electro Scientific Industries Inc., Portland, Ore., is beginning to offer its own compiler for use by others on the Digital Equipment Corp. PDP-11 computers. At the end of last year, Computer Automation Inc., Irvine, Calif., announced a combined compiler-interpreter for its own minicomputers. Both companies point out that Pascal, developed as a tool for teaching programming at the Technical University of Zurich, is simpler to use than either Fortran or Basic. ESI is aiming it at applications in automated test and data-acquisition systems and in its own laser trimmers. Computer Automation likes it for developing compilers and translators.

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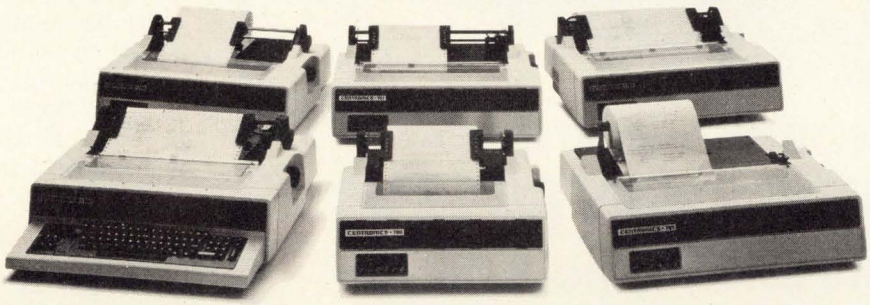

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the firm expects new markets to open for such applications as instrumentation for automotive and marine equipment.

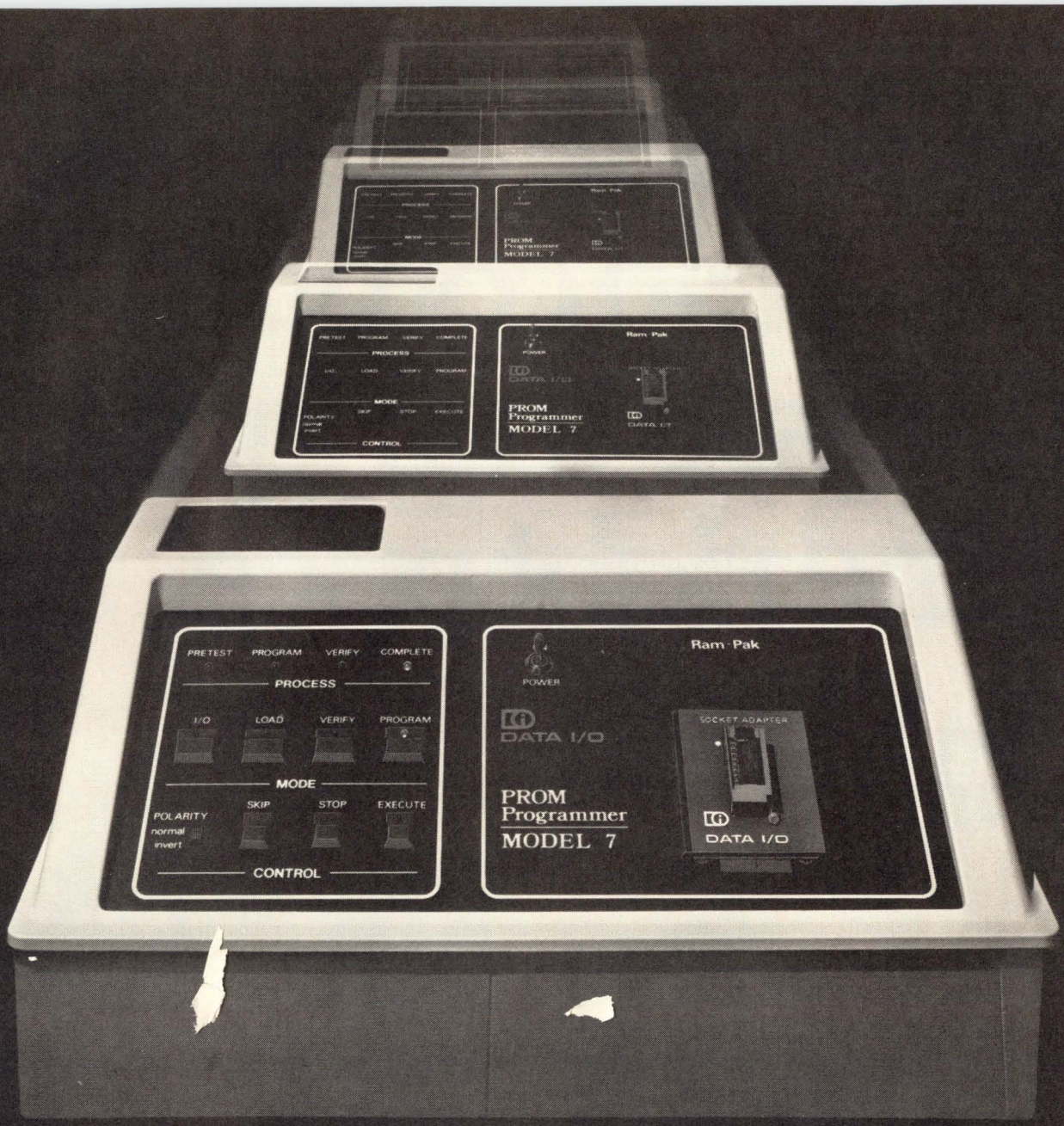
The keys to the low price are a custom complementary-MOS chip and selection of what features to include and what to leave out, says Horst Seperant, the product manager. He admits that the price is based on anticipation of a large production volume, but adds that the company hopes to hold costs down by using the electronics as a basic building block in future instruments.

Meter plus. Digital panel instrument from Analogic has 3½-digit light-emitting diode display. Unit also has differential inputs, external controls, and optional BCD output.

An Analog Devices spokesman questions the high volume. "We don't believe, in the long run, this meter can be sold at this ($39) price," he says. "It looks like a defensive reaction to the excellent reception we've had."

Dual-slope. At the instrument's heart, the custom chip performs the dual-slope integration for analog-to-digital conversion. Seperant notes that C-MOS was chosen for its low power dissipation, even though the instrument is not necessarily intended for battery use. Total power dissipation must be kept down to improve reliability, he says.

Analogic is offering the meter with either of two input ranges—±199.9 millivolts, which corresponds to a sensitivity of 100 microvolts for the least significant count, and the commonly specified +1.999 volts. Accuracy is within ±0.05%, which corresponds to 1 count out of 2,000, compared with ±0.1% for most others, he says. □



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Rockwell's instruction sets provide ROM efficiencies of typically 2 to 1 over other microcomputers. For example, some one-byte multi-function Rockwell instructions perform operations requiring five instructions in other systems.

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Model	MM76	MM77	MM78	MM75	MM76C	MM76D	MM76E
Description	Basic 76	Basic 77	Jumbo 77	Economy 76	High speed counter*	12-bit A/D converter	Expanded 76
ROM (x8)	640	1344	2048	640	640	640	1024
RAM (x4)	48	96	128	48	48	48	48
Total I/O lines	31	31	31	22	39	37	31
Cond. Interrupt	2	2	2	1	2	2	2
Parallel Input	8	8	8	4	8	8	8
Bidirectional Parallel	8	8	8	8	8	8	8
Discrete	10	10	10	9	10	10	10
Serial	3	3	3	—	3	3	3
In-line package	42 pin quad	42 pin quad	42 pin quad	28 pin dual	52 pin quad	52 pin quad	42 pin quad
Availability	Now	Now	Now	2Q 77	2Q/77	3Q 77	16 wk ARO

Power supply is 15v except low voltage version of Basic 76 available 3Q 77.
Typical power dissipation is 70mw.
*Two 8-bit or one 16-bit presetable up/down counter with 8 control lines.

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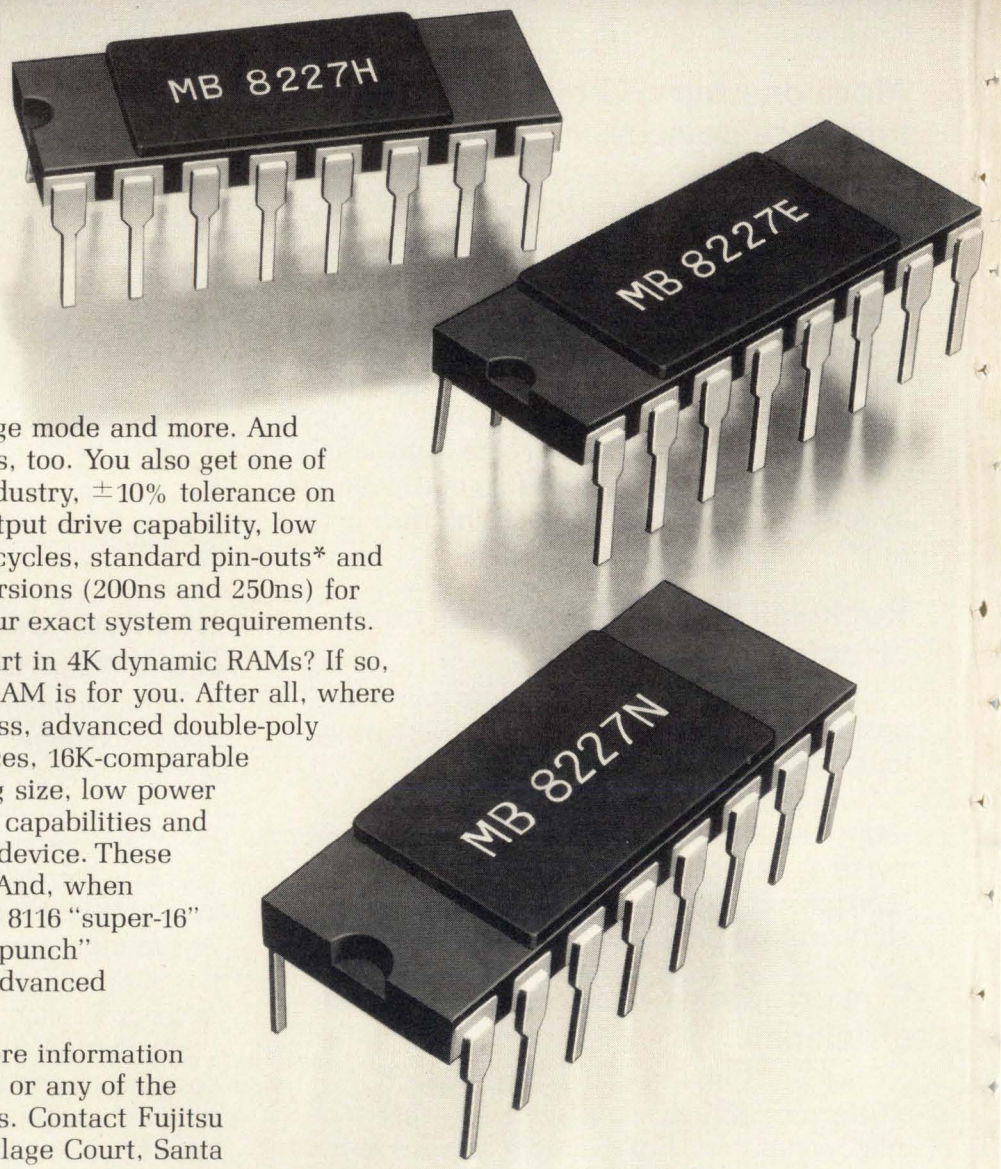

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Circle 48 on reader service card

Washington newsletter

Tests of a-m stereo begin in May; 1978 market seen

In the drive to get Federal Communications Commission standards set for a new consumer market in a-m stereo radio by early 1978, the National a-m Stereophonic Committee will begin six weeks of field tests on May 1. The committee **anticipates development of a major market, particularly in auto radios.** Test signals will be broadcast over the facilities of three commercial stations—WGMS in Bethesda, Md., WTOP in Washington, D.C., and WBZ in Boston—over periods of four to six hours early on Monday mornings when the stations are usually off the air. Signal measurements will be made by Atlantic Research Laboratories, Alexandria, Va.

At the same time, three a-m stereo systems submitted to the committee by Belair Electronics, Magnavox Co., and Motorola Inc. will undergo laboratory measurements of transmission fidelity through precise signal-encoding-and-decoding equipment and also with specially built a-m stereo radios.

NRL claims gains in GaAs growth for microwave devices

Naval Research Laboratory scientists say they have found a better way **to grow high-purity gallium-arsenide crystals and to produce uniform epitaxial GaAs layers** on substrates for microwave semiconductors. GaAs is the most promising microwave semiconductor material; silicon performs poorly at those frequencies. The NRL investigators—Soong Lee, Paul Nordquist, and Edward Swiggard—say their growth technique for uniform liquid-phase epitaxial layers involves etching substrates with a gallium solution immediately prior to layer growth to remove the damaged surface layer produced by heating. This process eliminates the need for a buffer layer between the substrates and the active epitaxial layer that is usually required in the conventional liquid-phase epitaxial growth process that is now in use.

ITC data sought for drive opposing TV-import curbs

U.S. consumer groups and retailers are pressing hard for release of the Federal International Trade Commission's staff report on its investigation of television-receiver imports after the ITC ruling that both monochrome and color receivers and being dumped on the U.S. market. The pressure is being applied because the staff report is said to contain **data showing TV retail prices would climb 15% if import quotas or tariff increases are invoked.** Such a claim was advanced by the White House Council on Wage and Price Stability in opposing curbs on imports [*Electronics*, Feb. 3, p. 48]. If the ITC staff findings are similar, the information would be used as part of a campaign to convince President Carter's consumer-oriented administration to reject or modify ITC recommendations to air domestic manufacturers.

New instrument detects geothermal energy sources

An instrument with the potential for **locating new geothermal-energy sources as deep as 30 miles below the earth's surface without drilling** has been developed for the Energy Research and Development Administration. Known as an "ultrasensitive three-axis superconducting magnetometer," the instrument was developed and tested at ERDA's Lawrence Berkeley Laboratory in California. It measures minute changes in underground magnetic and electrical fields in three dimensions simultaneously.

Washington commentary

The problems and promises of land-mobile radio

"New FCC Rules Mean More Mobile Radio," the article's headline declared. Though 27 years and eight months have passed since this magazine published that article, land-mobile radio in America is still in its infancy. *Electronics*' editors had every reason to believe then the evidence submitted by contributing author Jeremiah Courtney, Washington communications attorney and former Federal Communications Commission official. For Courtney documented and expounded upon the FCC's new land-mobile radio rules that were to become effective in July 1950. They were, he asserted, "the product of the most comprehensive study ever made of public safety and industrial-operational communications requirements."

Today the FCC is just getting around to approving the first operational tests of the cellular land-mobile technology devised by American Telegraph & Telephone Co. six years ago [*Electronics*, Jan. 3, 1972, p. 100]. It took the commission only three years to muddle through that proposal before it bought the idea in 1974. Then, thanks to AT&T's major alterations in its original plan, three more years somehow slipped away (see p. 32). No one is really willing to speculate how many more years will pass before land-mobile telecommunications becomes an affordable reality for most citizens. Meanwhile the marketplace waits.

The worldwide potential

It is a global market far larger than the United States alone, and it may not wait until American technology and those who oversee it are ready to exploit it. Motorola appears to be one company to recognize that fact. At the time of the recent FCC filing by its client, American Radio-Telephone Service Inc. of Baltimore, for a high-capacity development cellular system in the Baltimore-Washington area [*Electronics*, March 3, p. 38], Motorola acknowledged a commitment of $18 million plus to development of that technology. Motorola vice president Martin L. Cooper warned then of Japan's advanced effort to develop cellular systems via a joint effort by Nippon Telephone & Telegraph and multiple industry suppliers. "They are not building their system for Japan alone," Cooper declared, "just as we are not building our system just for Washington-Baltimore." Japan's effort is shrouded in secrecy, according to Cooper, who was refused permission when in Japan to see or talk with persons associated with the project.

Should Motorola's client fail to gain FCC approval for the $2.5 million cellular system bankrolled by Motorola, then Cooper will try moving its development program abroad. Markets are developing in countries ranging from Australia, which is planning a nationwide land-mobile net, to Brazil, Iran, and the four Scandinavian countries where a joint effort is planned for land-mobile service to customers throughout the peninsula.

Japan's challenge

But Japan's 800-MHz system is the major threat to American dominance of the U.S. consumer market. It is a threat well known to engineers and executives who have watched American jobs and dollars fly to Japan to pay for citizens' band radios, calculators, high-fidelity components, clock radios and television receivers. The fear that land-mobile transceivers may be next to go is supported by AT&T's award to Oki Electric Co. two years ago for the first 135 units to be used in its cellular test programs.

Admittedly, the market must develop before it can be lost. And Motorola's Cooper is convinced that a land-mobile market will not realize its potential until the monthly charge approaches that for a residential telephone. That time is still some distance away.

Indeed that time may never come if the FCC cannot find ways to accelerate its decision-making machinery and encourage land-mobile competition within regional markets between wire-line telephone companies and radio common carriers. This would require rejection of the misguided concept of one-carrier-per-region fostered by FCC Chairman Richard Wiley. But Wiley's term ends in June, and with the departure of commissioner Benjamin Hooks, that will mean a total of four FCC vacancies for President Carter to fill in the seven-member body.

Carter has promised many times to reshape the Federal bureaucracy into a more efficient and effective body. He would do well to make an early start on the FCC in areas where he can, while Congress chews on the larger issues of the AT&T-sponsored Consumer Communications Reform bill. If his FCC appointees are well chosen, Carter could limit further delay in land-mobile service. Wisdom in these appointments must include a White House appreciation of the challenge from Japan as well as encouragement to American producers to move overseas and compete in developing foreign markets before they are lost.

Ray Connolly

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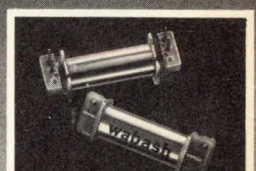

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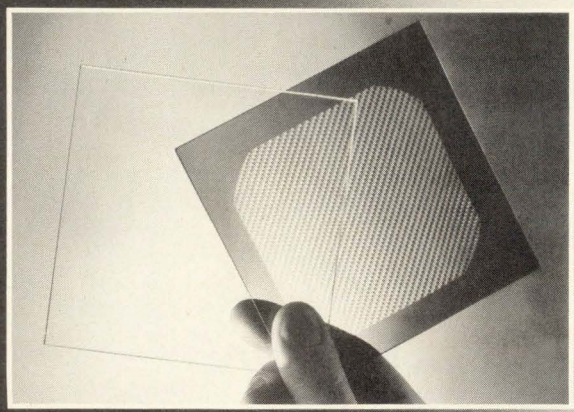

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CORNING

International newsletter

French mini makers fear expansion by CII-Honeywell Bull

Fears that the French government intends to push its new computer company, CII-Honeywell Bull SA, into the minicomputer and peripherals market has the rest of the country's computer industry up in arms. Its alarm stems from a suggestion by minister of industry and research Michel d'Ornano that CII-HB would have a better chance of overtaking IBM Corp. as the No. 1 computer manufacturer in the French market if it added to its lines.

The government has already poured some $100 million in subsidies into the recently formed company and influenced another $180 million in orders for it. **Some $150 million in subsidies is yet to come, and some of that could be used for a CII-HB push into the lower end of the market.** The French demand for minicomputers is expected to grow at 40% year in the near future, compared to an anticipated 15% growth for large computers. "We fully understand and agree with the government plan of helping CII-HB in the large-computer sector," says Georges Seban, president of both minicomputer producer Logabax SA and the Club Peri-Informatique, the French association of minicomputer and peripheral manufacturers. "But we cannot accept that the government aid and influence on orders would be used in the small-computer sector at the expense of all those French companies already in the market."

Matsushita makes lithium cell for thin calculators

In July, Japan's Matsushita Electric Industrial Co. will begin making a tiny coin-shaped long-life lithium energy cell to power calculators that may get as thin as 5 millimeters. The cell, 23 mm in diameter by 2.5 mm high, weighs only 3.1 grams. The company, which developed the power source in consultation with a calculator maker, plans to turn out 100,000 units a month for an original-equipment manufacturer. Matsushita has licensed the technology to Eagle-Picher Industries Inc. in Cincinnati.

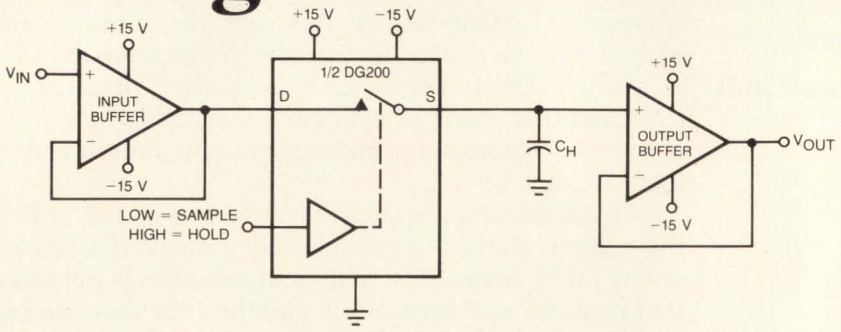
With a terminal voltage of 2.8 volts and capacity of 140 milliampere-hours, the cell is likely to last five years—the life expectancy of liquid-crystal displays. Energy density is an unusually high 378 watt-hours per liter. Leakage is no problem because the organic electrolyte—lithium borofluoride solute dissolved in gamma buthyrolactone—has no tendency to creep or salt like alkali electrolytes. The cathode is metallic lithium, and the anode is polycarbonmonofluoride.

Display emits bright fluorescent light from low power

Display-system designers will soon have a new device to work with—the fluorescence-activated display (FLAD). Invented at the Institute for Applied Solid State Physics in Freiburg, West Germany, the device uses a layer of plastic material appropriately doped with fluorescent organic molecules. In this layer, ambient light is collected, guided, and then emitted at the segments of the display's digits.

The FLAD dissipates the same power as a liquid-crystal display, but its light intensity is said to be much higher. Moreover, **the light can be any color in the spectrum betwen green and red,** the inventors say. West Germany's Siemens AG will produce the FLAD display first, initially for use in battery-operated digital tabletop and alarm clocks. Later, FLADs will be used in pocket calculators, portable instruments, and scales that indicate price and weight.

Can you spot the design error? Check page 4-37 in our new analog switch handbook.



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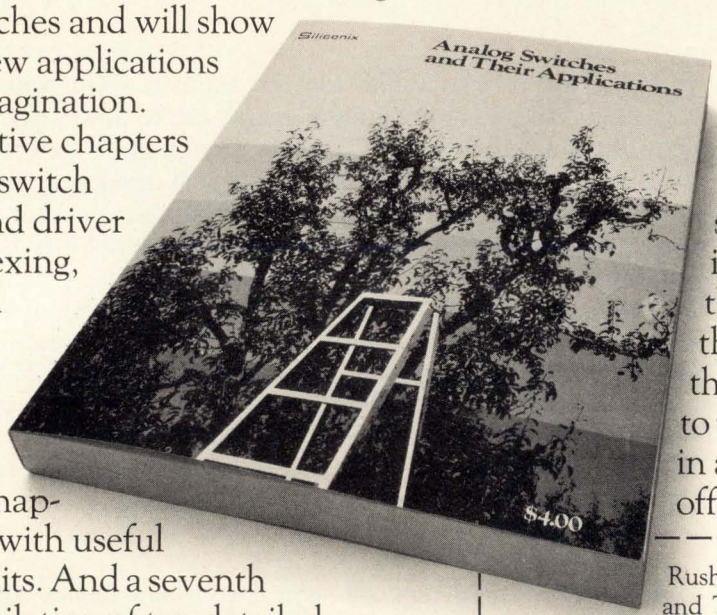

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Digital speech-interpolation doubles capacity of experimental phone system

A digital speech-interpolation system under development at Nippon Electric Co.'s Central Research Laboratory should double the number of conversations a given number of telephone circuits can transmit. Although expensive transmission circuits such as satellite links and submarine cables will benefit most, economies from decreasing costs of digital large-scale-integrated circuits should also make these systems economical for terrestrial circuits.

The relatively simple basic theory behind the system has been known for some time. Since the average person only speaks for 25% to 40% of the time during a conversation, less than half of the incoming telephone circuits will be active simultaneously, so long as the number is large enough to be statistically valid. A given number of individual circuits can be assigned for short time intervals so that twice as many conversations are transmitted.

In a digital system, a delay is easy to build with an inexpensive shift register. This delay, ahead of the switching circuits, permits the speech detector, assignment logic, and switching circuits to perform their assigned functions without cutting off the start of initial syllables.

Configuration. The experimental system consists of two terminals with common circuits that could handle 240 speech channels and half that many transmission channels between them. However, only 60 for speech and 30 for transmission are actually fitted with delay lines for operation. The common circuits on the transmit side are the speech detector, assignment logic, speech memory, and assignment-message transmitter.

Those on the receive side are the message receiver and assignment memory. The speech terminals include two standard European commercial pulse-code-modulated coder/decoders to handle 30 telephone channels each. These were selected rather than the 24-telephone-channel units used in Japan and the U.S. because 48 channels are not enough for speech statistics to be valid.

When all 30 transmission circuits are in use, any additional circuits that become active would ordinarily be frozen out. However, a bit-reduction technique in the experimental system makes available four additional channels by reducing the number of bits in each transmission channel to 7. The speech detector, which picks up PCM-encoded voice signals, works both on the level and rate of zero crossings because it is quite difficult to distinguish between noise and low-level voice, especially consonants. The speech detector also includes circuits that compensate for direct-current offset and drift.

The input to the detector is a branch off the main voice path, and its output provides an input to the assignment logic. The main speech path passes through a 16-millisecond

Around the world

Electret relay switches with little power

Researchers at the Ecole Supérieure de Physique et de Chimie de la Ville de Paris (ESPCP) have built prototypes of a relay with an electret, the electric analog to a magnet. In five years, this relay should be the predominant means of electric switching, predicts Jacques Lewiner, a professor at the ESPCP's Laboratoire d'Electricité Générale and co-inventor of the relay, along with Gerard Dreyfus, who also teaches at the school.

Lewiner points out that the electret device needs 10,000 to 100,000 times less switching power than conventional electromagnetic relays. Driving voltages are no particular problem, since they can range anywhere from about 30 to 150 volts. The prototype switches in less than 5 milliseconds, and the contact pressure is higher than 2 grams. Moreover, Lewiner explains, the relay can be half the size of a reed relay and is likely to be cheap to produce—the structure is simple, and the materials involved are relatively inexpensive.

The relay consists of an electret with an excess positive charge that is kept suspended midway between the plates of a shorted capacitor by the equal negative charges it induces on the plates. But if the electret is moved slightly toward one plate, the fields are unbalanced, and it is attracted to the nearer plate, where it stays. A pulse of the right polarity will force the electret to the other plate, where it again rests until switched back by a pulse of opposite polarity. Initial applications, thought to be about two years away, are expected to be in communications equipment.

Satellite tests microwave propagation

Although the basic mission of Japan's test satellite launched early this month is to practice techniques of firing the on-board rockets needed to station it in a geostationary orbit, three on-board transmitters will also test radio-wave propagation in the S, X, and K bands. Launched by the National Space Development Agency, Engineering Test Satellite II, also known as Kiku No. 2, is stationed at 130° east longitude above the small equatorial island of Kawe, Indonesia. Using three mechanically despun antennas, the satellite transmissions are expected to suffer less attenuation during heavy rainfall than do terrestrial systems, which suffer extremely high losses. The transmitter outputs, in effective isotropic radiated power, are 28 dBm at 1.705 gigahertz, 46 dBm at 11.50875 GHz, and 50 dBm at 34.52625 GHz.

delay and then into memory.

Signals in the 30 active channels feeding the speech memory are assigned time slots for transmission. At the same time, an assignment message is transmitted to the receiving terminal so that it can route the speed packets to the appropriate 60 output channels.

Assignments. Although these European PCM systems handle 30 speech channels, they transmit a total of 32 8-bit time slots. The assignment message is transmitted in the 31st time slot, and the complete assignment message requires six frames. Each assignment message thus consists of 48 bits—the 8 bits in each of the 32 time slots in the frame, multiplied by six frames. Only 24 of these bits carry information, and the remaining 24 are check bits in an error-correcting code because assignments are the most important data the system transmits. Since each channel is sampled 8,000 times per second, the time required to transmit each assignment message is 750 microseconds.

Because speech delay in the system is 16 milliseconds, the MOS memory must have a capacity of about 1 kilobit per incoming speech channel. Smaller bipolar random-access memories are also needed for the speech memory and for speech-assignment memory. The delay is insignificant in satellite systems that have an inherent round-trip delay of about 300 ms. □

France

Computerized French system helps route 600 trains a day in high-density zone

With some 600 trains a day to route safely through a 17-kilometer stretch of line made up of four main tracks and dozens of branches and sidings, the five-man switching-and-signaling crew at the new Versailles control center has plenty to keep it busy. But, next month, the workload will be substantially lightened when a $4 million minicomputer system begins handling much of the work.

The French national railways (SNCF) plans extensive automation of track switching in the years ahead, and the Versailles installation is a prototype for high-density zones, says Roger Retiveau, who is in charge of signaling and train automation for the SNCF. Less elaborate systems are already being tested near Tours and Toulouse for long-line switching.

At Versailles, SNCF built the system around two Télémécanique T 1600 16-bit minicomputers, each with an internal memory of 48 kilowords and a cycle time of 800 nanoseconds, plus a magnetic-disk mass memory with a capacity of 1,024 kilowords. In addition, a third T 1600 with an 8-kiloword memory handles two graphic display systems—one at the Versailles center and one at the Montparnasse station in Paris, where nearly all the traffic passing through the zone originates or terminates.

Backup. Both of the key T 1600s carry the same load of information, and either can handle the whole system. The disk memories store a block of 251 kilowords, a so-called "general tableau." This information, put together from the overall SNCF timetable for the region, consists of two listings: one with the identification number of all the trains scheduled to pass through the zone during a day and another showing the order in which trains normally should pass through each switch point. The general tableau gets changed only when the timetable is changed—usually twice a year—so that its data is supplemented by temporary listings to take care of changed track assignments, canceled trains, and the like.

Movements for any given day, though, are managed by means of a daily listing, compiled the day before from the general list. This detailed schedule, contained in a memory block of 264 kilowords, guides the associated minicomputer, although the chief controller can modify the details in real time when necessary.

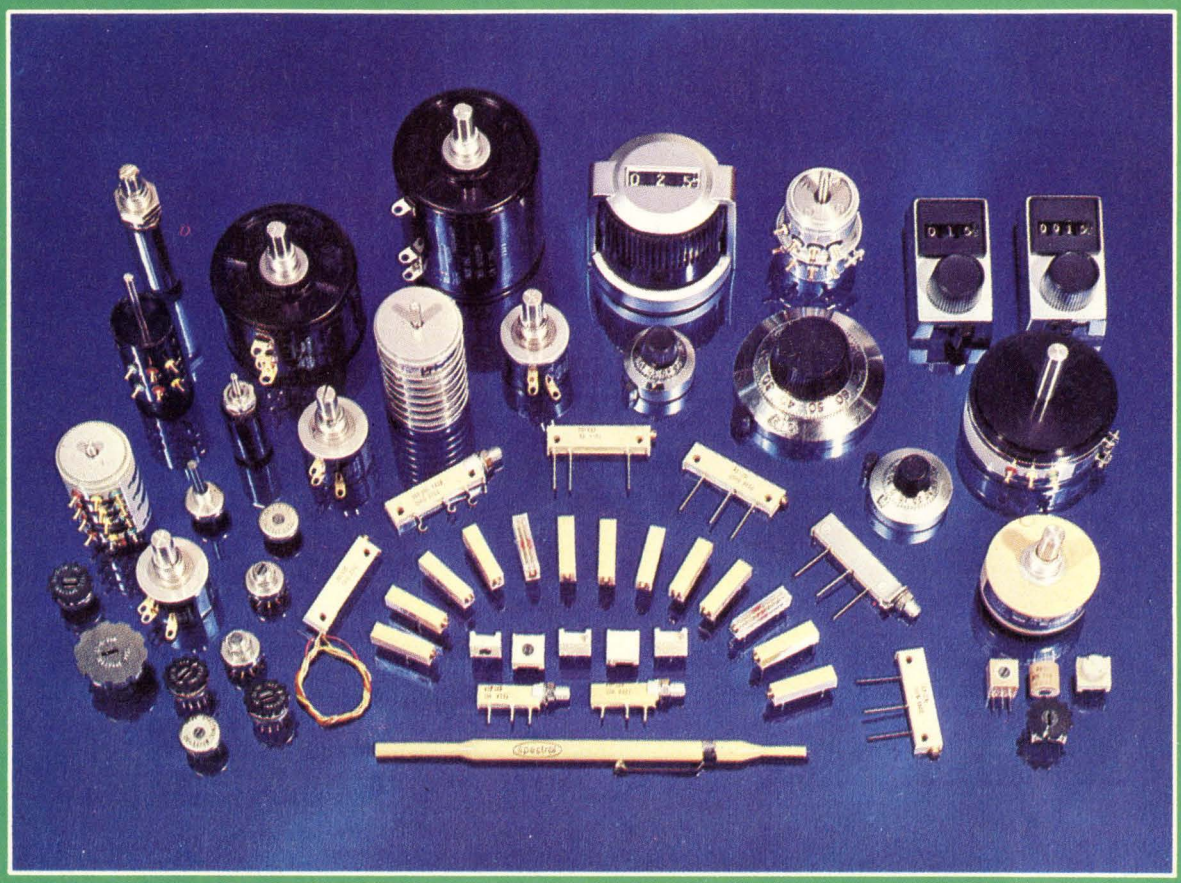
Activity in the zone shows up in the control center on a big board that displays the tracks and has windows for the switch blocks. As a train moves through the zone, the computer lights up its identification number from window to window on the board. Moreover, the chief controller and his assistant share a graphic display that shows time/space relations on the tracks, and each monitors an alphanumeric display that lists the succession of movements through junction points.

Monitoring junctions. Each of the three switch operators also has an alphanumeric display and a cathode-ray-tube terminal that displays the order of trains scheduled to pass through the two or four junction points he controls. The center is linked by 1,200-baud lines to displays in peripheral control posts where trains enter or leave the zone and to the control center at the Montparnasse station. Additional links control train-display boards in a half-dozen stations.

Although a lot of computer power backs up the two controllers and the three switch operators, the system is not fully automatic—far from it. As trains enter and leave the zone controlled from Versailles, most are identified by an operator at a peripheral post. His display lists the next nine trains scheduled to pass, and through his keyboard, he tells the computer when they enter the zone. Trains originating within the zone are usually signaled automatically, but sometimes manually.

The information needed to generate automatic switching signals is all there, since the itinerary for each train is also stored in the daily listing. For starters, though, SNCF has automated only two junction points, while the others are controlled by operators at the consoles, guided by displays that show the itinerary through the switch point. However, an operator can override the computer to reroute a train. □

A Line for All Reasons



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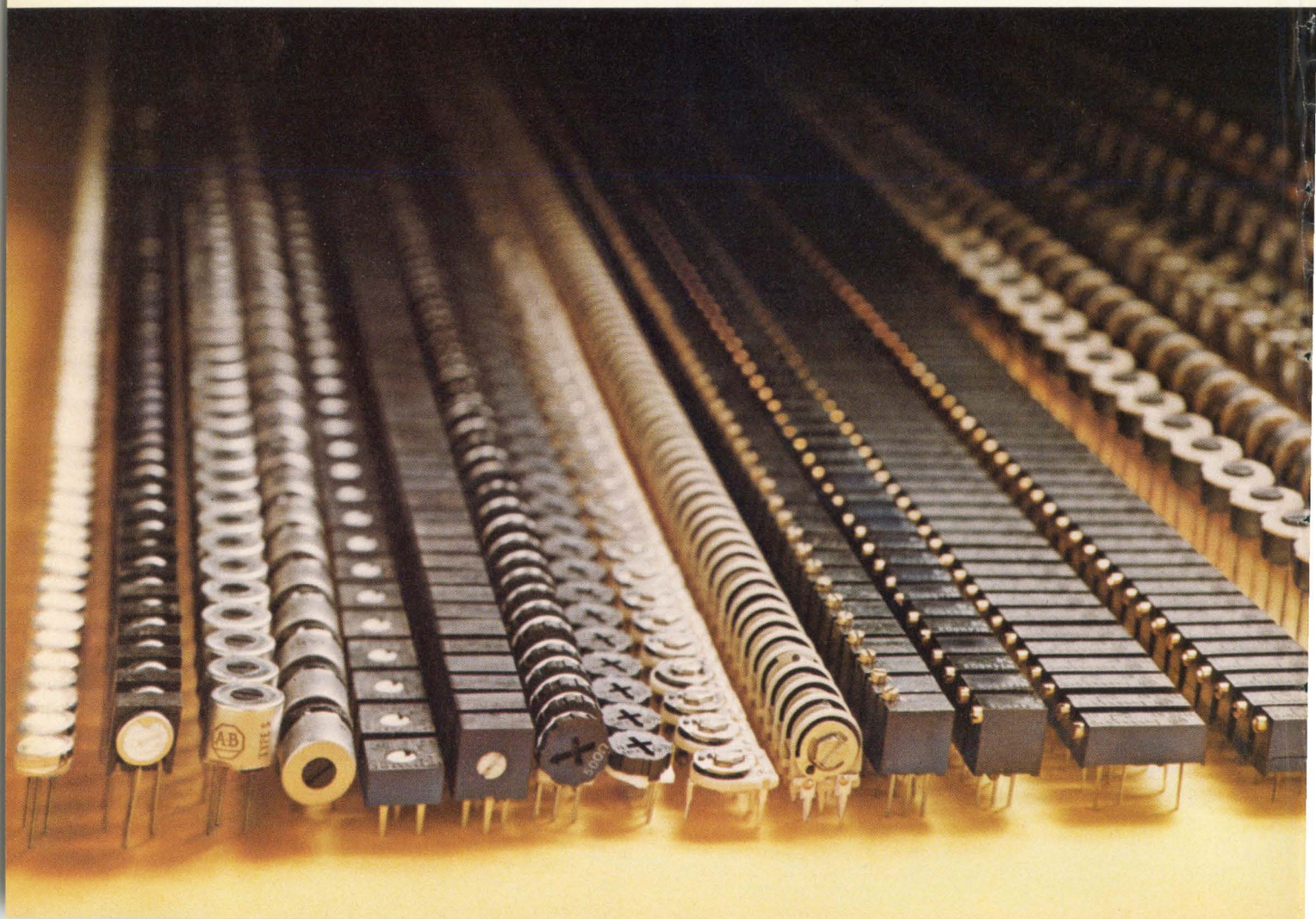

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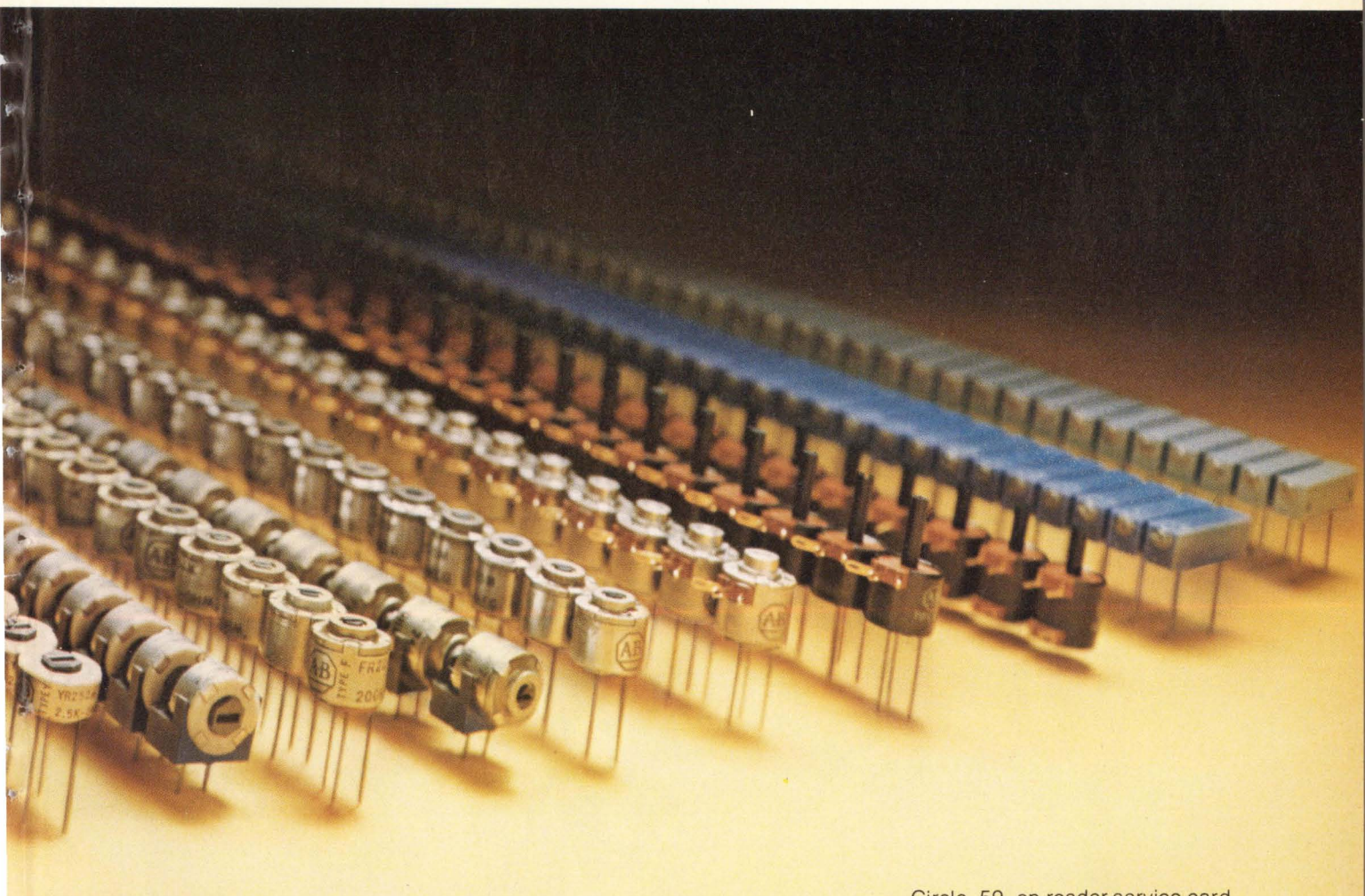

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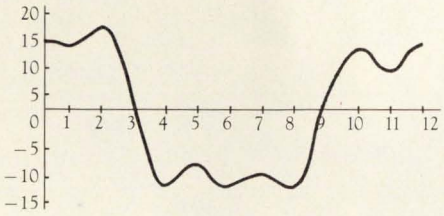

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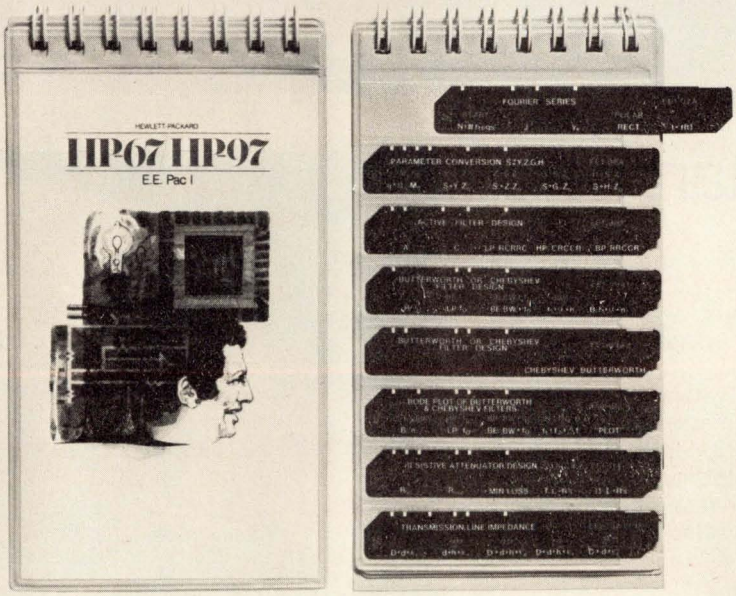

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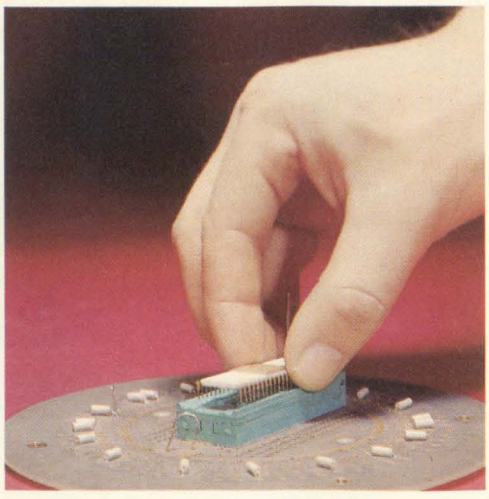

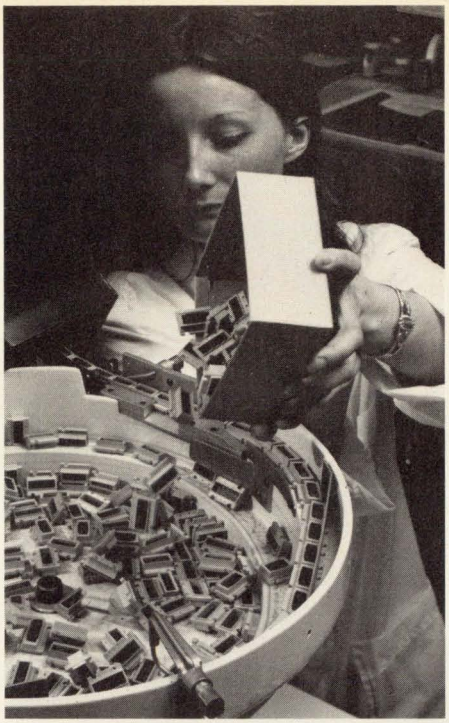

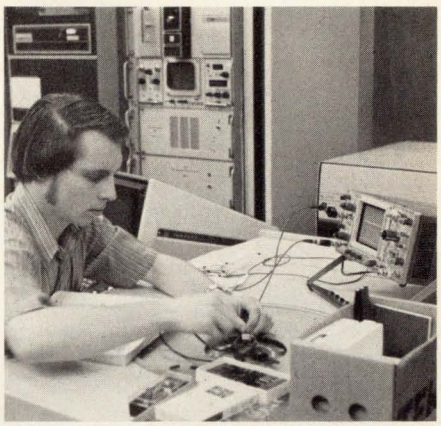

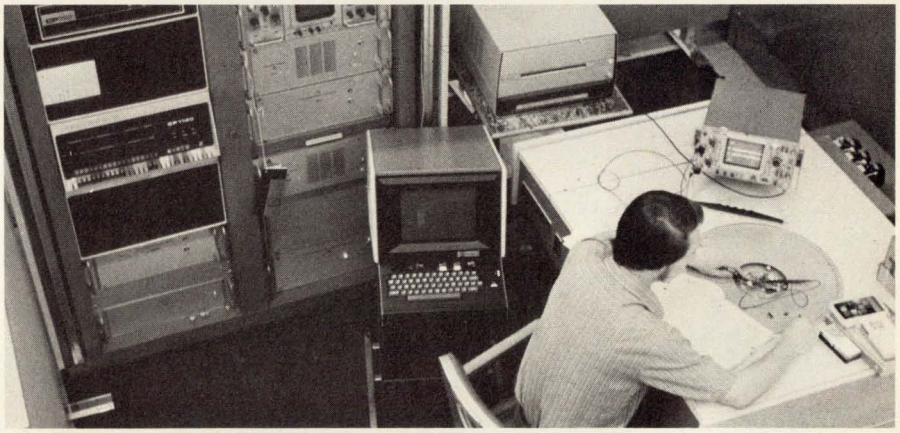

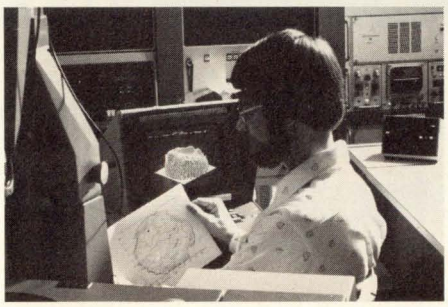

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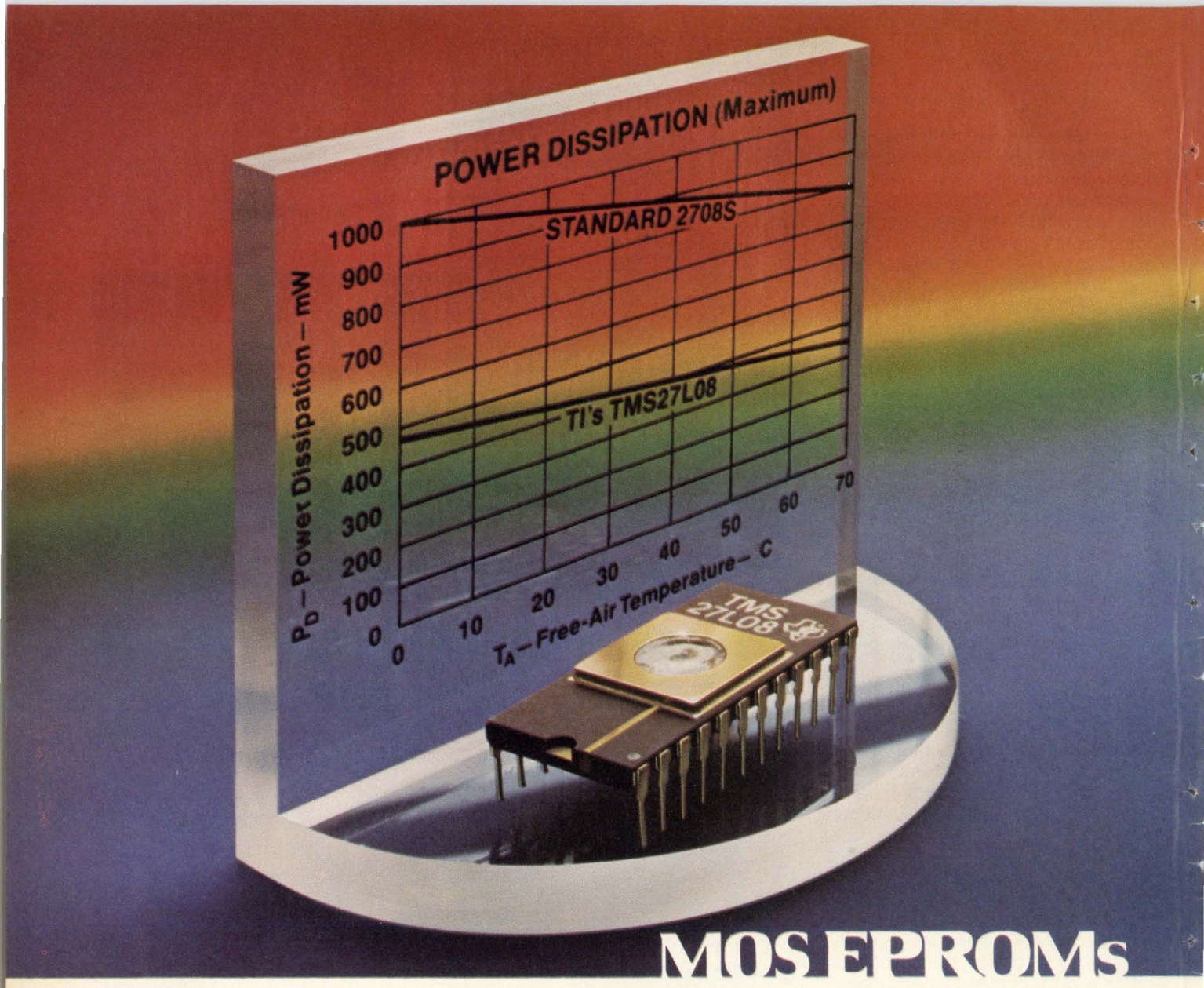

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Circle 64 on reader service card

Springtime brings mixed moods to Paris show

by the European editors of Electronics

European components markets always have been a patchwork affair, and this year, prospects for them seem particularly patchy. Consequently, the marketing men who will man the stands for some 1,200 companies at the Paris Salon Internationale des Composants Electroniques, March 31 through April 6, will be of several moods.

The most concerned group in the exhibition halls at the sprawling fairgrounds at the Porte de Versailles figures to be the people who do a big part of their business with industrial-equipment producers. Purveyors of parts to radio and television set makers will turn up reasonably assured, and the mood among microprocessor merchants will border on the buoyant. Overall, then, the market outlook can be characterized as all right or a little better. "Correct" is how Jacques Bouyer sums up.

Show time. Some of the throngs of visitors to last year's Paris components show prepare to look for company stands. This year, 1,200 companies will be exhibiting.

Bouyer heads RTC-La Radiotechnique-Compélec, the French components-producing company in the Philips group, and he is also president of the French trade association for active-components producers. Like most others in the business, he went into the year with some apprehension. Sales of components in France climbed 17% during 1976 to reach some $1.26 billion, a welcome turnaround from the slide in 1975. All the same, Bouyer points out, "we're still not back to 1974 levels in real terms."

To put it another way, business in 1976, although good, did not live up to the great expectations that many people had for it. Thomson-CSF, France's largest electronics group, pushed up its sales of components by more than 23% last year to $520 million, better than budgeted (the figures include television tubes, ferrites, relays, and transformers produced by other units in the parent group, Thomson-Brandt). "But the turnaround was very unequal," says Jean Caillot, a top marketing executive for the group. Consumer electronics picked up nicely, he explains, but other major sectors like computers and industrial electronics remained soft.

As a result, 1977 is difficult to call. "We're not terribly optimistic," Caillot says. And Thomson-CSF is not alone. The word from the two main trade associations for components—active and passive—is a cautious one: deliveries are expected to remain "satisfactory" for the first months of 1977. "We're neither pessimistic nor optimistic," Guy Baumont, secretary general for the two associations, told a press conference a fortnight ago. "We think the market's entered an 'average growth'

stage and don't see spectacular ups and downs."

Among the pluses is color TV, which has emerged as a market mainstay in France. Largely because French consumers did not go heavily for color until long after their neighbors in Northern Europe, the market for sets figures to grow solidly—but not spectacularly—for a few more years. Sales to dealers are expected to edge up to 1.20 million sets in 1977 from last year's 1.14 million, despite an overall slowdown in consumer spending.

Stalled. The plus a lot of people were counting on—fallout from the heavy spending the government has budgeted for a crash program to give the country a phone system worthy of it—has yet to materialize. "The startup has been slower than expected," Baumont said. The computer sector is slow, too, and the industrial-equipment sector is poor.

Microprocessors merit a mention. "Thanks to the microprocessor, electronics markets are holding up," maintains Jean-Claude Asscher, president of Tekelec-Airtronic, a company that manufactures, imports, and distributes both components and instruments. "Because of them, we're seeing many new clients."

The phenomenon is not limited to France, by any means. "The microprocessor market is running very strong," reports Tom Lawrence, European marketing manager for Intel Corp., which is battling Motorola Semiconductor for European leadership in microprocessors.

Germany. The 120-odd West German companies that will trundle their wares across the Rhine for the Paris show will come with a lot of confidence. Color-TV production sets the tone for components makers in their country, and a good year already seems assured. "The usually slow months of January and February for TV sales showed above-average gains this year," says Rüdiger Karnatzki, product manager at Intermetall GmbH, a member of the ITT Semiconductor Group. "Stocks are largely depleted," he goes on, "and a slackening in the months ahead is just not in the cards."

What may be in the cards, in fact, is a record output of 3.3 million color sets. That compares with just under 3 million sets last year and means that semiconductor makers have little to worry about. Gernot Oswald, director of integrated-circuit marketing at Siemens AG, reports that "sales are going according to expectations." A spurt of 25% to 35% is in sight, in other words. Dirk Vogler, manager of marketing administration at Texas Instruments Deutschland, pegs the growth for ICs somewhat lower—around 20%. That's because slow sales to professional electronics producers are pulling down the overall gain. For discretes, Vogler is looking for an expansion of only 8% to 10%.

Moreover, semiconductor sales to TV producers should continue high for a long time, even if set production stagnates after 1977, Karnatzki maintains. Because electronics has supplanted a lot of electrochemical components in German-made color sets, they now have about $40 worth of semiconductors in them, he figures. What with digital tuning, on-screen displays, and TV games, the content will go up to between $54 and $62 in the next few years, Karnatzki estimates. The advent of Teletext, the so-called TV magazine, would push the figure even higher.

Attraction. Spring brings the Paris components show, and with it this year moods ranging from buoyant for microprocessors to cautious for industrial equipment.

But like the French, the Germans do not see much joy in the industrial sector. "The pickup in industrial electronics that we expected to come late last year did not occur, and neither did it come so far this year," says TI's Vogler.

Siemens' Oswald is a bit more sanguine He says he has already seen signs pointing to an upturn in the communications and data-processing sectors later in the year.

Britain. The UK contingent will turn up at Paris with much the same scene to report, albeit viewed through the aberrations of a British-market looking glass. "TV is very good right now. December and January sales were higher than in the last few years," says Alan Hall, marketing director of ITT Semiconductors.

But, countering the trend on the Continent, "EDP looks strong right now," he adds, pointing to the healthy condition of ICL and the Burroughs and NCR manufacturing operations in the country. To no one's surprise, Hall terms the industrial sector weak, and he finds telecommunications peculiar with ups for things like automatic-call units, but stagnant for semi-electronic exchanges. Hall's global reading: "We're seeing growth, but nothing dramatic." He puts semiconductor growth at less than 15%.

To Stephen Forte, managing director of General Instrument Microelectronics Ltd., the UK market looks "flat as a pancake." But the pickup that started last year in Europe is continuing, he feels. "There's no dip at all," he maintains. Forte rates TV games as one of the most exciting markets at the moment (they are a specialty of his company) and has pocket calculators at the bottom of his list of semiconductor outlets. □

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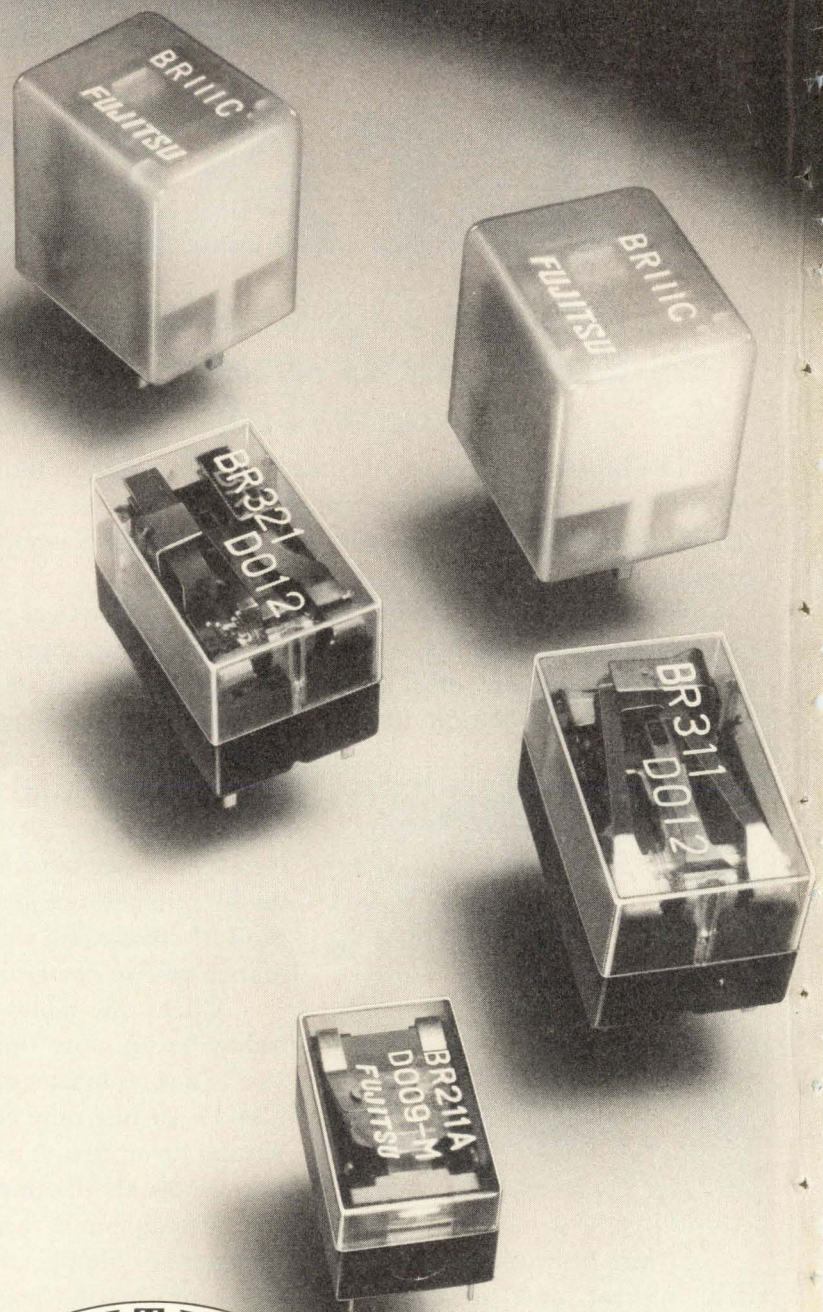

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Circle 68 on reader service card

Components

Germanium transistors hang in there

Lansdale's Miller is optimistic as firm invests in new production facilities, but major competitor foresees no growth in market

by Larry Waller, Los Angeles bureau manager

Do germanium transistors, long overshadowed by silicon devices, have a future? The answer depends on who is talking. Overflowing with enthusiasm is Jack Miller, vice president and general manager of Lansdale Transistor & Electronics Inc. of Phoenix, which last April bought Motorola Semiconductor's germanium lines.

"There is still a sizable world market for germanium power devices—$30 million to $45 million worldwide," he says. His estimate is based on the replacement market for worn-out germanium transistors in existing equipment, plus support for on-going programs, most of which are military. But the best growth, in Miller's view, should come from the "power squeeze," which will cause designers to turn back to germanium because of recognized high-power efficiencies at lower voltages than silicon needs. Moreover, Lansdale is backing this with a substantial program for expanding the former Motorola line and improving manufacturing.

Expressing the pessimistic view, a major competitor's president, Oliver O. Ward, observes, "It's hard to see germanium transistors as a growth market. Most of us would be satisfied to see it stay stable." His firm, Germanium Power Devices of Andover, Mass., has been in the business since it began in the 1950s, watching such giant suppliers as RCA, Raytheon, and ITT drop out in the 1960s as silicon took over.

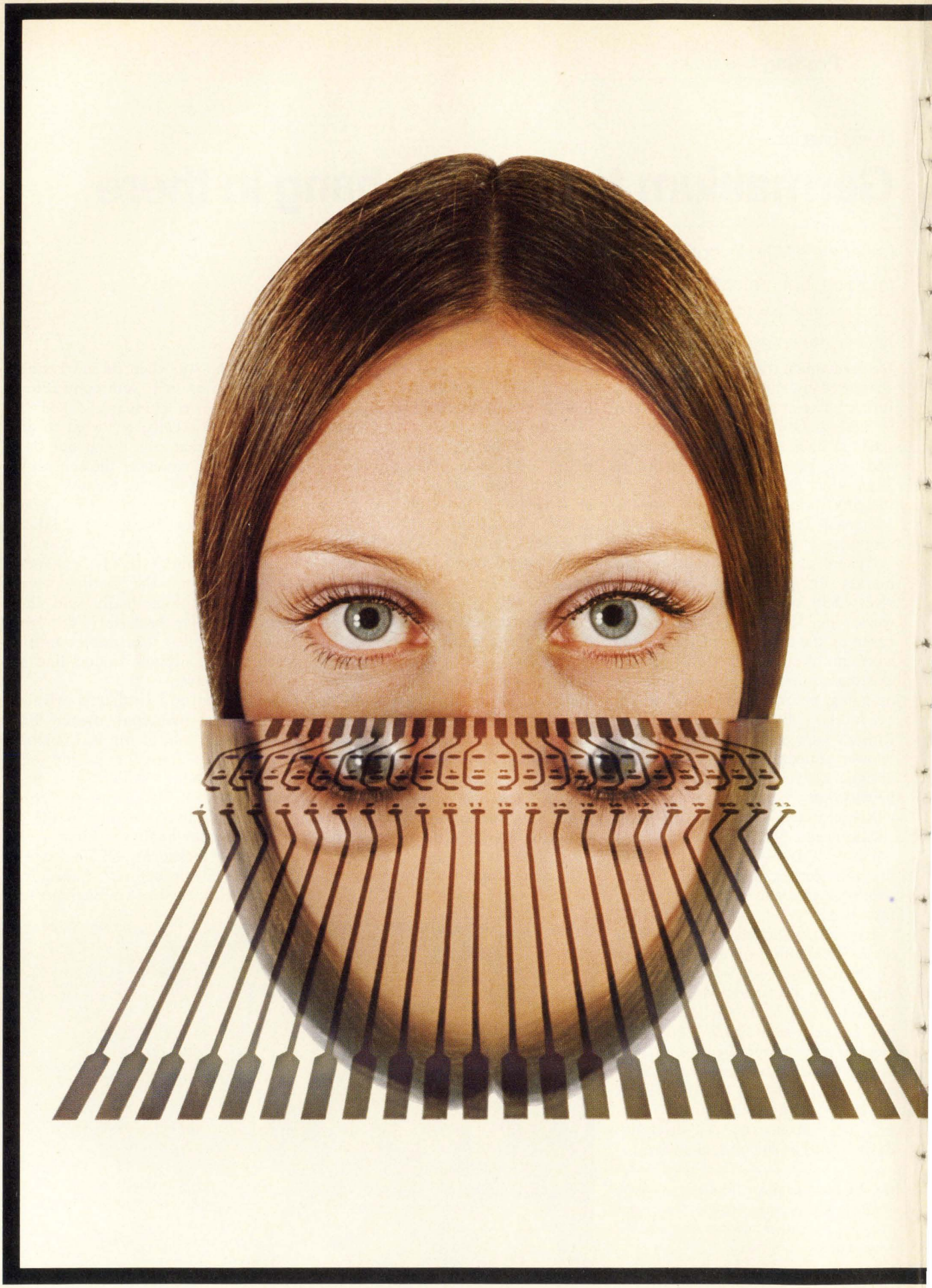
Ward, in fact, puts the market now at only $20 million to $25 million, including big captive suppliers like the Delco division of General Motors. Although germanium continues to be used, especially "where low saturation voltages are critical," he is skeptical about the possibility of new applications.

Miller's and Ward's divergent views, which could reflect in basic ways the differing prospects of the booming and optimistic Sunbelt and the troubled Northeast, even extend back to the size of germanium sales in the peak year, 1963. Ward pegs that year's market at about $65 million, but Miller says that figure is "much too low; [it is] more like several hundred million." However, both agree that silicon transistors, which cost less, operate at higher temperatures and offer other advantages, have made germanium manufacturing marginal or worse for big companies.

Cutting loose. Motorola, for instance, wanted out by 1971, says Miller, who was then its marketing manager for all semiconductor products. The company faced a dilemma, he recalls, of "what to do with a line that was dying out but not dead." To cut costs, the company moved production to Guadalajara, Mexico. This move did not work, Miller observes. Because the labor content of transistors is too low in relation to materials, the cheaper wages south of the Border were negated. Motorola finally sold the germanium line because it did not make sense to "allocate more resources" to a minor product line, a spokesman says.

Miller went to Lansdale, a private firm, when principal owner Ed Pincus asked him to run it. Looking at germanium from the outside was "an eye-opener," Miller says, because it offered the kind of opportunity he had been seeking to fill a semiconductor-business niche. "I could have kicked myself," he says. "I never saw it before." Lansdale, which then specialized in buying and

On the line. Lansdale Transistor is adding products and facilities. Here is the furnace operation on its production line for 60-ampere power transistors.



marketing phased-out semiconductor-device lines, has since decided to stick entirely to the germanium business.

Essentially, the Lansdale manager thinks his company can do well because "we're in a position where it's our only business, and we can concentrate on doing a better job on manufacturing and marketing." The lack of large-company overhead is another plus, he points out.

Lansdale already has initiated changes. The chief one is moving all manufacturing from Guadalajara to Phoenix as a preliminary to broadening the product line. The move was spurred by high materials duties, shipping snarls, telephone breakdowns, trouble in replacing equipment, and political instability, Miller says.

Sees the pluses. Miller believes that the continuing problems faced by germanium—principally the negativism of customers who worry as suppliers disappear—are outweighed by its potential. He says that the need to conserve energy gives the opportunity to "get into the new designs," particularly in heavy-current—20-ampere and up—applications to be found in industrial and process-control situations. "Higher current, backup-battery systems are another place germanium is suitable," he claims.

Getting the present crop of circuit designers acquainted with germanium is another hurdle, Miller admits, estimating only "10% are familiar with it." One possibility is a promotional campaign aimed at getting designers to treat germanium "as a brand new material."

Designers using germanium power devices confirm their advantages, but they also confirm Miller's appraisal of germanium's problems by voicing uneasiness about the dearth of suppliers.

For example, one computer engineer observes that, because of this prospect, his company's management is at the point of terminating germanium-transistor designs for power supplies, despite satisfactory performance.

On the other hand, Milton Hodges,

Probing the news

design engineer at Maco Manufacturing, which makes citizens' band equipment accessories in Memphis, Tenn., says germanium is "imperative."

Not only is it the solution "where large current has to be controlled at variable impedance," but it is cheaper than silicon. A counterpart, Terry Marsala at Federal Signal Corp., Blue Island, Ill., notes that germanium's lower saturation is important in building electronic emergency sirens that require 200 w at 12 v.

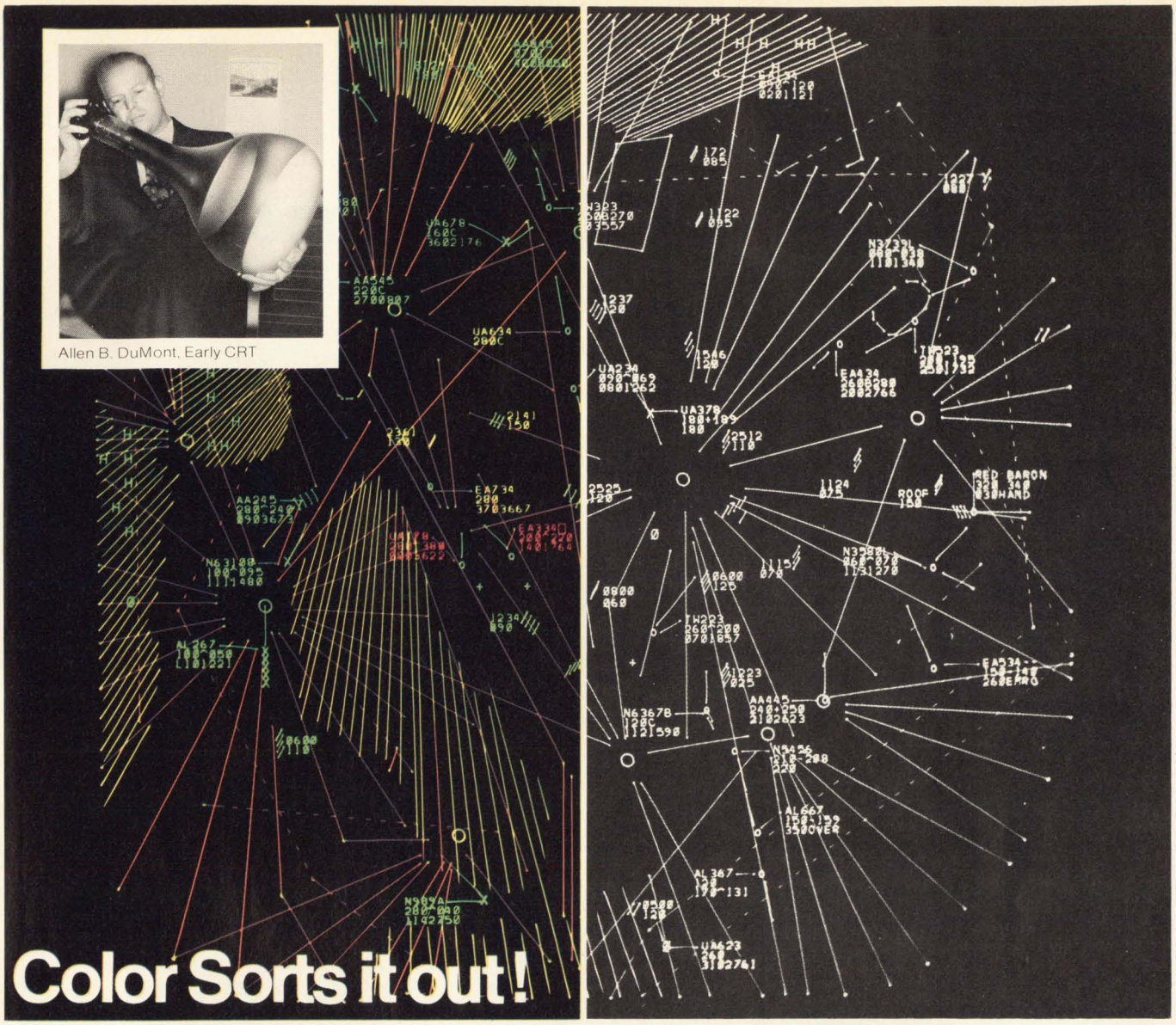
Another designer of uninterruptible power supplies says that only germanium transistors permit reversing base-emitter voltages for battery operation. His supervisors also are nervous about the availability of germanium, and he wishes "suppliers would do more research."

But Miller contends that such problems can be overcome, and Lansdale's expanson is directed toward that end. The company has spent more than $200,000 to refurbish a building for all operations, and the first power alloy devices are now being completed. Another similar line will be phased in soon; general-purpose amplifier and diffused-base devices are scheduled to follow by late spring. Previously, Motorola had sold only premium units. These transistors, which handle up to 280 v, are 60% faster than power alloy types, he notes.

Also, Lansdale has "redefined the families" described in the old Motorola catalog to offer a wider specification choice. The result is a 50% hike in products available, Miller says. Some prices even came down in this process, and he foresees no general increase, in fact, "unless material costs go up."

Miller, who professes to be "very pleased with profits," places the current annual sales rate at $5 million to $10 million, and he is looking forward to even better results.

How does competitor Ward regard Miller's sunny outlook? "I just hope they're right. Nothing would please me more," he says, since his firm would benefit. "But realistically, I don't see it as a growth market." ☐



Typical Air Traffic Control Presentation Courtesy CPS Inc.

For more than forty years, ever since DuMont introduced the commercially-produced cathode-ray tube (inset, above), professional users of high-resolution CRTs have worked with only a part of their natural visual capacity. They have been limited by single-color phosphor screens. Multi-color screens have been available, but only in low-resolution shadow mask and similar tubes.

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Circle 73 on reader service card 73

Integrated electronics

CCDs edge toward high-volume use

A-d converter chip from GE and analog memory from Hitachi may push charge-coupled technology into the low-cost arena

by Lucinda Mattera, Components Editor

Now five years old, CCD technology may be on the verge of making a big splash in low-cost, high-volume applications. Two new charge-coupled devices could serve as the springboard: the first CCD analog-to-digital filter and a CCD analog memory for television signal processing.

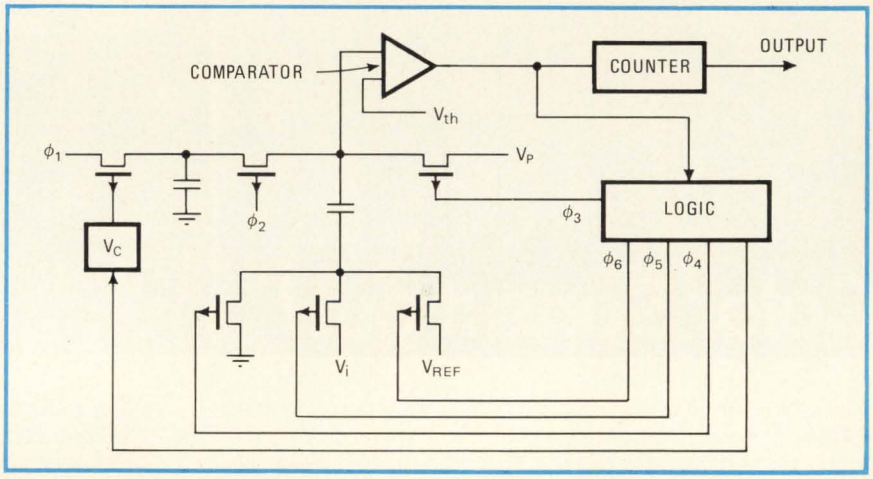
The technology has been limited chiefly to fairly expensive, complex, special analog functions for the military. Next to nothing has appeared for industrial markets. Some CCD integrated circuits have been developed for other civilian applications, but, other than for TV cameras, most of them have been experimental devices delivering less than satisfactory performance.

For the industrial marketplace, the Research and Development Center of General Electric Corp. in Schenectady, N.Y., has fabricated the first CCD analog-to-digital converter as a p-channel MOS chip providing a resolution equivalent to 10 to 12 binary bits. From the Central Research Laboratory of Hitachi Ltd. in Japan comes a 64-stage differential analog memory that delivers performance good enough for a variety of video signal-processing systems in consumer equipment.

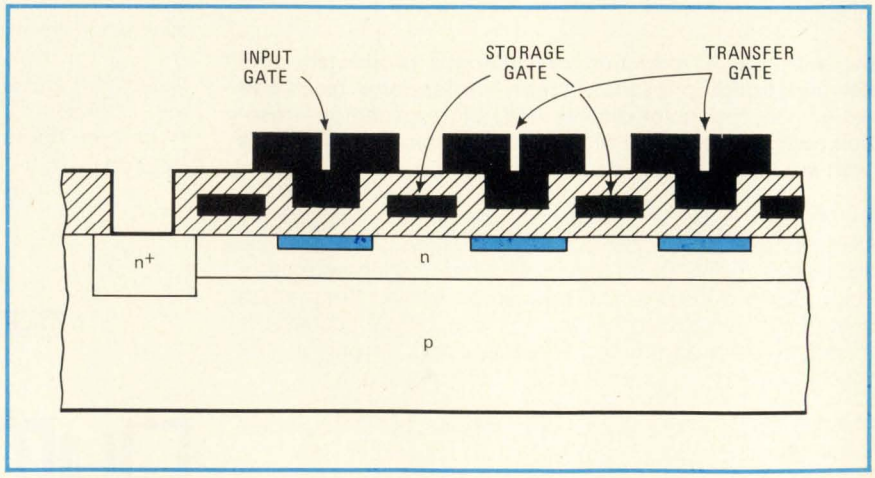
The GE converter chip is big, measuring 240 by 180 mils, but it contains a comparator, voltage reference, clock, counter, and all necessary control logic—in fact, it even has decoder/drivers for gas-discharge displays. Operating speed, though, is slow: about 20 milliseconds total for a 10-bit conversion. The device, which runs at a clock frequency of up to 500 kilohertz, resolves analog inputs to within better than 1 millivolt, digitizing them to an accuracy of ±0.5 least significant bit.

Chip operation relies on the transfer of fixed-size charge packets from one site to another, with conventional digital circuitry controlling the conversion process. The number of these charge packets needed to fill a potential well to a predetermined threshold level is linearly related to the magnitude of the input dc voltage.

The conversion cycle is divided into four parts: reference and mea-



Big worker. General Electric's analog-to-digital converter, above, though a large chip, houses comparator, voltage reference, clock counter, and all needed logic on the chip.



No jitters. Hitachi's memory chip, right, is intended for use in TV sets, video phones, and video-tape recorders to cancel ghosts or eliminate frequency jitter.

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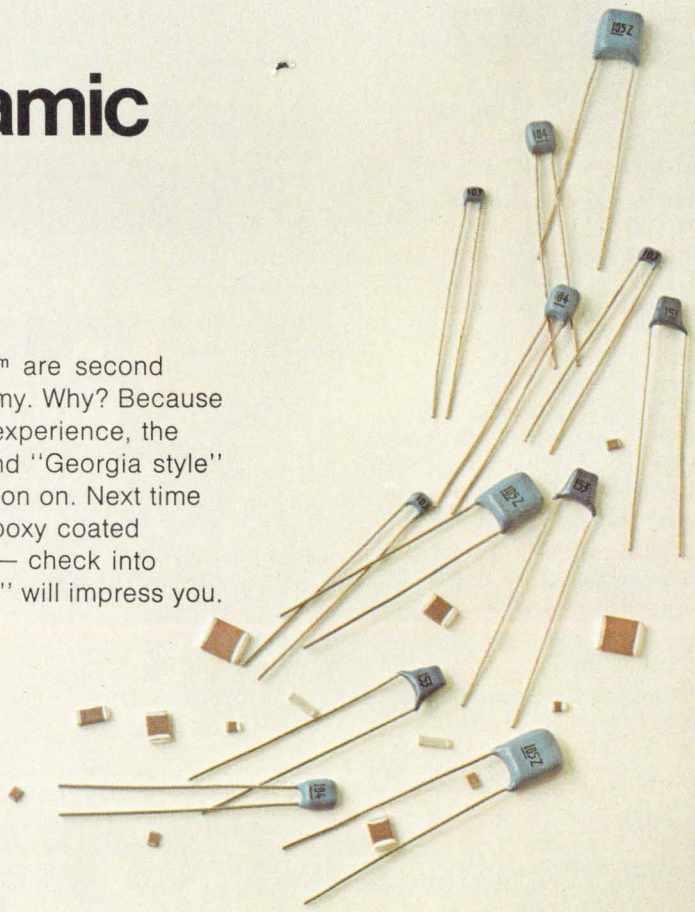

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Probing the news

sure periods, each preceded by a zero period. During each period, charge packets move from one circuit node to another in synchronism with the clock pulses. This arrangement provides an accurate measure of the input voltage, which may be as large as 10 volts.

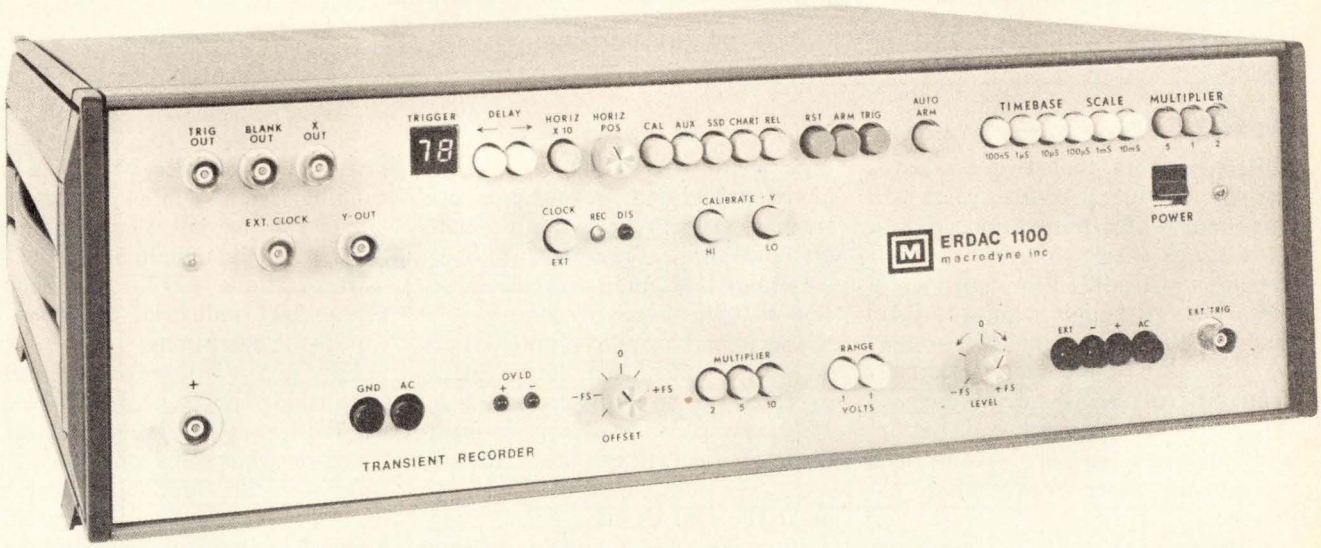
Although CCD analog memories for video applications are not new, they have operated over only a relatively narrow input-voltage range and have produced output voltages that fluctuate. Hitachi's new CCD memory chip, however, holds output dc level shifts to around 1% and handles input voltage changes of about 2.5 V. The firm says the device is suitable for use in TV-ghost cancelers, video-telephone systems, and frequency-jitter cancelers in video-tape recorders.

Fabricated with n-channel double-polysilicon-gate technology, the chip is a bulk charge-transfer device containing a pair of 64-bit memory arrays and two symmetrical clock pulse generators. The clock circuits are the key to the device's performance. Each one consists of a shift register producing the four-phase clock signals needed for proper device operation, inverter circuits that introduce a slight delay between the clock phases, and push-pull buffers capable of driving high-capacitance gates with 15-nanosecond rise and fall times.

The memory can operate at frequencies of 4 kHz to 28 megahertz with only a single master pulse source (built with Schottky TTL) and two power supplies. Signal-to-noise ratio is a high 53 decibels compared to about 30 dB for earlier devices. At 10 MHz, the new memory dissipates a total power of about 600 milliwatts.

There are no immediate commercial prospects for the devices. A spokesman at GE points out that its part was developed for in-house use in appliances and instruments with digital readouts. Hitachi says its memory chip is at least three years from the market and mentions that it still needs work in the laboratory to reduce current drain and improve its output circuit. □

Macrodyne fills the megahertz gap.



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Materials

Four-inch wafers encounter roadblock

Conversion by semiconductor manufacturers from smaller material is held back by unused capacity in 3-in. production lines

by Judith Curtis, San Francisco bureau

Silicon vendors, tooled up and eager for semiconductor makers to convert to 4-inch-wafer production, will be twiddling their thumbs a while longer until idle 3-in. capacity is absorbed. Although some 4-in. production lines are running—notably at Fairchild Semiconductor, American Microsystems Inc., Advanced Micro Devices, Intersil, and National Semiconductor Corp.—conversion is moving more slowly than expected.

"It appears that the semiconductor houses are not 3-in.-capacity-limited, and they are not ready to experience learning-curve losses till more 3-in. capacity is used," says Stewart Alade, marketing manager at Siltec Corp., wafer supplier in Menlo Park, Calif. Moreover, David Brooks, national sales manager at Wacker Chemical Corp.'s Santa Clara, Calif., division, adds, "Demand hasn't developed as we expected it would." Wacker is supplying only about 3% of its total wafers in the larger sizes.

An important clue is semiconductor makers' attitudes on production-equipment purchases, and they do seem to be buying some equipment designed to handle the larger wafers. More important, though, "people are insisting that all equipment be 4-in.-compatible," says Edward Segal, North American marketing manager at Cobilt Corp. in Mountain View, Calif. But most companies, he says, are slowly adding 4-in. production lines next to their 3-in. lines.

Vanguard. Some companies, however, are processing 4-in. devices. AMD has a new facility to handle the larger wafers. The economic advantage is apparent: that one facility alone enables AMD to double its MOS startup capability. The first products off the line are AMD's 4-kilobit dynamic RAM line, with microprocessors to be phased in soon.

AMI is making silicon-gate devices on 4-in. wafers; that entire line is expected to be fully converted by 1979, says Carm Santoro, vice president of operations. AMI recently spent $15 million on equipment to make the 4-in. devices.

Intersil's MOS division is gearing up to produce two of its 4,096-bit random-access memories on 4-in. slices. The firm plans "to be 100% converted on all high-volume products in the next year," says Mary Ann Potter, operations manager. National Semiconductor is installing 4-in. capability on its memory and microprocessor lines. Eventually, says a spokesman, all 4,096-bit RAMs and all new n-channel devices will go on the big wafers.

In the Lone Star state, Texas Instruments spokesmen decline to comment about specific plans for conversion, but Mostek Corp. says it has been running evaluation quantities of 4-in. wafers. "The results haven't been overwhelmingly positive for high-density random-access memories," an official says. "Four-inch material might make sense on totally static circuits or random logic. He adds, "Our primary concern in switching to 4-in. wafers is about the availability of a continuing supply, and we'd like to see a little better control of radial resistivity and bulk inpurities."

Pilot lines. Back East, General Instrument Corp.'s Microelectronics division in Hicksville, N.Y., has been running several 4-in. pilot lines since late last spring, but it has no plans to build a production line for the big wafers before 1977, says Robert Fink, chief industrial engineer for worldwide operations.

Fink says it will make little difference what devices or processes first use the larger wafers. "It will all be based on what sales look like at the time we start producing with the 4-in. wafers. It is strictly a consideration of capital equipment and facilities—not devices or processes."

Similarly, RCA Corp.'s Solid State division in Somerville, N.J., plans to move into production with 4-in. wafers, but division spokesmen decline to detail their timetable. However, much of the present production equipment is said to be incompatible for the large size.

Economy governs. In most companies, the pace of conversion has been influenced more by the economy than by technical problems. Expected warping problems, for instance, did not materialize, say most device makers. At Intel, however, conversion is going slowly because of that company's heavy commitment to projection printing, says Ted Jenkins, manager of die production. "The availability of 4-in. projection printers for production is insufficient," he says.

Intel is currently testing some new equipment that promises to perform as well on 4-in. wafers as on the 3-in. size. If, as Jenkins expects, the equipment measures up, "most facilities could be converted readily." He estimates that Intel could be two-thirds converted to the larger wafers in one and a half years. □

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4101/4110

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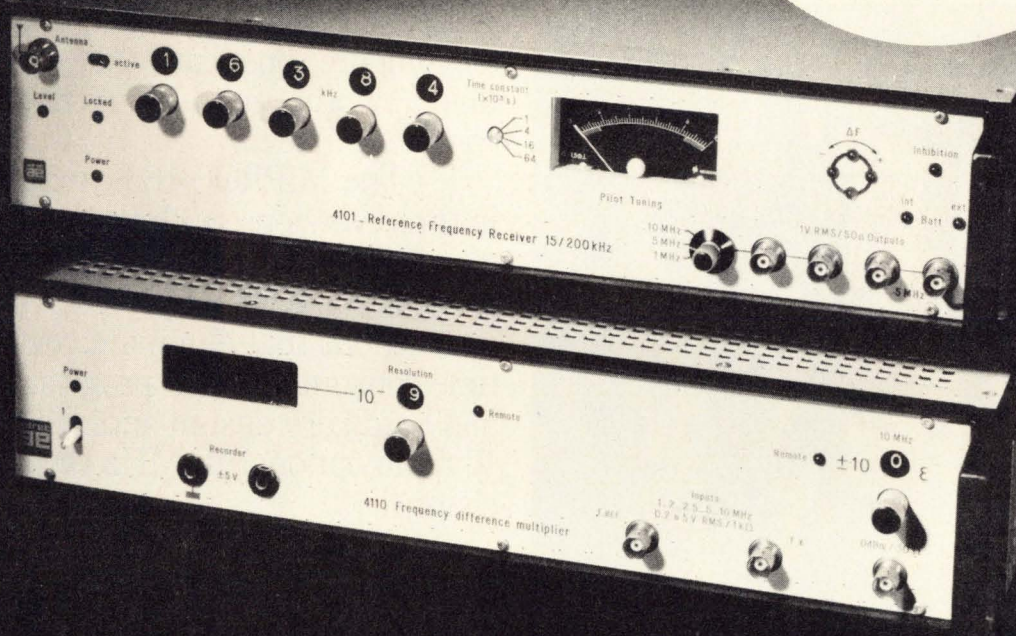

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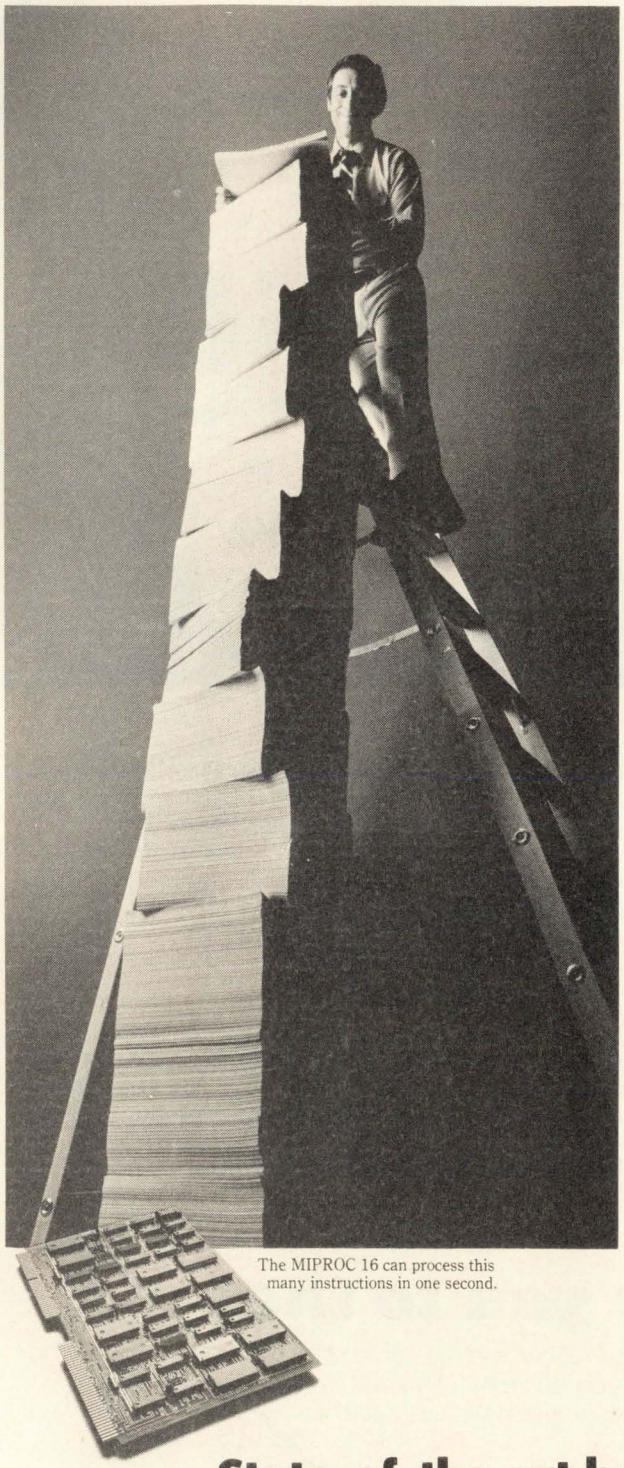

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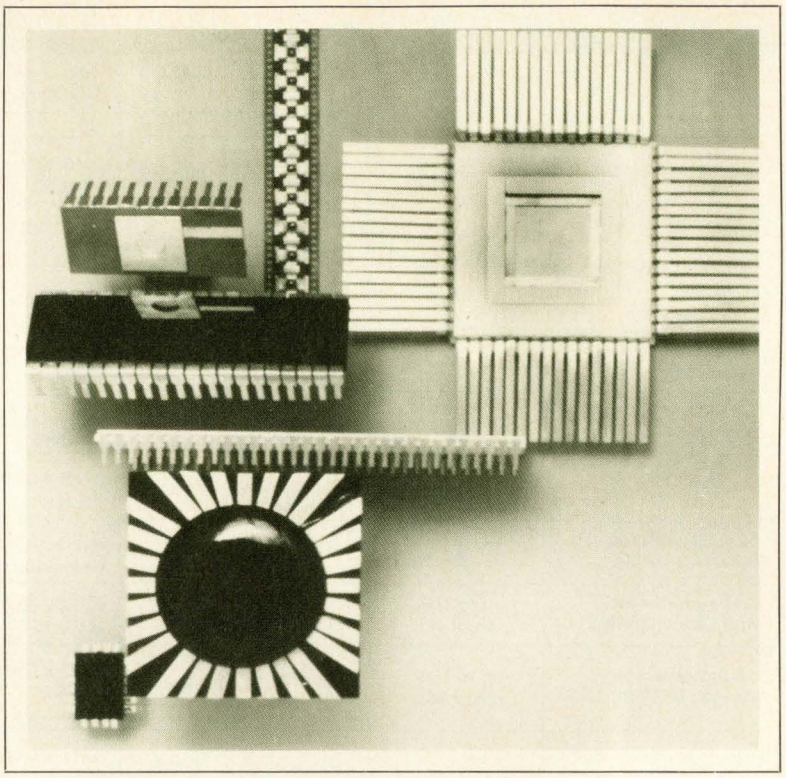


Growing pin count is forcing LSI package changes

At high pin counts, DIPs waste board space, so designers are trying chip- and film-carriers

by Jerry Lyman, *Packaging & Production Editor*

☐ For all the enthusiasm with which system designers greet each new advance in LSI circuit density or speed, the chilly morning-after thought is always: how does this affect the chip package? Finding the right package for both the system and the chip nowadays raises a long list of questions, involving package performance and ease of handling as well as the basic issue: size.

Only a very large dual in-line package, made of ceramic, not plastic, can supply the more-than-40 pins that the most complex of today's microprocessor or memory chips demand. But since 3-inch-long bodies take up a lot of board space, computer designers in particular are turning to more exotic but more appropriate packages. Particularly popular is the ceramic chip-carrier, and Table 1 lists other challengers to the DIP, including the flat pack, more chip-carriers, and the film-carrier.

Their sheer variety complicates the system designer's task enormously. It is no longer possible to select just by price, as it was when the options were largely limited to plastic versus ceramic versus glass-ceramic DIPs. Shape and size are suddenly critical—how easy

TABLE 1: TYPICAL LSI PACKAGES

LSI package type	Maximum number of leads	Method of attachment to pc board	Removal from pc board	Pc-board area, including leads (in.)	Hermetic seal	Approximate price per lead (¢)	Availability
Cofired ceramic DIP	64	wave solder or socket	difficult	2 x 0.600 (40 lead)	yes	4	readily available
Cerdip	40	wave solder or socket	difficult	2 x 0.600 (40 lead)	yes	2½ to 3	readily available
Plastic DIP	40	wave solder or socket	difficult	2 x 0.600 (40 lead)	no	1	assembled in house
Cofired ceramic chip-carrier	64	socket	simple	0.460 x 0.430 (40 lead)	no	2	readily available
Leaded chip-carrier	64	reflow-solder	simple	0.770 x 0.770 (36 lead)	yes	slightly more than ceramic chip carrier	available on special orders
Minipak	28 40 in the future	reflow-solder	simple	0.500 x 0.500 (28 lead)	no	0.4	package only available from GI
Flatpack with leads out all four sides	64	reflow-solder	simple	approx the same as leaded chip carrier	yes	1	readily available
Ceramic substrate with clips on 4 sides	up to 156 (proposed)	reflow-solder or socket	simple	0.650 x 0.650 (44 lead)	yes	not available	in design stage at Berg
Plastic pre-molded chip-carrier (AMP)	up to 156 (proposed)	reflow-solder or socket	simple	0.650 x 0.650 (44 lead)	no	not available	will be available in 24-lead type in mid-1977
LID	40	reflow-solder	simple	0.450 x 0.450 (40 lead)	no	1	readily available
Film carrier	40 to 64	reflow-solder or wire-bond	simple	about 0.312 x 0.132 (40 lead)	no	not available (depends on chip, tape)	not generally available in U.S.

Source: Electronics

will it be to redesign a board, once it has been laid out? Reliability levels and power dissipation vary, hermeticity may be lacking, not all functions are available in all package types. In addition, details that the engineer could ignore with the old reliable DIP may now be stumbling blocks—for instance, ease of assembly on and removal from a circuit board, and the method of attachment to a board.

To pass on all the high performance of large-scale integration to the system, the package must be capable of holding a chip maybe 350 mils square, with lead counts of up to 80, and dissipating as much as 5 watts of power. Till now, DIPs have housed about 95% of all LSI. Molded plastic DIPs, however, are comfortable with no more than 40 leads and only at the lower, metal-oxide-semiconductor levels of power dissipation. Cofired heat-sunk ceramic DIPs with 64 leads do better. But the rival ceramic chip-carrier occupies about a third the board space and also degrades chip performance less because its lead resistance is lower.

Not that ceramic chip-carrier is entirely satisfactory. A task force at the Electronic Industries Association recently wrote an unusually comprehensive standard for chip-carriers that solved many of their problems. But even so, chip-carriers share one of the major lacks of the larger, over-24-lead DIP: there is no automatic insertion equipment designed to handle them.

Ease of manufacture and handling is the whole rationale of the film-carrier. Strictly speaking, the film-carrier is not a package at all. It is a series of micro-interconnects—usually etched out of the copper surface of a tape—to which the LSI chips are automatically bonded. Then reels of the tape plus chips can be automatically bonded to a board or substrate or maybe even a plastic DIP.

Since the versatile DIP will no doubt continue to dominate all but the highest levels of the LSI world, a discussion of its several varieties (pp. 82–84) precedes the sections on the various chip carriers (pp. 84–90) and the film carrier (pp. 90–91).

Dual in-line packages

The dual in-line package may be made of ceramic, a glass and ceramic mixture, or plastic, but the Cadillac of them all is the cofired or multilayer alumina ceramic DIP. Made by 3M Co., Kyocera International Inc., Metalized Ceramics Corp., and NGK Insulator Ltd., it is the most reliable—and the most expensive. Because of its reliability, it is the package in which most new and expensive LSI circuitry makes its bow. But because of its cost, it is usually replaced by other types of DIPs as soon as all the production problems are ironed out and the chip starts being produced in high volume.

The manufacture of the multilayer DIP is an elaborate and painstaking process. The basic element is uncured (green) alumina tape. Screened onto the top of the tape are metalized patterns, which where necessary include

vias—square holes filled with the screened-on metal—for connection to other layers. These metalized layers are then laminated together and fired in a furnace, creating a strong, monolithic structure. A lead frame is brazed to the top or side of the package, which can now be shipped to the user along with a metal lid.

Single-cavity cofired DIPs typically consist of three layers—the top one bearing the seal ring, the middle layer bearing interconnections to the lead frame, and the bottom layer for the chip bonding pad. Dual-cavity DIPs could have four or five layers. Multiple-cavity packages, however, are fairly rare. They are used mostly for low-volume custom applications, though they do occasionally turn up in volume production—at Fujitsu Ltd. of Japan, for instance, where three-cavity 16-pin DIPs house current-mode-logic devices.

Still, even the simplest cofired DIP is costly, in time as well as money. Designing a new package requires 10 to 12 weeks and up to $10,000 for tooling costs. Ceramic is fragile, too, making it harder to ship and handle automatically than resilent plastic.

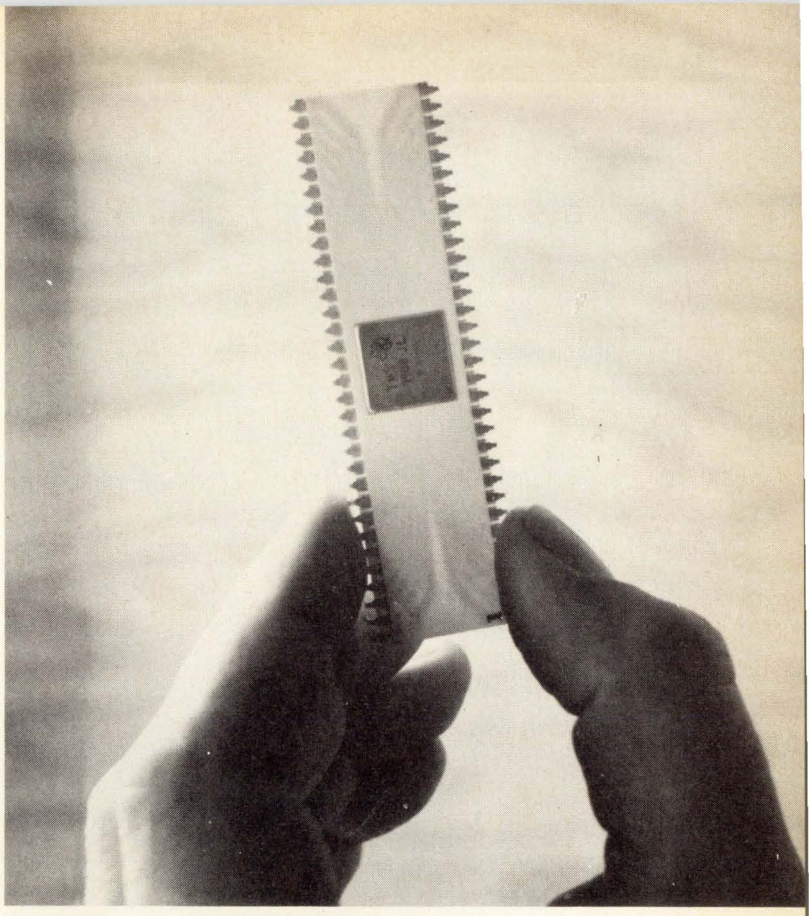
Sometimes, though, only a cofired DIP will do. It is the only DIP type to handle as many as 52 or 64 leads successfully. Not entirely coincidentally, a 64-lead type also happens to be the largest cofired DIP available (Fig. 1). Since this unit is about 3.2 inches long by 0.9 in. wide, it is doubtful whether there will be too many packages made that are larger.

Indeed, it was in an effort to keep them small, despite big lead counts, that some package manufacturers have gone to the slightly more expensive quad in-line package or QUIP. The QUIP has its leads arranged in two staggered rows on 50-mil centers instead of the 100-mil centers of the DIP. Consequently, 42-, 52-, and 64-lead QUIPs are about half the length of comparable DIPs. Rockwell Microelectronics Devices division, Anaheim, Calif., originated the QUIP about eight years ago, and it is now in use at Motorola, Siemens AG, and AEG-Telefunken as well as Rockwell, to package microprocessors, memories, and other dense LSI circuits.

Other advantages of cofired ceramic DIPs are, to quote Harold Ottobrini, president of Metalized Ceramics Corp., Providence, R.I., "superior heat dissipation, true hermeticity, and high package-sealing strength." The ceramic DIPs are superior to plastic DIPs in lead strength, he adds, because the lead frames are brazed on. They are also unlike plastic DIPs, he points out, in giving the user "the ability to test a device in an open package, which saves him money by obviating the final sealing step if the device doesn't work or allows him to repair it."

Finally, in comparison with the glass-ceramic Cerdip, the ceramic DIP can sustain a wider chip cavity, thanks to its solid sidewall. "With a Cerdip," explains Ottobrini, "the sidewall may crack when the leads are bent—a big consideration in very large LSI devices."

The type of ceramic used for the cofired packages is 94% to 96% alumina, which is normally white but can be made black by the application of a coloring material early in the manufacturing process. Black ceramic is now coming into favor for screening out light from photosensitive chips. According to Jim Wade, market manager for ceramic packaging at 3M's Electronic Products division in St. Paul, Minn., "the new trend at many IC companies is to use black ceramic for all ceramic packages since it is the same price as the white."



1. Big DIP. The largest commercially available package for LSI chips is this 3.2-by-0.9-inch, 64-lead, cofired ceramic dual in-line package. Packages of this type are only used for complex, expensive LSI circuits like microprocessors and extremely large memories.

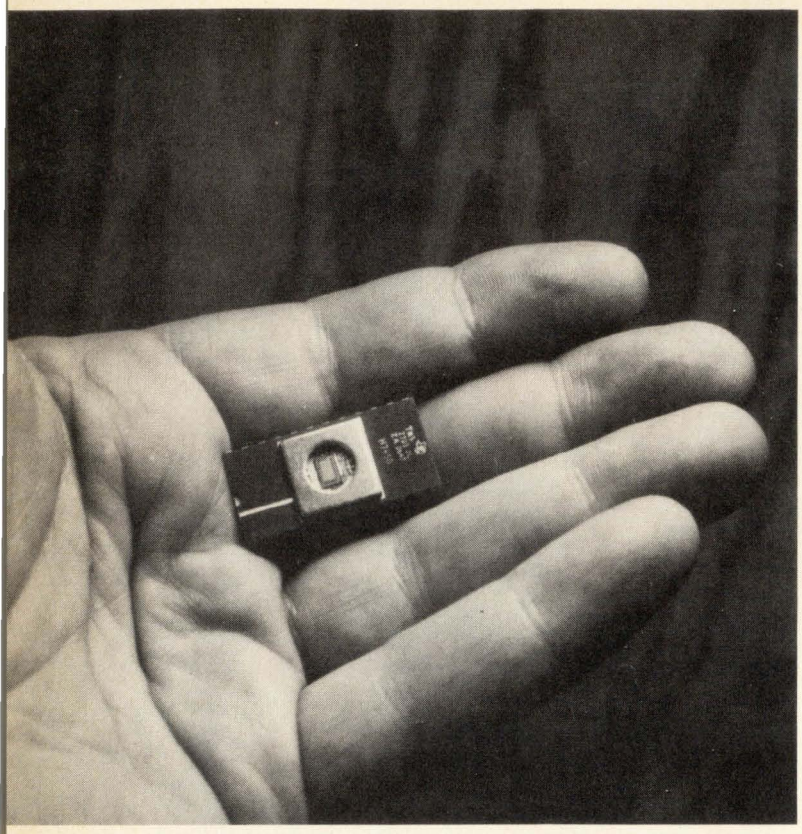
Cerdips and window frames

Whether black or white, however, purely ceramic DIPs are losing many IC sockets to a class of packages priced between it and the plastic types. Made of ceramic inmixed with glass, the package comes in either Cerdip or window-frame (Fig. 2) versions.

The Cerdip has a two-piece construction, a cap and base made of pressed ceramic glass. To package a chip, the Cerdip base is put on a heater block till the glass element melts and a lead frame can be embedded in it. Next the chip is attached to a gold pad in the cavity in the base and wire-bonded to the leadframe. Later the cap is sealed to the completed base in a special oven.

The window-frame type is heavily used for memories that are erasable by ultraviolet light (though cofired packages are also available with built-in optical windows). The chip user buys preassembled top and bottom glass-ceramic pieces already fused to a lead-frame. A gap or window in the top piece uncovers the die-attach cavity in the base, enabling the user to place the chip through the window into the cavity and bond it in place. Finally, a quartz or sapphire lid is pressed into the opening to act as the medium for ultraviolet light.

Makers of the window-frame glass-ceramic DIP include Coors Porcelain Co., Golden, Colo., and Diacon



2. Optical window. Special cofired ceramic-glass DIPs, equipped with quartz or sapphire lids transparent to ultraviolet light, are used to house erasable read-only memories. UV light directed through the lid erases a memory's program in preparation for reprogramming.

Inc., San Diego, Calif, and Plessey Frenchtown, N. J. The Diapac, Diacon's version, is about two thirds the price of a Cerdip and is rugged enough to be shipped overseas. However, the Cerdip's assembly is more easily automated.

At present, Cerdips commercially available from Kyocera, Coors, Diacon, and Plessey Chatsworth, Calif., have at most 40 leads, although George Fujimoto, marketing applications engineer of Kyocera International Inc., Sunnyvale, Calif., sees this number eventually rising to 48 to 52. Originally, according to Fujimoto, many integrated-circuit companies were concerned that the temperature required to seal a Cerdip might damage MOS chips. But new glasses that melt at lower temperatures have ended this concern.

The big advantage of the Cerdip is price. An assembled 14-lead cofired ceramic DIP costs about 80 cents, a 14-lead Cerdip costs about 17 cents, and a plastic DIP of the same configuration costs 9 cents.

For hermeticity, of course, the Cerdip is superior to the plastic DIP. It also dissipates power better than the plastic DIP and indeed almost as well as the cofired type.

Unlike the cofired package, though, the Cerdip is not commercially available with more than 40 leads (as noted), it cannot be left open for chip testing, and it lacks the strength of the cofired monolithic structure. But unfortunately like the cofired DIP, it has a tendency to crack during automatic insertion into pc boards.

Nevertheless, at the present time, about 25% to 30% of all ceramic and glass-ceramic types used are Cerdips, and this percentage is growing. The Cerdip is even finding favor in some consumer applications, where it beats out plastic because it can lengthen product life or improve reliability. For example, Atari Corp., the manufacturer of television games, uses mostly plastic DIPs but houses a critical read-only memory in a 24-pin Cerdip.

A plastic world

Other DIP users besides Atari are reluctant to accept the molded plastic variety in all the applications for which it is qualified, despite the reams of test data from IC manufacturers. Exceptions are Data General Corp., Southboro, Mass., a major user of LSI, which packages 75% of its ICs in plastic DIPs, and its largest competitor, Digital Equipment Corp., Maynard, Mass., which uses only plastic packages for standard LSI. At the IC manufacturers themselves, the ratio of plastic to ceramic packages ranges from 50/50 to 95/5.

Almost all plastic packages today are made of Epoxy B or Novalac, which has been in use for this purpose since about 1972. By now hundreds of millions of IC packages using this formulation have been made, and most IC manufacturers are willing to give out their packaging test results (based on MIL-STD-883A).

Representative of these are the results of a Texas Instruments environmental test on a plastic-encased 4,096-bit random-access memory (see Table 2). It shows that most failures occurred in the pressure-cooker test, which is equivalent to putting the ICs in live stream.

This particular test, although the conditions are rarely found in actual operation, accurately indicates that plastic DIPs are most vulnerable to moisture—a fact confirmed by the published test results of other companies. Still, in the real world, plastic DIPs function reliably in most consumer, computer, and industrial applications where high humidity is not encountered.

A lesser limitation is the fact that plastic packages are only available with up to 40 leads. Above 40 leads, molding and leadframe problems limit the production of larger DIPs because of excessive costs. But for up to 40

TABLE 2: TEST OF 4,096-BIT RAM IN PLASTIC DUAL IN-LINE PACKAGE

Environment	Quantity	Cumulative failures at hour shown			
		48	168	500	1000
85° C operating life	214	0	0	0	0
150° C storage life	30	0	0	0	0
85° C/85% relative humidity (biased)	78	–	0	3	–
85° C/85% relative humidity (no bias)	30	–	0	0	–
Moisture resistance (MIL-STD-883, 1004)	38	–	0	0	–
		48	64	80	96
Pressure cooker (15 psig, 121° C)	78	1	2	2	3

Source: Texas Instruments

The problem of power

Power dissipation, with the new prominence of bipolar large-scale integration and the trend to greater circuit density and higher speeds, is becoming a problem for all package types, not just the dual in-line standards. It has not normally been a problem in packaging metal-oxide-semiconductor chips, which generally dissipate from 0.5 to 1.5 watts at most. Even with present bipolar logic, this figure generally rises only to 3 W. But today, higher-power LSI devices are starting to appear, posing a challenge to package designers.

So far as DIPs are concerned, the typical thermal resistances of their materials are: 25°C/W for cofired ceramic, 26°C/W for Cerdips, 53°C/W for unmodified plastic, and 23°C/W for plastic with a thermal slug.

Ceramic obviously dissipates about twice as much power as a standard plastic DIP, and normally the cofired ceramic DIP is chosen for large chips. But even in a 3-in.-long, 64-lead package, the chip heats up fast enough to limit power to the 2-to-3-W range when the package is to be used in free air.

One option is to increase a DIP's heat dissipation by cementing a finned heat sink to its top. There are also commercial heat sinks that can be clipped to it, to reduce chip junction temperatures or allow the package to be used in higher ambient temperatures.

A case history is to the point. TRW Inc., Redondo Beach, Calif., recently had to decide how to package a new 5-W bipolar product, the commercially available MPY 16 16-bit parallel multiplier. Initially, Jim Buie, senior staff engineer at the TRW Electronic Systems division, used the 64-lead flat pack with a heat-conducting stud cemented onto it directly below the die cavity. The result was excellent in terms of thermal resistance, which measured only 5°C/W between the surface junctions and the heat stud. But the difficulty of mounting or soldering the package plus stud made Buie decide to try a 64-lead DIP.

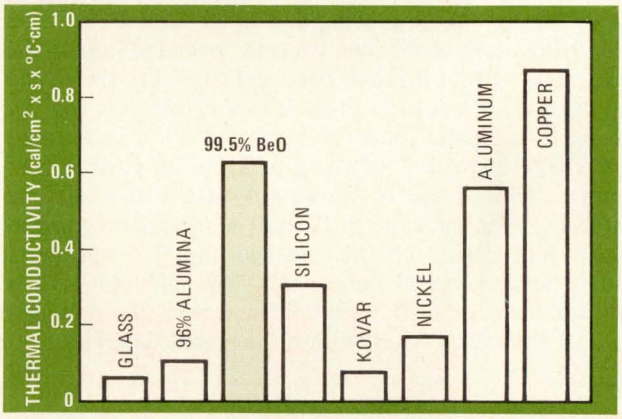
With the DIP, however, the thermal resistance from the chip junction to the top of the package, even with a heat sink cemented to it, was an unsatisfactory 20°C/W. TRW's solution was simple. It turned the DIP body upside down, by bending the leads in the opposite direction so that now the die cavity faced downward. Then when a finned radiator was cemented to the new top of the DIP, the thermal-conductance path from chip to radiator was much shorter.

The entire 3-by-0.8-in. ceramic surface of the inverted 64-lead DIP is covered with the nine-fin heat sink (shown below). From heat sink to the 300-by-300-mil chip inside, thermal resistance measures only 7.5°C/W. The sink alone exhibits 9°C/W in still air and only 5°C/W in flowing ambient air.

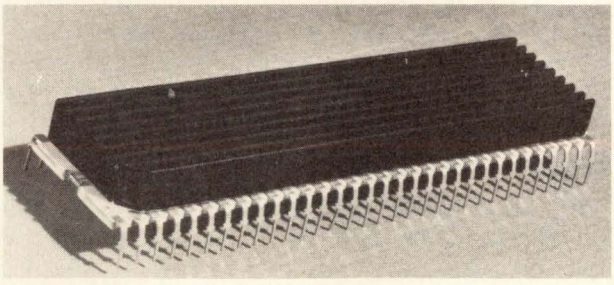
The alternative to heat sinks for power dissipation is to go to a package material with better thermal conductivity, namely a beryllium oxide ceramic. National Beryllia Corp.'s Berlox is more than seven times as thermally conductive as alumina (see chart).

Standard dual in-line packages and flatpacks for LSI also can be made using BeO_2 as substrate. "Cerdips also can be constructed with this material for only about 10% over the price of alumina glass units," says Peter Fleishner, vice president of technology for National Beryllia Corp., Haskell, N.J. As high-speed bipolar technology moves into LSI, Fleishner sees BeO_2-based packages gaining ground since the other possibilities—heat sinks, studs, radiators—become cumbersome above the 1-W dissipation level.

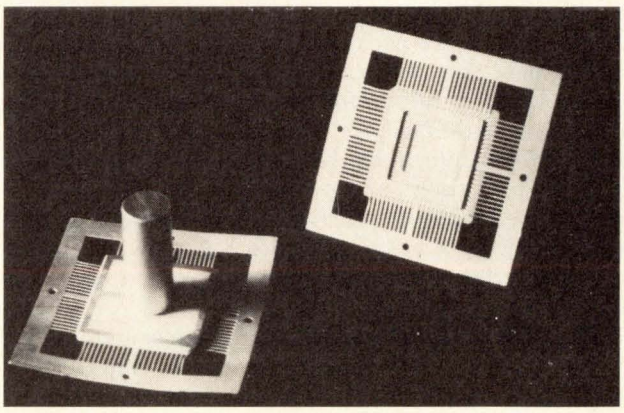
Admittedly, in custom packages the use of heat sinks has led to some exotic designs. The photograph at bottom right shows one of them—an 84-lead ½-in.-square chip-carrier with an integral heat sink. 3M Co. designed it for a large mainframe firm, which needed to house a high-speed emitter-coupled logic circuit that would be capable of dissipating several watts.



BeO_2. One approach to increasing a package's power dissipation is to try a beryllium oxide ceramic substrate. Beryllium oxide has about six to seven times the thermal conductivity of alumina.



DIP power. A DIP housing a 16-bit parallel multiplier has its chip mounted face down. This gives the shortest thermal conductance path from the chip to the special nine-finned radiator.



Carrier power. Ceramic carriers can house a high-power chip. This 84-lead, ½-inch-square unit with an integral heat sink was designed by 3M for an ECL chip dissipating several watts.

leads the manufacture of chips in plastic packages is easily automated, and that is one of the prime reasons for their popularity. Adds Carl Carman, Data General's vice president of engineering, "Plastic packages are more uniform in shape than ceramics, again facilitating their automatic insertion into boards. Also the headers of conventional ceramic and Cerdip packages can be put on in such a way that the package won't fit the automatic insertion equipment properly."

The advantages of plastic DIPs should by now be apparent: the lowest cost, the most predictable form factor, and the most resilient (and in this sense the strongest) packaging. Also, "it has the fewest infant-mortality failures of any packaging type," says Robert Beard, director of semiconductor assembly at National Semiconductor Corp., Santa Clara, Calif. "What this means is more systems out the door with less rework."

Minicomputer manufacturer Data General, however, has found plastic packages less reliable than the IC makers predicted, although the company will not go into specifics. Carl Carman says "We can test plastic-packaged parts more because they are cheaper to begin with, which is why we use so many plastic packages."

Carman maintains that the relative costs of the device and the package have to be weighed to come up with the best cost tradeoff for the finished device. For example, he says that if the chip being packaged costs 20 cents or so, putting it in a 80-cent ceramic package can make sense, leading to a finished part cost of $1.00. But if the chip costs $1.00, it pays to cut the finished part cost by putting it in plastic for a total cost of only a little more than $1.00, instead of jumping to $1.80 by putting it in ceramic. "But if you're working with a $10 RAM," he continues, "the package price isn't a significant portion of the total price of the finished unit." Even here, though, Data General houses the 4,096-bit RAM that it manufactures in plastic because the device dissipation is just 250 milliwatts—well within the plastic capability.

Chip-carriers

As LSI chips keep increasing in complexity and size, computer packaging designers in particular have had to contend with the placement of tremendous quantities of the extremely large (40- and 64-lead) dual in-line packages. If used, these packages would require additional boards, increasing the overall system size, and also would degrade circuit performance because of their long lead length. It was this situation that caused the designers to examine the ceramic chip-carrier now in use in hybrid applications, and they soon came to the conclusion that the larger chip-carriers (24 to 64 leads) gave a considerable space advantage over the equivalent DIPs. With the carrier, area reductions of at least three to one were easily achievable.

Package performance improved, too. Because of their radically shorter lead length, the small chip-carriers allowed the upper frequency limit of a typical circuit to be increased by three over a DIP-housed unit. Lead resistance at high pin counts is also much lower in a chip-carrier than in a comparable DIP, which can run into problems on this account at the interface with low-input-resistance transistor-transistor logic. Finally, the ease of removal of the reflow-soldered ceramic was a significant improvement over the DIP.

The concept of the small, leadless, cofired chip-carrier originated at 3M Co., the intention at first being merely to solder them to the ceramic substrates used in thick-film hybrid work. As made by 3M and Kyocera, the chip-carrier is a square multilayer ceramic package, on the bottom of which is a pattern of gold bumps on 40- or 50-mil centers. Also inside, on the bare ceramic, is a gold base pad for chip bonding. A metalized frame makes it possible to put a top lid on for a hermetic seal.

Connections from the lead fingers of the internal IC pad to the external bumps are made through vertical metalized grooves on the side surfaces of the chip. These grooves are fabricated as metalized vias that also provide the perforations at which the carriers are snapped apart. The chip-carriers are then attached to a hybrid substrate by being reflow-soldered to pre-solder-coated lands. The carriers can easily be removed either for replacement or for testing or burning in the chip.

A collection of cofired chip-carrier types is shown in Fig. 3. At present the largest standard chip-carriers are 64-lead types. These units are about one third the length of a 64-lead DIP.

Comparison of the DIP with the ceramic chip-carrier yields some interesting data. A 24-lead cofired ceramic DIP is 1.2 in. long and 0.600 in. wide, has a 0.200-in.-square chip cavity, and costs 80 cents. On the other hand a 24-lead chip-carrier is 0.400 in. on a side, has a 0.235-in. cavity, and costs 40 cents.

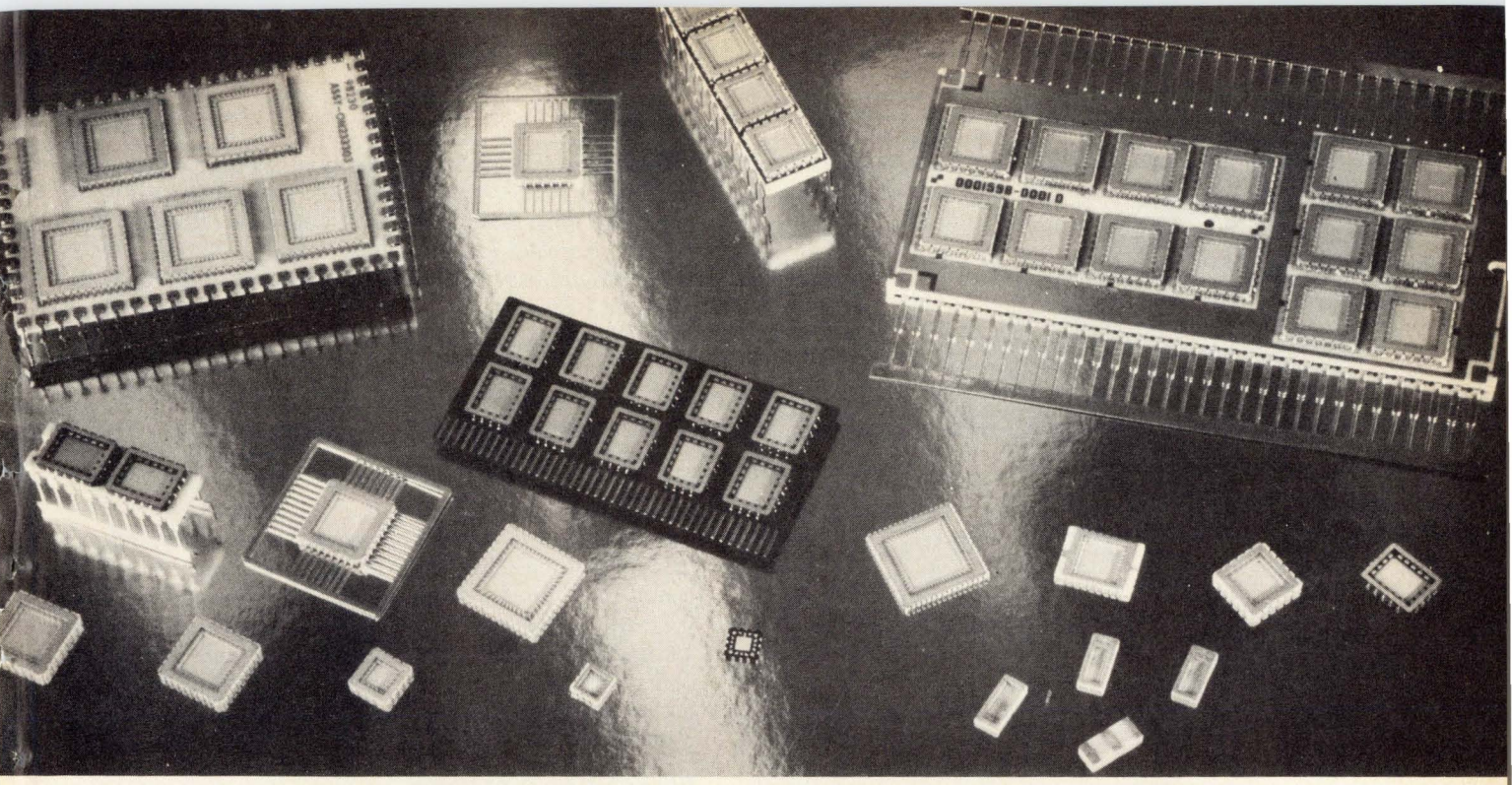
Normally the chip-carrier is a three-layer device. But in an effort to lower the cost 3M has made two- and even single-layer chip-carriers. Offsetting their lower cost, however, is the fact that it is harder to seal them and to bond chips to them.

An interesting variation of the chip-carrier is supplied by both 3M and Kyocera. This is the leaded chip-carrier, which is available in 24- and 36-leaded versions from 3M and with up to 64 leads from Kyocera. It resembles a flatpack because its leads extend from all four sides. Compared to the bumped chip-carrier, this leaded chip-carrier has a larger footprint (or pattern on the substrate) but is easier to handle and can be successfully soldered to a pc board or hybrid substrate because of its compliant leads.

As yet, though, most IC manufacturers are still only at the stage of evaluating the ceramic chip-carriers. An exception is Mostek Corp., Carrollton, Texas, which is buying 18-, 24-, and 40-lead chip-carriers and is supplying 4,096-bit RAMs in them. Mostek had previously made the small plastic flatpack shown in Fig. 4 and eventually might make its own plastic chip-carrier.

In-house chip carrier

If Mostek does decide to build its own, it will be following the example of many other IC companies who have designed their own chip-carrier. In the U.S., General Instrument Corp., Hicksville, N.Y., has been supplying consumer-type LSI circuits in its Minipak for about a year. The Minipak (Fig. 5) is a small square glass-epoxy board about a third the size of a DIP. The LSI



3. Carrying chips. The cofired ceramic chip-carriers shown along the bottom of this view come in a variety of forms—note the leaded chip-carriers in the lower left and upper center. Several large and small ceramic mother- boards for the groups of carriers are also shown.

chip is bonded to a plated interconnect pattern that connects to solder bumps on the bottom side of the carrier. A drop of epoxy protects the chip.

This particular carrier can be reflow-soldered to a pc board. The units are available with up to 28 pins, have 50-mil solder-pad spacing, and cost an average of 0.4 cent per lead. By now the company has now supplied hundreds of thousands of calculator, clock and TV-game LSI chips in this package for applications where temperature and humidity are not serious considerations.

In Japan, Nippon Electric Co. has developed the rectangular 56-pin plastic carriers as well as the 52-pin plastic flatpacks. Finally, Fujitsu Ltd. has designed an interesting leaded ceramic chip-carrier (Fig. 6) that can be piggybacked with another unit of the same type.

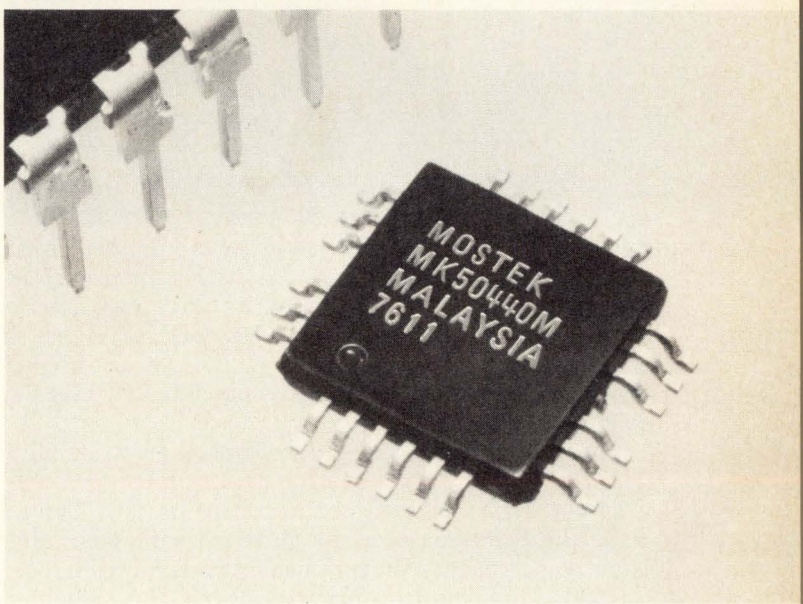
In Europe, SGS-ATES, the largest Italian IC house, is buying ceramic chip-carriers and developing a plastic chip-carrier with dimensions of 10 by 10 mm. Siemens also purchased ceramic chip-carriers and will eventually supply chips in these and other chip-carriers in the future. Plessey in England is sampling chips in 14-lead carriers, while the large Sescosem division of Thomson CSF in France is just starting to investigate chip-carriers.

Flatpacks and LIDs

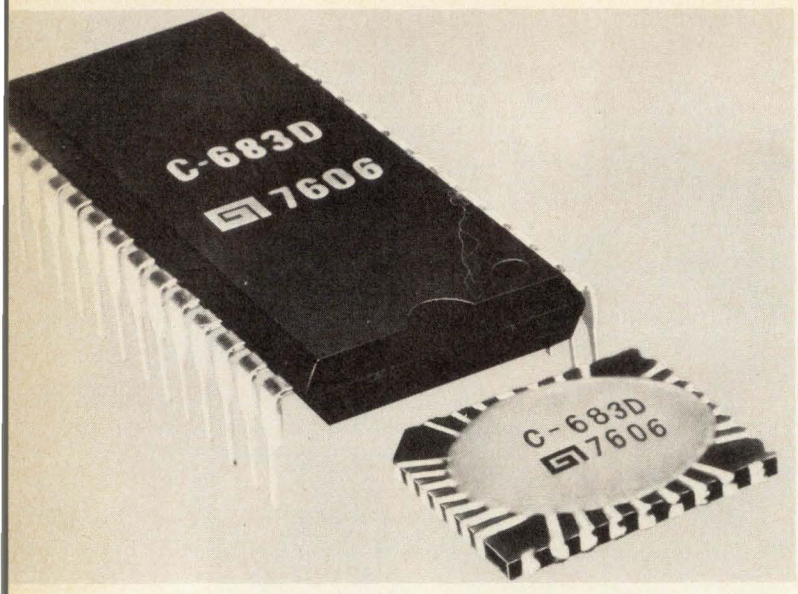
One of the earliest IC packages was the flatpack, a flat square package with two rows of ribbon leads emerging from opposite sides. This package found its niche in military and aerospace applications, mainly because of its small size, true hermetic seal, and proven reliability.

Today, newer, more compact flatpacks are surfacing in the commercial world. For instance, Jim Murphy, Diacon's sales manager, says that the increase in size of DIP packages is turning people back to a flatpack type of structure. He believes the new high-power bipolar RAMS will need flatpacks with BeO_2 or alumina substrates.

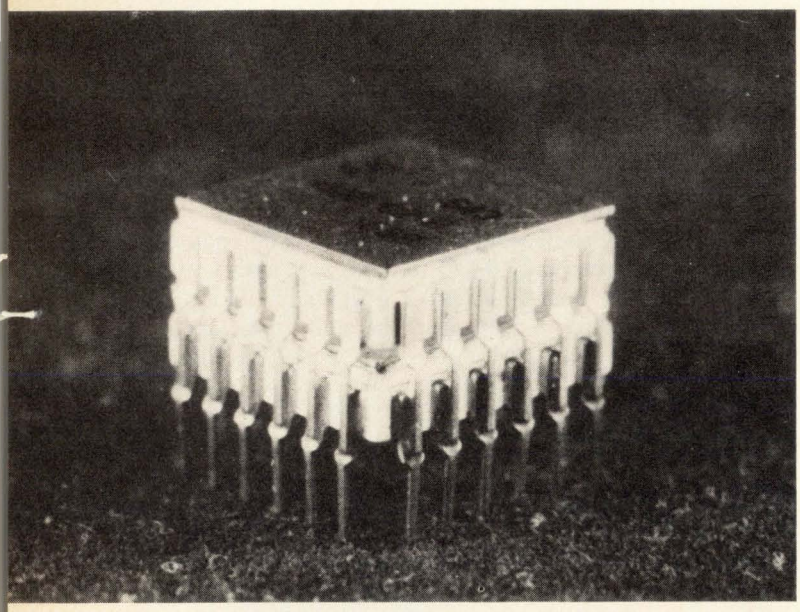
Flatpacks are available with up to 64 leads on 50-mil centers, and they take up much less space than a DIP. The newer flatpacks, with leads poking out through all four sides, are almost comparable to the chip-carrier in the pc board area they occupy. For instance, the body of a 24-lead flatpack is only 0.375 in. on a side and covers exactly the same board space as a standard bumped ceramic chip-carrier, except for the additional space taken up by its leads. Moreover, price of this glass-



4. Plastic pack. Mostek, like several other IC companies, has designed its own specialized package—a small plastic flatpack with leads emerging from all four sides. The flatpack is used for MOS consumer chips such as digital watch and calculator circuits.



5. Epoxy-glass pack. General Instrument supplies a line of MOS chips in this ½-inch-square, low-cost epoxy-glass carrier called a Minipak. On the bottom are solder bumps that can be reflow-soldered to a pc board. A drop of epoxy protects the chip.



6. Piggyback. Going against the trend to leadless chip carriers is the novel 24-pin ceramic chip carrier used by Fujitsu for memory chips. The 0.5-inch-square unit is designed so that it can be stacked on top of an identical package to increase memory density.

ceramic flatpack is 60 cents as compared to $1.50 for the ceramic chip-carrier.

Two other advantages of the flatpack are testability and low lead resistance. The standard chip-carrier needs a special test socket to accommodate its gold bumps while the flatpack can easily be tested with small alligator chips attached to its ribbon leads. Lead resistance, a possible problem with bipolar chips, is 100 milliohms for a chip-carrier's gold bumps, only 16 to 20 milliohms for a flatpack using a lead frame.

Murphy therefore sees the chip-carrier and the four-sided flatpack finding two separate niches: chip-carriers for MOS work, and flatpacks for the higher-powered, high-speed bipolar logic.

Another ceramic chip-carrier that has been around for some time is the leadless inverted device. Originally it was used only for small-scale-integrated circuitry, but now there are 40- and 44-pad versions for LSI chips.

Built by Plessey Frenchtown of Frenchtown, N.J., the LID has a square ceramic body with elevated terminal pads. The body is built up from three metalized layers, and the terminals are on 35-mil centers. As usual, an IC is attached to the base of the cavity and wire-bonded to the LID's pads. Then the chip and its leads are sealed with a drop of epoxy. Finally, the package is inverted, and its terminal pads are reflow-soldered to a hybrid substrate.

Size for size, a 40-lead LID measures exactly the same as a 40-lead chip carrier—0.450 in. on a side. But lead counts may not go much higher. Also, the LID is not hermetically sealed. Although it is being used on some aerospace projects where the overall system package is sealed, its main use is in commercial hybrid work, in pocket pagers and digital watches, for example, because of its low cost.

Socketed chip-carriers

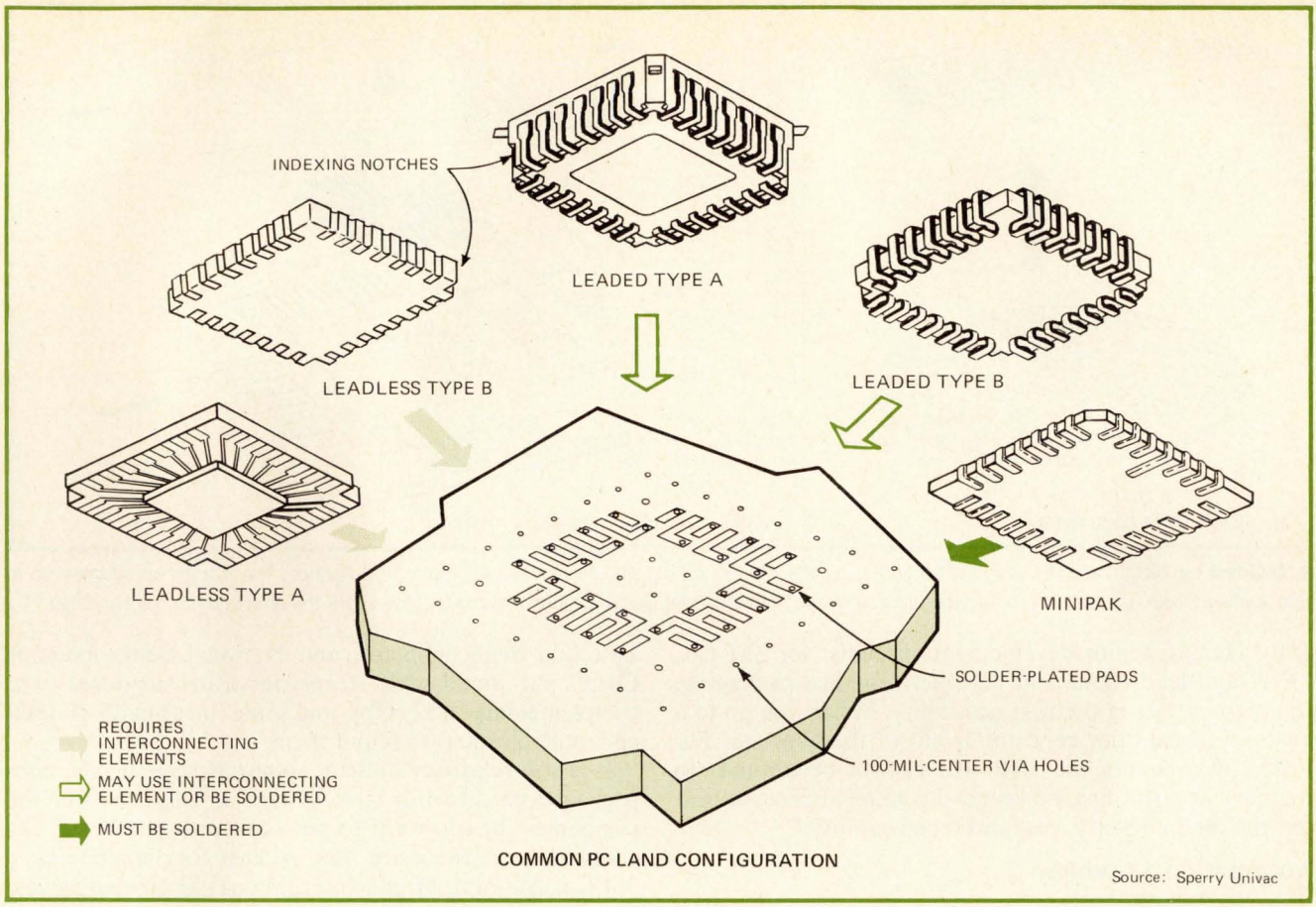
Still, for high-circuit-density applications, neither LIDs nor flatpacks are as popular as the ceramic chip-carrier, despite several potential difficulties in its large-scale application to pc boards. First, chip-carriers are difficult to solder to glass-epoxy material. Secondly, they are designed for hybrid substrates with 40-mil footprints while pc-board users prefer a 50-mil footprint. Finally, because newer chip-carrier types are arriving on the scene, all people concerned with this device had to be pulled together to generate a standard acceptable to users, IC companies and package manufacturers.

A ceramic chip-carrier that reflow-solders easily to a matching ceramic substrate cannot be directly attached to the glass-epoxy pc board found in most large commercial equipment—the differential temperature coefficient between the pc board and the ceramic is just too great. Then, too, the pc board flexes with temperature, enough possibly to fracture a connection at a reflow-soldered bump of the chip-carrier.

One solution is to mount the ceramic chip-carrier in a socket having compliant (soft, deformable, metallic) leads that could take care of the difference in temperature coefficient of thermal expansion. Another solution, proposed by AMP Inc., Harrisburg, Pa., was to design a plastic chip-carrier with resilient leads that could be connected directly to either ceramic or epoxy-glass multilayer substrates.

The problem of the 50-mil-spaced footprint is covered by a standard produced in early December 1976 by the Electronic Industries Association's Jedec task group JC-11.3.1, consisting of computer mainframe and IC and LSI packaging companies. Chaired by Dan Amey, engineering manager of packaging techniques at Sperry Univac, Bluebell, Pa., the group wrote a comprehensive standard on chip-carriers. The basic idea of the standard is illustrated in Fig. 7.

Four different chip-carriers, each with the same



7. Interchangeability. The JC-11.3.1 task group of the EIA has generated an LSI package standard for devices with interconnections on 50-mil centers. The result could be the creation of five different families of chip carriers that would interconnect with a common pc footprint.

dimensions and 50-mil lead spacing, will fit one standard socket, which in turn will fit a standard pc pattern. A fifth carrier with 50-mil lead spacing but with slightly larger overall dimensions will not fit the socket and must be reflow-soldered to the board. Two of the leaded carriers can also be soldered directly to the board. This standard allows a user to freely interchange LSI package types without redesigning his board.

In Fig. 7, leadless type A is a single-layer ceramic carrier presently made by 3M. This unit has to be socketed to go on a pc board. Leadless type B, a multilayer ceramic chip-carrier must also be socketed.

Leaded type A is AMP Inc.'s design, which is perhaps the most radical. It is the premolded chip-carrier with compliant leads that can be either soldered or plugged into a socket. Leaded type B is a ceramic substrate, suitable for LSI or a multichip hybrid, with compliant metal clips soldered on all four sides. Carriers of this type have been proposed by Berg Electronics, New Cumberland, Pa., along with a socket to accept this carrier. Berg also has come up with a design for a universal carrier socket.

The last unit is GI's Minipak, which was described earlier. It can only be reflow-soldered to a board.

The proposed carrier family would cover devices having from 28 to 156 leads with square packages ranging from 0.450 to 2.05 in. on a side.

The AMP concept deserves closer attention because the manufacturing process is fully automated. It combines a film-carrier approach with a premolded lead frame. Flow of the process is shown in the series of diagrams presented in Fig. 8.

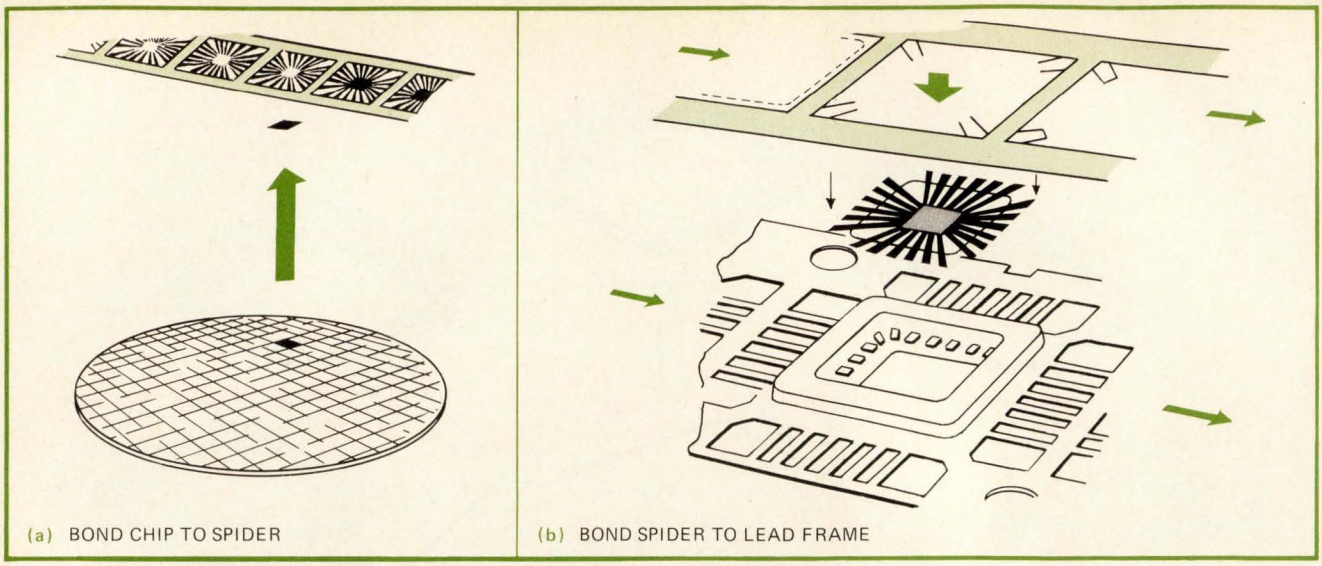
Combining film- and chip-carriers

In the first step, an LSI chip is bonded to a beam tape. Next, the bonded chip on its interconnect is removed from the tape and attached to a leadframe, which has a premolded cavity. After a wash and drying step a bottom cap (which could be a decoupling capacitor) is inserted in the premolded cavity. Then a drop of silicone jelly covers the chip to protect it, and a top cap is forced on. Additional operations trim and form the leads and remove the carrier from the lead frame.

At present, AMP is putting a 24-lead package into production that will meet the new Jedec standard's dimensions. A customer will buy reels of the pre-molded sockets and will then be able to bond and seal LSI chips at his own facility.

Of course chips can be bonded to these carriers by either the film-carrier method (see p. 90) or standard automated wire bonding. AMP has already designed a socket that fits both its own package and the ceramic chip-carrier.

Will the chip-carrier sweep out all other forms of packaging? No, but it should see heavy use from now on particularly in computer and memory applications. Says



8. Molded carrier. The AMP plastic chip carrier blends the film-carrier and premolded-leadframe approaches. The IC chip is mounted on a film, excised from it, and bonded into the plastic cavity. Then after cleaning, a drop of silicone is placed over the chip and the cavity sealed.

Billy Hargis, senior development specialist for 3M Co., "For high-lead-count and high-performance packaging, the chip-carrier is the best possibility. When you go to a 84- or 128-lead device, a DIP is out of the question. For lower lead counts the DIP will always be around. In memory applications, however, the chip-carrier will beat out the DIP in density, cost and replaceability."

Automation a problem

One continuing objection to the chip-carrier is that there is still no equipment for its automatic placement on a pc board. However, for DIPs with over 24 leads there is no automatic insertion equipment either. A natural progression therefore seems likely from the DIP to either the chip-carrier or the film-carrier.

Film-carriers

All of the previously discussed methods of interfacing LSI chips to the outside world—DIPs, QUIPs, and ceramic and plastic chip-carriers—have a rigid construction that envelops the chip. However, a flexible if skeletal "package" for active chips has been around since the early 1960s—the film-carrier.

In this method [*Electronics*, Dec. 25, 1975, p. 61] a sprocketed nonconductive film has IC interconnect patterns (spiders) etched into its laminated copper surface. Reels of this film or tape are fed along with specially bumped IC chips into an automatic bonder. When the tape emerges, a chip is bonded to each individual pattern. By now all-copper tape is often used, but the basic assembly method remains the same.

The reels of bonded chips can either be fed into other automatic machines, which excise the chip plus its pattern and bond the outer leads of the pattern to a leadframe, or the chips on tape can be used directly on a pc board or hybrid substrate. The whole setup is well suited to automated high-speed handling.

In the U.S., the film-carrier is being used mainly in combination with DIPs. TI, Motorola Inc., RCA Corp., Fairchild Semiconductor, and National Semiconductor Corp. put small-scale transistor-transistor-logic ICs, complementary-MOS chips, and some linear chips on tape and mold plastic DIPs round them.

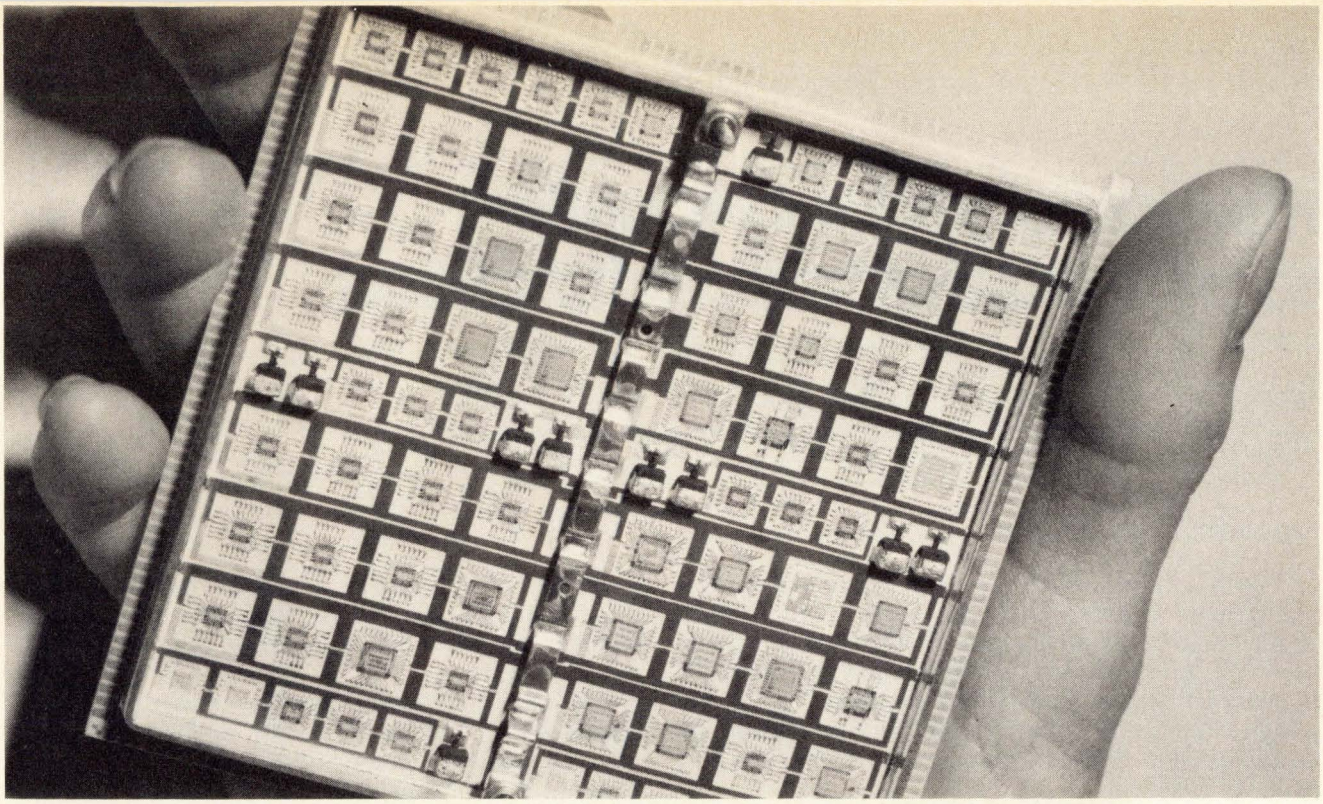
It is still relatively difficult to purchase a specific chip packaged on a reel or strip of tape in the U.S. But for companies that do want to put their own purchased LSI chips on tapes there are now at least four companies—3M Co., St. Paul, Minn., International Micro Industries, Cherry Hill, N.J., Pactel Inc., Westlake, Calif., and National Semiconductor's Dynatape division, Santa Clara, Calif.—that will manufacture and supply tapes. For the first time some of the IC companies will "bump" a wafer for a customer (build up the metal I/O pads of each chip in the wafer). So a company with enough resources to buy the special bonding equipment can put its own chips on tape. But this ability is still beyond small and medium-sized companies.

A major U.S. user

One of the few large users of the technique in the U.S. is Honeywell Information Systems in Phoenix, Ariz. HIS is now in full production of a large computer mainframe, the system 66/85 [*Electronics*, Feb. 17, p. 40], in which the basic packaging module is a ceramic substrate to which are bonded maybe 100 chips taken from various film-carriers.

In the Honeywell system, bipolar LSI chips are automatically bonded to a three-layer tape, tested electrically on the tape, excised from the tape, automatically positioned on a 80-by-80-mm-square substrate, and then reflow-soldered to the substrate. The chips used are mostly Honeywell-designed and -manufactured current-mode logic and have up to 44 leads (only 40 leads are connected to the substrate). The substrate in Fig. 9 holds almost as much circuitry as a standard 12-by-12-in. pc board. A similar method has been in use at Honeywell Bull in France for some time.

To quote Wayne Umbaugh, senior engineer, advanced technology engineering, HIS Phoenix, "The only way we



9. Micropackage. Current-mode-logic chips on film-carriers are bonded to a 80-millimeter-square multilayer ceramic substrate that is a module of the Honeywell Model 66/85 computer system. This dense packaging technique is necessary to fully utilize CML's high gate speeds.

could take advantage of the high-speed characteristics of current-mode logic was to go to the dense packaging of the film-carrier/multilayer-hybrid combinations which gave the required high interconnect density."

In its basic bare-bones form, the film-carrier method is more popular overseas. In Japan, both Toshiba and Nippon Electric will supply devices on tape. Many of Toshiba's 35-mm film-carrier devices are actually used in watches. The film-carrier is cut to fit the full size of the watch cavity and also serves as a substrate to mount other components. Other devices of this type are finding their way into Japanese cameras and calculators (especially the thin types). NEC furnishes LSI chips on 35-mm tape for a joint Toshiba/NEC computer, which is built around film-carrier ICs reflow-soldered to square multilayer ceramic substrates.

In Germany, Siemens is supplying MSI chips on Super-8 film and is investigating the possibility of supplying LSI chips on tape. Again, most of this output is going for consumer applications. Gerndt Oswald, marketing manager for Siemens AG's components division, believes the low cost of film-carrier guarantees it a good future, but adds, "One serious requirement has yet to be fulfilled—that suppliers agree on a standard carrier and standard tooling." There have been some efforts along this line in the U.S., but what is really needed is an effort on a par with that just done for chip-carriers by the EIA.

Whither next?

LSI chips on film will obviously have their largest impact on the hybrid market. How quickly and fully this comes about will depend on the availability of bumped chips and low-cost bonders.

Chuck Spence, Mostek's manager of assembly development, says his company has been evaluating the method. "Current technology dictates putting bumps over the entire wafer," he comments. "This is fine for TTL or C-MOS with high probe yields, but for higher-technology devices with low probe yields, the cost of bumping the entire wafer and then using only a small portion of it outweighs the cost savings involved in the beam-tape system. If a process can be perfected that bumps the tape, it would be a cost-effective method for lower-yielding IC technologies, since then standard chips could readily be applied to the bumped 'tape.' "

Actually Pactel Corp., Westlake, Calif., has such tape [*Electronics*, Oct. 28, p. 118] but cannot yet supply it in the quantities an IC manufacturer would need. Several other IC and packaging companies are researching this problem.

Robert Beard of National Semiconductor believes the film-carrier rather than chip-carrier has a chance of becoming the dominant technique for handling LSI "because it is similar to techniques already used in the mainstream of industry." He says, "Since the chip can be mounted directly on the pc board and protected with a cover, what the technique does is to eliminate the need for packaging. The equipment that mounts the chip onto the board is the only new element. But it's not replacing anything; rather it's eliminating the need for several steps and kinds of equipment."

The AMP approach, of course, combines both the film-carrier and chip-carrier technique (p. 89). More marriages of the two techniques may yet result, for a number of reasons. For instance, devices on single-layer copper tapes cannot be tested or burned in on the nonisolated tape. But placing the excised chip and beams in an inexpensive chip-carrier could solve this problem. □

Programming a calculator to plot mathematical functions

Special SR-52 program formats the curve of any function as a trail of decimal points on a background of ones

by Warren B. Offutt, *Cutler-Hammer Inc., Milwaukee, Wis.*

☐ The SR-52 calculator has enough programming space and computing power for its companion PC-100 printer to plot mathematical functions. Although the setup is not in the same league as large-scale plotters connected to computers, plots made within the limitations of the printer can illustrate complex mathematical expressions, as well as show ripple spacing, lobe levels, extrema, and points of inflection.

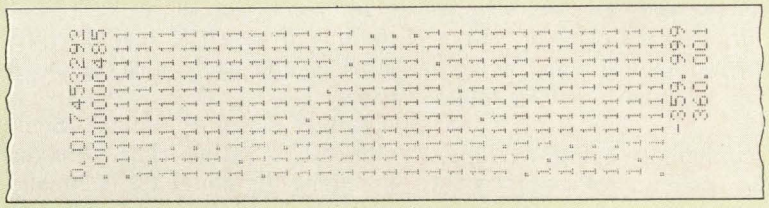
A special SR-52 program formats the curve of any function as a trail of decimal points on a background of 1s. However, by adding a few program steps, the user can vary the printout to increase its visual impact (see "Varying plot formats," p. 94).

The 11-character width of the PC-100 can resolve 10 ordinate (dependent variable) values for each abscissa (independent variable) value. Used in this unorthodox way, the printer can plot each data point within ±5% accuracy over the range of ordinate values.

Moreover, the user may easily examine in detail any desired section of a graph by calling for successive replots over any range of abscissas. By this adaptive process, he can scrutinize functions and optimize constants on line much more easily than by point-by-point calculation.

Because the plotting range is limited, the program searches the function over the specified range of abscissas and then automatically adjusts the ordinate scale to show the maximum detail. If, for example, the function to be plotted had ordinate values ranging from 73 to 77, a scale of 0 to 100 would be wasteful and produce little detail; the program, therefore, automatically selects the appropriate scale and prints out the minimum and maximum ordinate values before going to the plot.

The program (table, p. 95) requires 147 programming steps, leaving uncommitted locations 147 through 223 for the functions to be plotted. The function routine, labeled A, recalls its abscissa from register R15. After the program has been entered in memory, the user merely assigns the step size (or independent variable



$$f(x) = \left| \frac{\sin x}{x} \right|$$

LOCATIONS	CODES	KEYS	COMMENTS
150 – 151	46 11	*LBL A	
152 – 156	53 43 01 05 32	(RCL 15 sin	sin x/x
157 – 161	55 43 01 05 54	÷ RCL 15)	sin x/x
162 – 163	40 30	$*x^2$ $*\sqrt{x}$	absolute value
164	56	*rtn	

1. Sinusoidal function. Graph of (sin x)/x shows abscissas from −359.999° to +360.001°. Axis is shifted by .001° to avoid the operation 0/0 when x = 0. Magnitude of function at x~0, shown as .017453292, is mixed radians and degrees; multiplying by 180/π will normalize.

increment), the number of points desired, and the starting value of abscissa. By keying E, he starts the calculation.

The program runs through a complete calculation over all specified values of abscissas to search for the function's maximum and minimum—the upper and lower limits of the ordinate—which are printed out prior to the plot. The routine then reinitializes itself and repeats the calculation.

This time, for each data point, the decimal point in a string of 1s is moved between the ordinate extremes to represent a graph point accurate within ±5% of full scale. Following each such printed point, the abscissa is either increased or decreased to its next value. After all the points have been plotted, the starting and ending values of abscissas are printed out.

Entering user instructions.

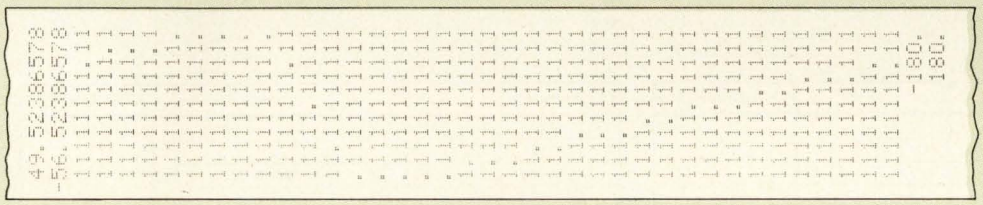
The desired function, labeled A, can be placed in any location between 147 and 223, thereby becoming, in effect, a subroutine of the plotting program. This status should be considered when writing the function routine. Because the two-deep nesting capability (sub-subroutine) of the SR-52 cannot be exceeded, a depth of one subroutine within the program of the function to be plotted is the limit. In programming the function, all flags are free, and all labels except A, E, and E′ may be used.

The plotting program leaves registers R01 through R11 free for the user, and working data must be stored in this sequence:

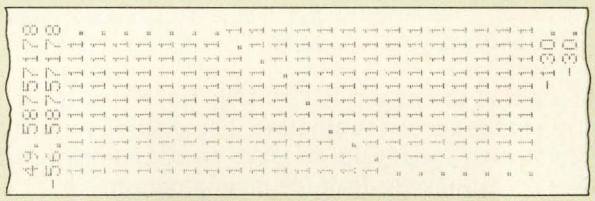
- The starting value of abscissa x_o goes to registers R15 and R16.
- The number of plotted points desired, n, goes into registers R17 and R18.
- The increment of abscissa, Δx, goes into register R19.

By pressing E, the user starts the plotting routine. After a minute or so, the calculator completes its survey of the function to be plotted—it selects the ordinate-value limits, adjusts the scale factor accordingly, and begins the plot. Points appear at a rate of one every 2 to 5 seconds.

For subsequent plots, values must be entered again in registers R15 through R19. If previously selected values are to be repeated, they must be re-entered in registers R17 and R15, since they serve as indexes.



Δx = 10°



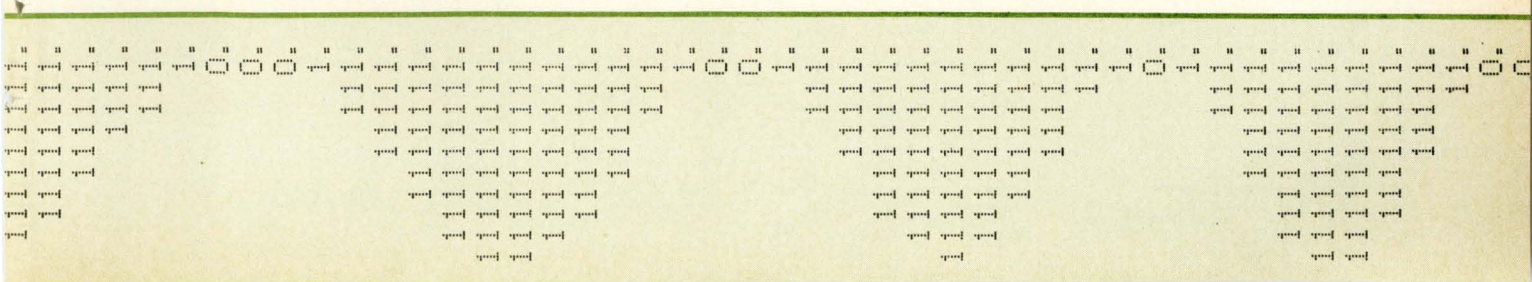
Δx = 5°

$$f(\delta) = \tan^{-1}\left(\frac{-P_c a_o \sin(\delta+\psi)}{1-P_c a_o \cos(\delta+\psi)}\right) + K$$

REGISTERS	
00	temp.
01	$P_c = 2$
02	$a_o = 0.4$
03	$\psi = 80°$
04	$K = -3.5$

LOCATIONS	CODES	KEYS	COMMENTS
150 – 151	46 11	*LBL A	
152 – 155	53 53 13 65	((C ×	
156 – 159	12 32 54 55	B sin) ÷	
160 – 164	53 01 85 13 65	(1 + C ×	
165 – 167	12 33 54	B cos)	Select quadrant
168 – 171	80 01 08 05	*ifpos 185	Compute arctangent in 2nd and 3rd quadrants
172 – 174	54 22 34	) INV tan	
175 – 178	85 01 08 00	+ 180	
179 – 183	85 43 00 04 95	+ RCL 04 =	
184	56	*rtn	Add K
185 – 187	54 22 34	) INV tan	Compute arctangent in 1st and 4th quadrants and add K
188 – 192	85 43 00 04 95	+ RCL 04 =	
193	56	*rtn	
196 – 197	46 12	*LBL B	Subroutine computes $(\delta + \psi)$
198 – 201	53 43 01 05	(RCL 15	
202 – 206	85 43 00 03 54	+ RCL 03)	
207	56	*rtn	
210 – 211	46 13	*LBL C	Subroutine computes $(-P_c a_o)$
212 – 215	53 43 00 01	(RCL 01	
216 – 221	65 43 00 02 54	× RCL 02) +/–	
222	56	*rtn	

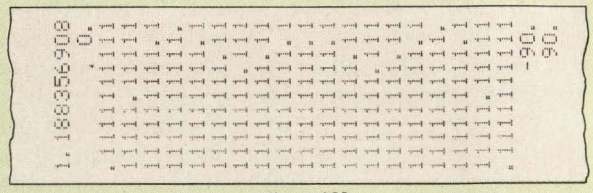
2. Phase-shift function. The SR-52 and printer can easily plot complex functions like this one, which has a shape not clearly described by the equation. Note the use of sub-subroutines in this program. Lower plot is a magnification of upper plot between −130° and −30°.



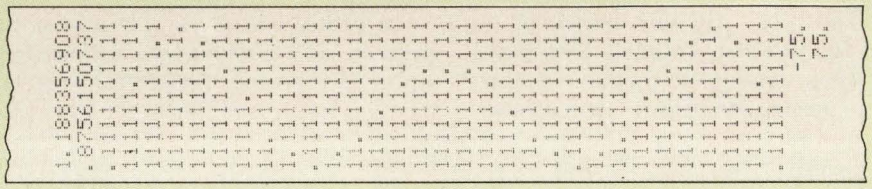
Varying plot formats

When operating the SR-52 calculator and its printer as a mathematical plotter, output formatting is limited only by the available memory space and the user's imagination. The routine was designed to use a minimum number of programming steps and hence allow the maximum space in the memory for the functions to be plotted.

However, anything goes. A program published in the users' group publication ("52-Notes," Vol. 1, No. 3) included a few more programming steps that placed 8s to the left of the decimal points to increase the visible impact of the plot. Moreover, the plot shown at the bottom of the page was right-justified merely by using a fix-0 command. Though it has an interesting appearance, the function is actually inverted.



Δx = 10°



Δx = 5°

$f(\theta) = 4/\pi\ (\cos\theta - 1/3\cos 3\theta + 1/5\cos 5\theta)$

LOCATIONS	CODES	KEYS	COMMENTS
150 – 151	46 11	*LBL A	
152 – 156	53 53 04 55 59	((4 ÷ π	} 4/π
157 – 159	54 65 53	) X (	
160 – 163	43 01 05 33	RCL 15 cos	} cos θ
164 – 168	75 53 43 01 05	− (RCL 15	

LOCATIONS	CODES	KEYS	COMMENTS
169 – 172	65 03 54 33	X 3) cos	} 1/3 cos 3θ
173 – 175	55 03 85	÷ 3 +	
176 – 179	53 43 01 05	(RCL 15	
180 – 183	65 05 54 33	X 5) cos	} 1/5 cos 5θ
184 – 188	55 05 54 54 56	÷ 5)) *rtn	

3. Square wave. Plots are shown for a square wave, represented by its Fourier cosine series truncated after three terms. Lower plot magnifies the ripple portion of the upper by changing increment (Δx) from 10° to 5°, and expanding range of −75° to +75°.

A plot of the function, $f(x) = |(\sin x)/x|$ is shown in Fig. 1. This example illustrates some of the nuances encountered with trigonometric functions.

The abscissas are shifted by .001° to avoid the singularity at $x = 0°$, which would invoke an error in the program. The maximum value of ordinate $f(x)$ is printed out as .017453292. Although the function is understood to have a maximum of unity, the abscissas in all these examples are handled in degrees, rather than radians. Multiplying .017453292 by $180/\pi$ converts the number to its proper value.

Flexibility demonstrated

A second example demonstrates the flexibility of the function subroutine. Figure 2 shows the plot of a complex phase-shift function to the expression:

$$f(\delta) = \tan^{-1}\left[\frac{-P_c a_o \sin(\delta+\psi)}{1-P_c a_o \cos(\delta+\psi)}\right] + K$$

where the program steps and the constants are shown at the right of the figure. Particularly important is the use of = in the function subroutine. The plotting routine has been written specifically to leave no operations pending when operating outside of the main program.

In this example, the expressions $(\delta + \psi)$ and $(-P_c a_o)$ were evaluated by means of subroutines, labeled B and C respectively, which are actually sub-subroutines of the plotting program. The upper plot covers a range of $-180°$ to $+180°$, and the lower one expands the detail in the area of the major phase shift, from $-130°$ to $-30°$.

Magnifying details

Detailing areas of interest is a powerful aspect of the plotting program. Figure 3 shows the magnifying capability of the plotter. When a square-wave function is described only by the first three terms of its Fourier cosine series:

$$f(\Theta) = 4/\pi(\cos\Theta - 1/3\cos 3\Theta + 1/5\cos 5\Theta)$$

it exhibits a significant ripple in its waveshape. The

SR-52 GRAPH-PLOTTING PROGRAM

LOCATIONS	CODES	KEYS	COMMENTS
000 – 001	46 15	*LBL E	$f(x_0)$
002	11	A	Initialize f_{min}
003 – 005	42 01 02	STO 12	Initialize f_{max}
006 – 008	42 01 03	STO 13	Decrement number of data points, n, and calculate x
009	10	*E′	
010	11	A	f (x)
011 – 013	42 01 04	STO 14	
014 – 018	75 43 01 03 95	– RCL 13 =	Store latest f_{max}
019 – 023	22 80 00 02 07	INV *ifpos 027	
024 – 026	44 01 03	SUM 13	
027 – 029	43 01 04	RCL 14	
030 – 034	75 43 01 02 95	– RCL 12 =	Store latest f_{min}
035 – 038	80 00 04 02	*ifpos 042	
039 – 041	44 01 02	SUM 12	
042 – 044	43 01 07	RCL 17	Test for final increment
045 – 049	22 90 00 00 09	INV *ifzro 009	
050 – 052	43 01 03	RCL 13	
053	98	*prt	Print f_{max} and f_{min}
054 – 056	43 01 02	RCL 12	
057	98	*prt	
058 – 060	43 01 06	RCL 16	
061 – 063	42 01 05	STO 15	Reenter x_0, n
064 – 066	43 01 08	RCL 18	
067 – 069	42 01 07	STO 17	
070	11	A	
071 – 075	75 43 01 02 95	–RCL 12 =	

LOCATIONS	CODES	KEYS	COMMENTS
076 – 080	55 53 43 01 03	÷ (RCL 13	Calculate f(x), normalize, and adjust scale factor
081 – 085	75 43 01 02 95	–RCL 12 =	
086 – 088	65 01 00	× 10	
089 – 092	85 93 05 95	+ .5 =	
093 – 095	42 00 00	STO 00	
096 – 097	09 20	9*1/x	Construct string of ones
098 – 102	22 58 01 01 01	INV *dsz 111	Move decimal point to correct position and print
103 – 106	65 01 00 95	× 10 =	
107 – 110	41 00 09 08	GTO 098	
111	98	*prt	
112 – 114	43 01 07	RCL 17	Test for final increment
115 – 118	90 01 02 04	*ifzro 124	
119	10	*E′	Decrement n, calculate x
120 – 123	41 00 07 00	GTO 070	
124 – 126	43 01 06	RCL 16	Do next x
127	98	*prt	
128 – 130	43 01 05	RCL 15	Print initial x
131	98	*prt	Print final x
132	81	HLT	
133 – 134	46 10	*LBL *E′	Subroutine for decrementing n and calculating new x
135 – 139	01 22 44 01 07	1 INV SUM 17	
140 – 142	43 01 09	RCL 19	
143 – 145	44 01 05	SUM 15	
146	56	*rtn	

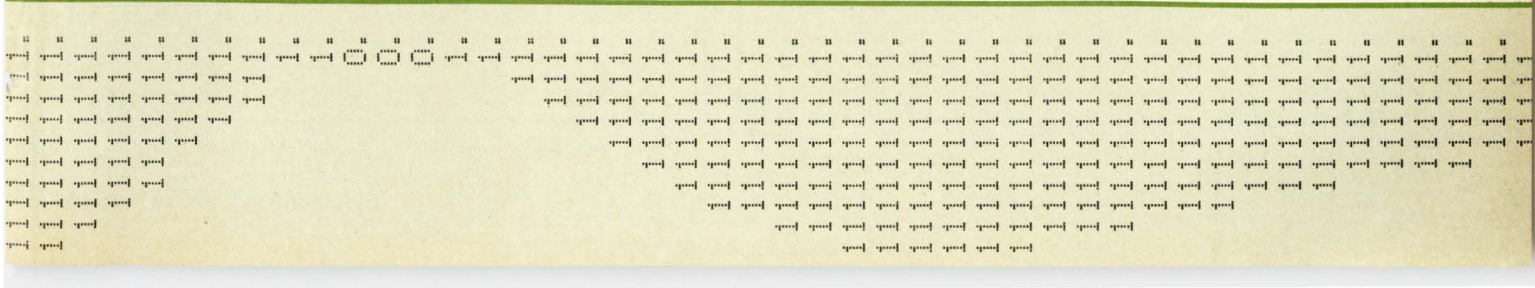
INSTRUCTIONS

- Program function to be plotted in locations 147 – 223. Begin with LBL A and end with rtn. Get value of abscissa from register R15
- Store increment of abscissa in R19
- Store number of points in R17 and R18
- Store starting value of abscissa in R15 and R16
- Press E to start plot
- For replots , R15 and R17 must always be reinitialized

REGISTERS			
00	used internally	10	free
01	free	11	free
02	free	12	f_{min}
03	free	13	f_{max}
04	free	14	f(x)
05	free	15	$x_0 + n\Delta x = x$
06	free	16	x_0
07	free	17	n
08	free	18	n_{max}
09	free	19	Δx

upper plot shows the function over a range (Θ) of -90° to $+90^\circ$ in steps of 10°. To obtain more detail of the ripple on top, the lower plot is repeated over the range of -75° to $+75^\circ$ with the increment decreased to 5°. Differing ranges may be specified for other details of interest as well.

For those SR-52 users without printers, the program can still be of value, especially for plotting graphs by hand. To find maximum and minimum values of a function in a specified range, the user employs steps 000 through 057 plus subroutine E in locations 133 through 146. Once the program is run, the maximum value is then found in register R13, and the minimum is in R12. These values greatly aid in setting up the scale. When the program is used without the printer, no entries are stored in R16 and R18. □



Current-compensated op amp improves OTA linearity

by Jacob Moskowitz
Raytheon Co., Portsmouth, R. I.

The control-input resistance of operational transconductance amplifiers which is nonlinear at low bias voltages, must be made linear if the device is to be used in certain voltage-controlled amplifier or automatic gain control applications. Here is a control scheme that provides a linear gain characteristic while preserving the full output-voltage swing of the OTA.

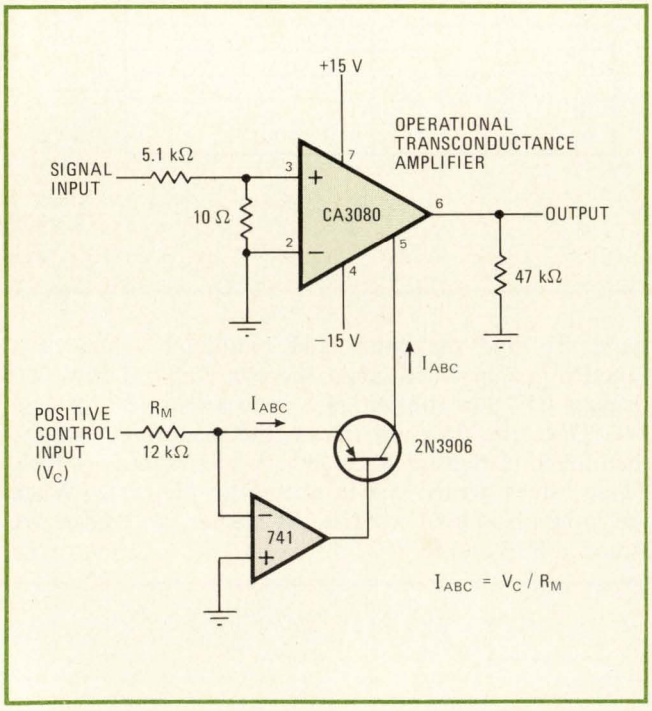
In OTAs such as the RCA CA3080, a forward-biased pn junction between the bias-current terminal and the chip substrate (negative supply) causes the nonlinearity of the control input resistance. Placing a resistor between the control voltage source and the bias terminal swamps nonlinear effects for large bias voltages, but fails to linearize the gain for biases of less than a volt or so.

A better solution, proposed by Walter Jung in the April 1975 Journal of the Audio Engineering Society, provides good linearity by means of a controlling op amp. This solution is practical for OTAs operating in an op-amp summing mode, but since the negative supply pin of the OTA is tied to the output of the controlling op amp, the output-voltage swing of the OTA is limited to values between the output voltage of the op amp and the positive supply voltage.

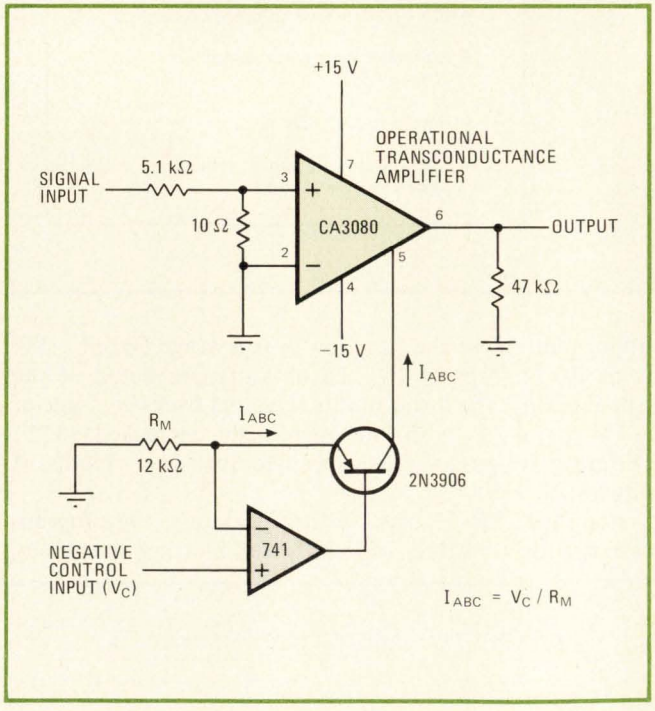
A linearizing scheme permitting full output voltage swing is shown in Fig. 1. In this version, a pnp transistor in the feedback path of the controlling op amp produces a current source linearly proportional to bias voltage V_C. This provides both gain-to-control-voltage linearity over a large control range (almost four decades), and minimum gain (in the linear portion) when V_C is zero. It is also much better suited for vca or agc applications than are four-quadrant multipliers, since control voltages below 0 will not produce negative outputs. Instead this circuit only turns off harder, which is most practical in audio work. In addition, the circuit of Fig. 1 requires no adjustment or trimming.

Figure 2 shows a similar circuit for use with negative control voltages. Since the control voltage is applied to the noninverting input of the op amp, the circuit exhibits a much higher input impedance than the circuit of Fig. 1, while the linearity characteristics are much the same. Both circuits offer a minimum linear gain at $V_C = 0$ and will only turn off harder for control voltages of the opposite polarity. Both allow full bipolar output voltage swing. □

1. Linearizing the OTA. A pnp transistor provides current feedback for controlling op amp to linearize operational transconductance amplifier under bias of less than 1 V. The higher the transistor's current gain, the better.

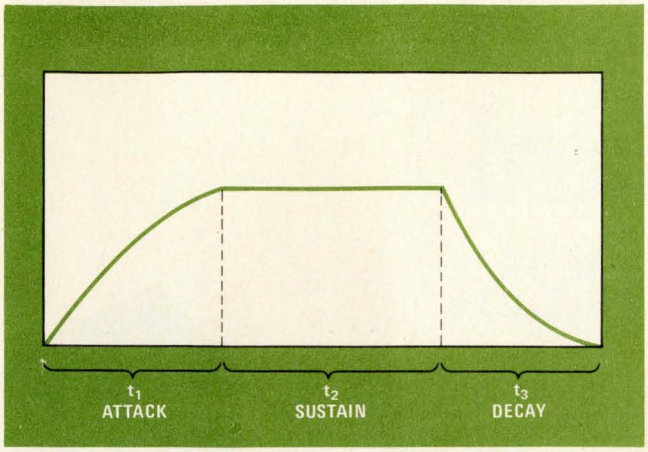


2. Negative OTA controller. For biasing OTAs with negative voltages, transistor/op-amp network is reconfigured as shown. Note controlling voltage is applied to noninverting input of op amp; input impedance is thus much greater than in circuit at left.



Timer generates trapezoid for musical synthesizers

by Roland Bitsch
Anzefahr, West Germany



1. Envelope. Shape of the envelope waveform—attack (t_1), sustain (t_2), and decay (t_3)—in addition to timbre (harmonic content) distinguish the sounds of musical instruments. Woodwinds have fast attack, quick decay; plucked strings are the opposite.

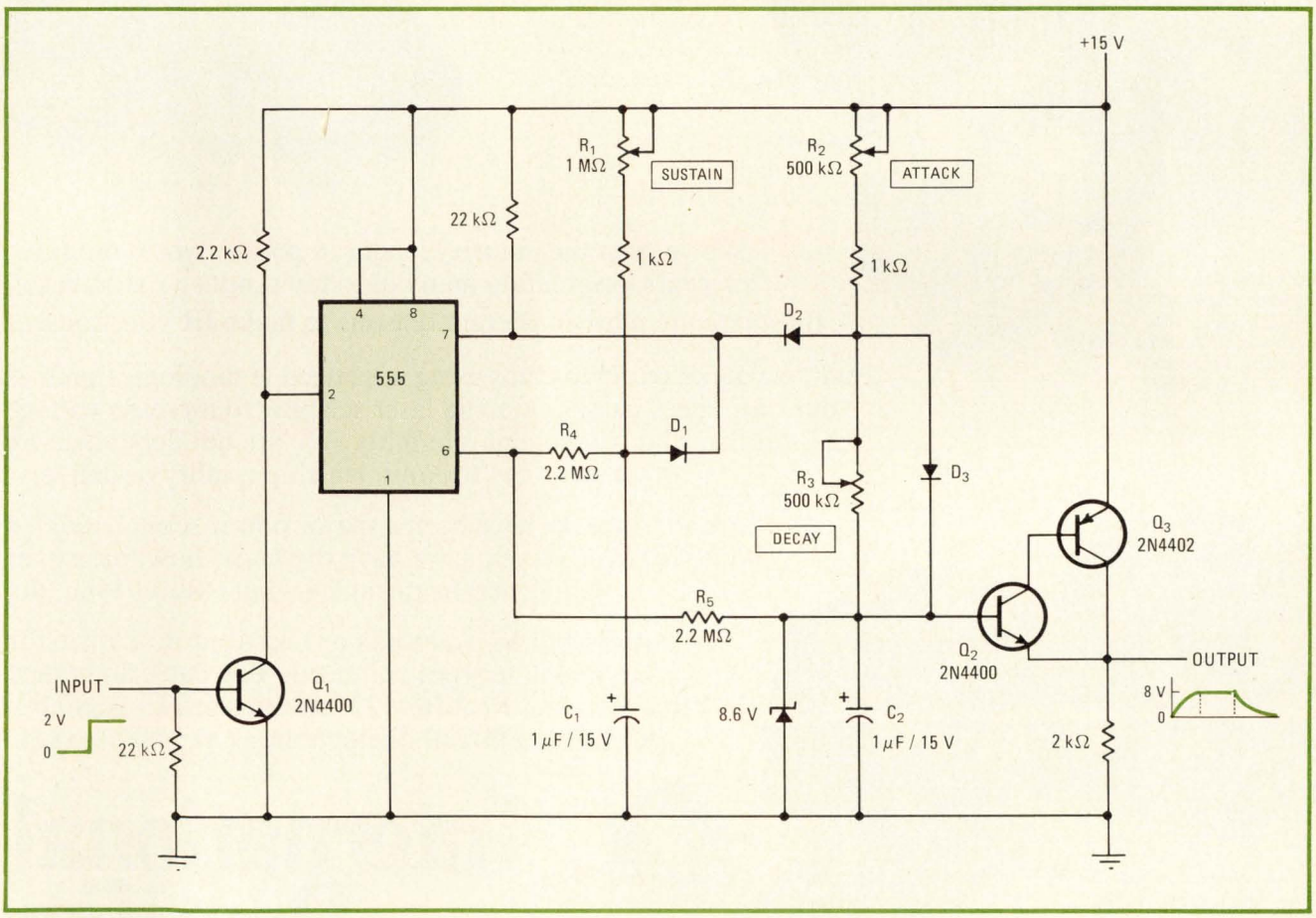
To build a trapezoidal-waveform generator of the kind used as an envelope in electronic music synthesizers, only a 555 timer integrated circuit and a few discrete components are needed. The circuit can vary the waveform's attack, sustain, and decay times over a wide range and puts out a signal with a maximum amplitude of 8 volts.

Figure 1 shows the three time increments characteristic of this envelope generator. Since its attack and decay signals are functions of charging capacitors, its waveform exhibits exponential rise and fall times. But linear ramps may be obtained by charging each capacitor with a constant current—a bipolar or field-effect transistor inserted in its charging circuit does the job.

Figure 2 is the generator circuit. The input is a 0-to-2-v positive pulse, which is compatible with most keyboard-type voltages. The RC network differentiates the pulse, and transistor Q_1 inverts it, to provide the necessary negative-going trigger for the timer.

Triggering the timer sets the flip-flop within the chip, and the discharge pin (7) goes high. Diodes D_1 and D_2, now reverse-biased, permit timing capacitors C_1 and C_2 to charge through sustain control R_1 and attack control R_2, respectively. C_2 ceases to charge upon reaching the breakdown voltage of the zener diode (8.6 v), and this event ends the attack period, t_1.

C_1 continues to charge until the voltage at the threshold pin (6) of the timer, determined by the R_4-R_5 summing junction, reaches approximately 10 v. The flip-



2. Waveform generator. Timer circuit puts out envelope waveform suitable for modulating tones of a musical synthesizer. Trigger input is a 2-V positive pulse; output has a maximum amplitude of 8 V and variable attack, sustain, and decay times of up to several seconds each.

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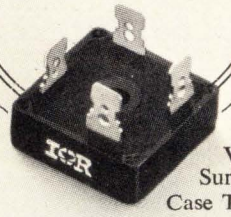

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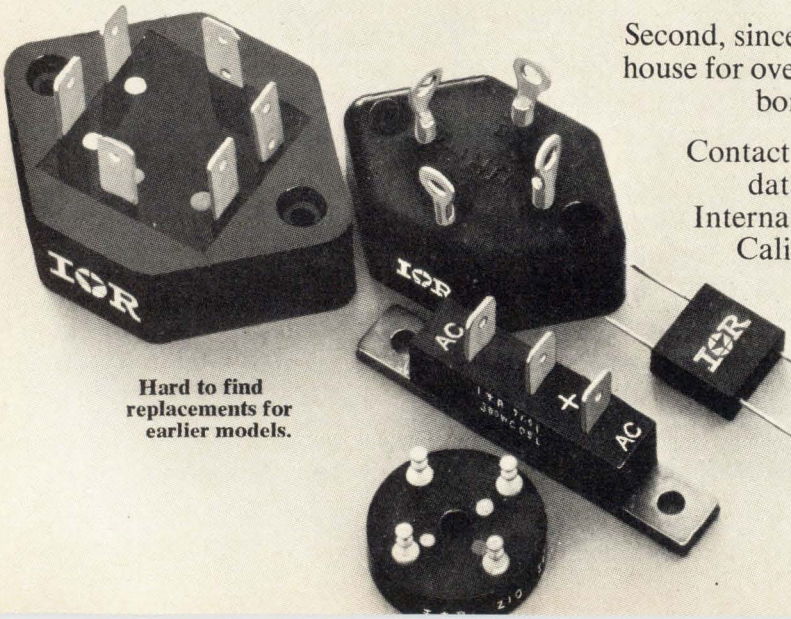

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Circle 98 on reader service card

flop within the chip is then reset, and this event ends the sustain period, t_2.

Reset of the internal flip-flop drives the discharge pin (7) low, allowing C_1 and C_2 to discharge through forward-biased diodes D_1 and D_2. Capacitor C_2, discharging through potentiometer R_3, determines the decay time period, t_3. Note that R_3 is shorted by D_3 when C_2 is charging during the attack time.

For linear ramps, the constant current sources must be placed in the R_2 and R_3 charging legs. However, the audible difference between linear and exponential attacks and decays of short duration is not so great. □

Multiplexer scans keyboard for reliable binary encoding

by Merritt E. Keppel,
Richmond, Va.

The myriad keypad-coded requirements in point-of-sale and other data-entry applications require a reliable, bounceless binary encoder. This inherently bounceless complementary-MOS circuit encodes up to 16 inputs and latches each BCD number for stable output.

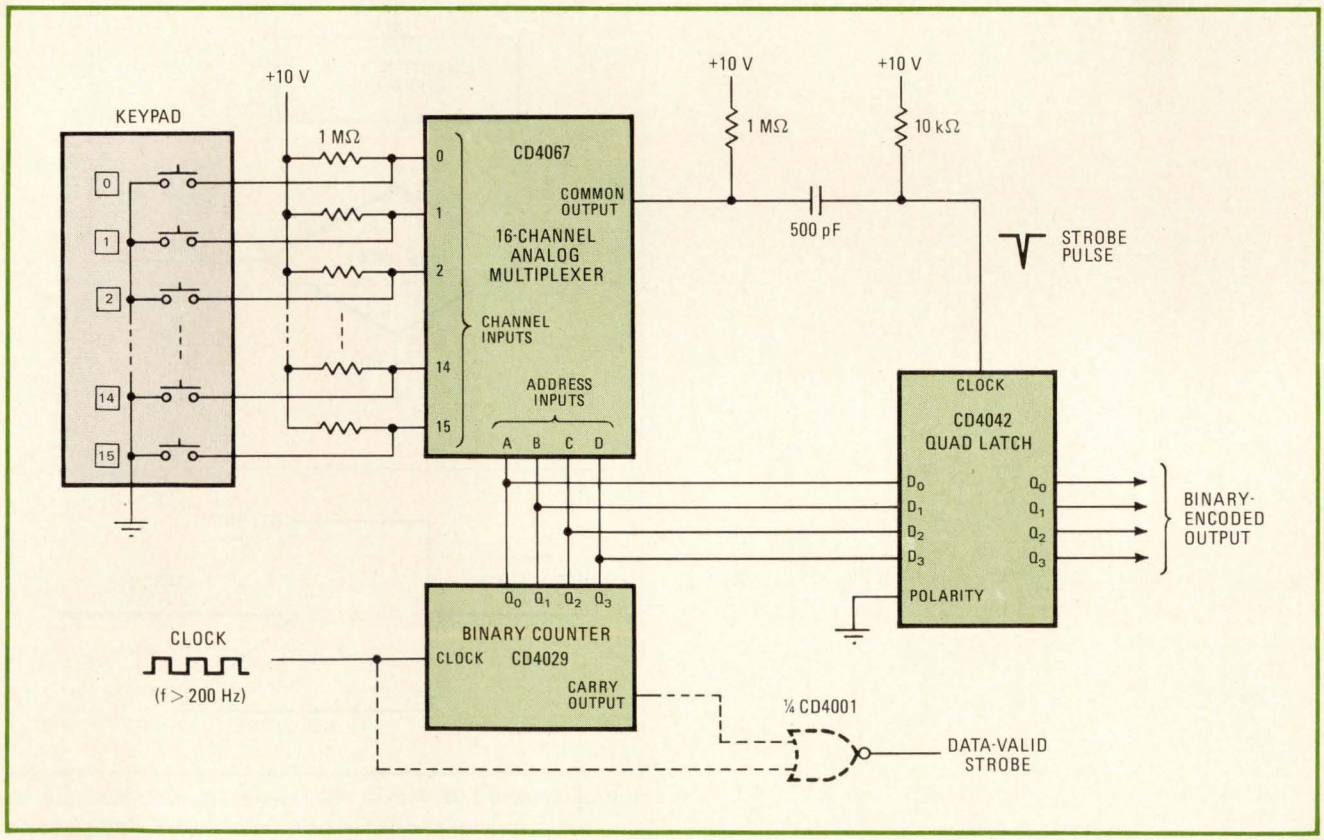
As shown in the figure, the keypad is scanned by an RCA CD4067 16-channel analog multiplexer. Each of the inputs has a 1-megohm pull-up resistor. When a key is depressed, the appropriate channel is driven low. A clock source, which can be derived from the device using the keypad, drives a CD4029 4-bit binary counter. Scanning occurs as the counter addresses the multiplexer.

When the counter has addressed an input to the multiplexer that is low, the common-out pin of the multiplexer goes low for one clock cycle. A differentiating network changes this pulse into a negative spike used to strobe the counter data (the binary representation of the particular key input) into the CD4042 quad latch. The binary word remains in the latch until another key is depressed, providing a stable output.

The circuit is inherently bounceless, since a noisy input will latch itself on its first negative transition and remain stable until another input is selected. The scan rate is not critical, but the clock frequency should be greater than 200 hertz for a normal key-entry rate.

In some cases, the processing equipment to which the circuit is connected will require a data-valid strobe. This can be accomplished by gating the clock with the carry-out pin of the counter. A two-input NOR gate, such as in a CD4001 quad package, provides a data-valid strobe one half a clock pulse before the beginning of every scan cycle. □

Designer's casebook is a regular feature in *Electronics*. We invite readers to submit original and unpublished circuit ideas and solutions to desgn problems. Explain briefly but thoroughly the circuit's operating principle and purpose. We'll pay $50 for each item published.



Keypad encoder. By using a CD4067 multiplexer to scan a keypad, switches need not be debounced for binary encoding. Quad latch at right holds digit encoded until next digit is entered. A NOR gate may be added as shown for data-valid strobe.

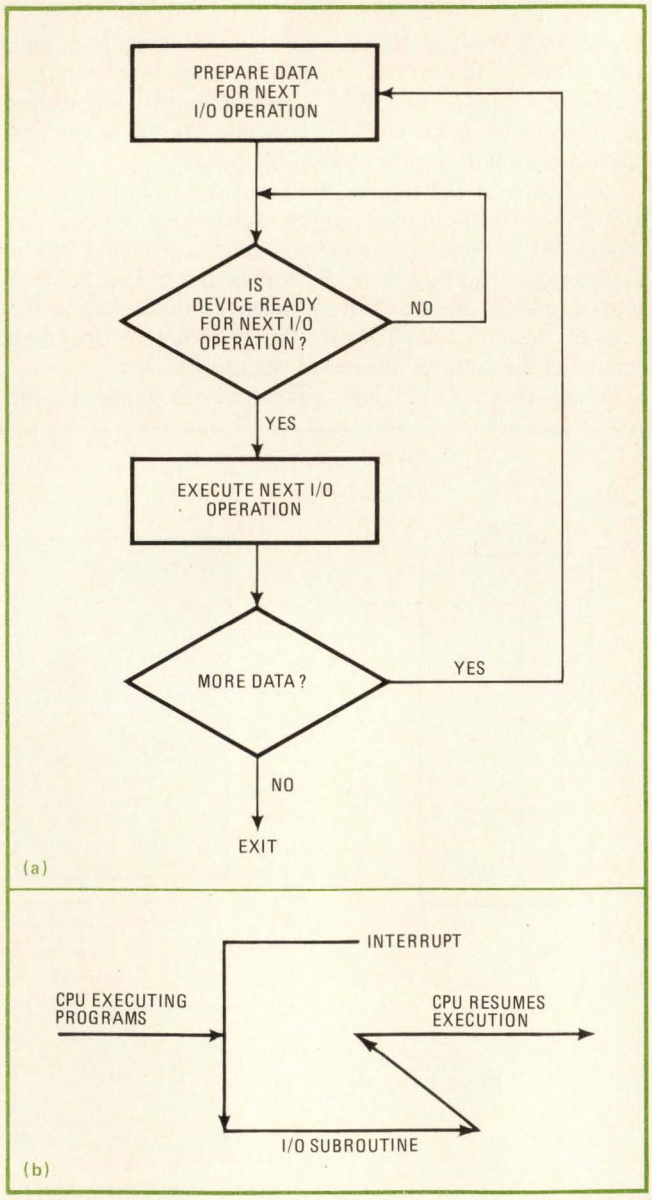
Making mini I/O upward-compatible

Automatic input/output architecture keeps software uniform, hardware costs low when the system adds peripherals

by Jerry Washburn, *Computer Automation Inc., Irvine, Calif.*

☐ All too often, the minicomputer user who wants to add extra peripherals to his central processor finds himself in trouble with the input/output interfaces. Maybe the increased throughput would be beyond the capacity of his existing programmed I/O interface, or maybe he would be forced to buy an expensive direct-memory-access controller simply to accommodate a low-speed magnetic-tape unit.

The answer is a unified input/output architecture that can be expanded upwards, in terms of both performance and versatility, without needing extensive hardware changes or difficult reprogramming. Drawing upon existing I/O techniques, the approach allots the highest common factor of all I/O requirements to the minicomputer software, distributes the rest to intelligent peripheral controllers, and uses multiplexers to link these new



1. Programmed I/O. Typical programmed-I/O sequence (a) runs four basic steps until all data has been transferred. For programmed I/O with interrupt (b), the CPU stops execution, jumps to an I/O program, and then returns to the interrupted program.

controllers to the minicomputer's memory bus.

Among the other advantages of this systems approach, the software reserved for I/O inside the minicomputer can now be much more uniform. Moreover, the setup guarantees isolation of the various peripherals' tasks at low hardware costs.

I/O architectures

The traditional I/O architectures—programmed I/O, interrupt I/O; integrated I/O, and direct memory access—contribute to this new architecture basically by supplementing each other's deficiencies.

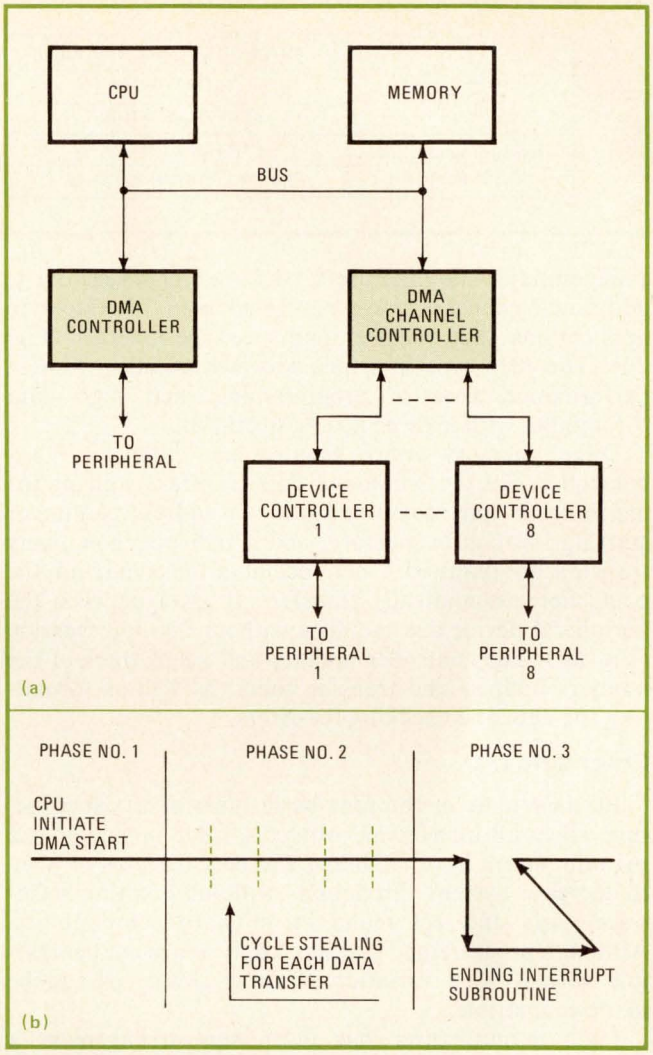
Programmed I/O, the most economical interfacing concept, uses the central processing unit, under software control, to perform most I/O control functions (Fig. 1). Essentially, all data transferred between memory and the I/O device passes through the CPU's accumulator, involving the CPU in all the burdensome controller functions. The method is popular for interfacing low-speed peripherals to minicomputers because it provides hardware at low cost. But in order to do so, it sacrifices ease of programming, software uniformity (the ability to use similar protocols and programs for various types of I/O architecture), task isolation, and system performance.

To illustrate, every character transferred by programmed I/O requires execution of 5 to 25 macroinstructions, a process that may take up to 50 microseconds. This can limit data transfer rates to 20,000 characters per second—too slow for disk and tape units and even for some low-speed peripherals. Also, when the peripheral must initiate the data transfer, the software has no way of knowing it in advance. Therefore, as soon as a modem receives data, the computer must read it or lose it. Alternatively, a program could remain in a loop, waiting to service the device, but then the computer would be idle for extended periods.

Therefore, to allow a peripheral device to initiate an I/O operation, programmed I/O must be supplemented by interrupts. Interrupt I/O requires less CPU overhead and provides better system throughput than simple programmed I/O because the CPU does not need to anticipate each data transfer from the I/O controller, and it can perform other system operations while waiting. However, to get this efficiency, timing and interrupt hardware must be added to the I/O controller. Most minicomputers use interrupt I/O in real-time system operations and in multiperipheral system applications.

Integrated I/O, because it needs specialized CPU firmware, has most I/O controller logic built into the central processor. Although the hardware for this architecture may be more cost-effective than the other types, the CPU must act as an inefficient I/O controller, thereby impacting unrelated CPU functions and reducing throughput. Equally important, a failure in the integrated-I/O hardware can shut down the entire computer system. But, despite these drawbacks, integrated I/O is used in many large computers to minimize system costs while maintaining software compatibility.

Most manufacturers of large computers have adopted DMA for all interfacing because the technique minimizes software needs while optimizing performance. But the architecture also increases hardware costs. Accordingly,



2. Direct memory access. Typical computer-DMA interface (a) uses single controllers or a channel controller with individual device controller. Simplified flow-diagram (b) shows data transfers by DMA with cycle stealing, and then an interrupt to report completion.

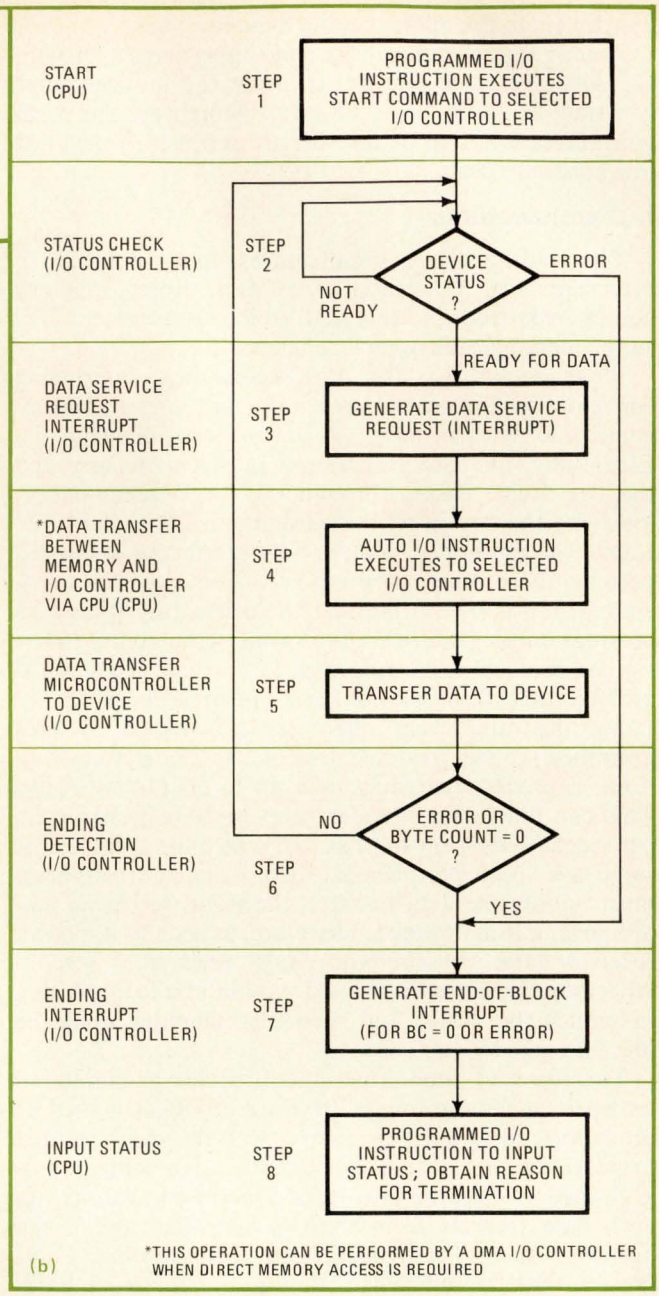
COMPARISON OF MINICOMPUTER INPUT/OUTPUT ARCHITECTURES

L = LOW
M = MEDIUM
H = HIGH

	COST	EASE PROGRAMMING	SPEED	SOFTWARE UNIFORMITY	SYSTEM THROUGHPUT	TASK ISOLATION
PROGRAMMED I/O	L	L	L	L	L	L
INTERRUPT I/O	M	M	L	L	L	L
AUTO I/O (CPU)	M	M	H	M	M	M
AUTO I/O (DMA)	H	H	H	H	H	H
DMA	H	H	H	M	H	H
INTEGRATED I/O	L	L	H	M	L	L

DATA INTERRUPT LOCATION	AUTOMATIC I/O INSTRUCTION
	BYTE COUNT
	BUFFER LOCATION
ENDING INTERRUPT LOCATION	JUMP AND STORE *$+1
	ENDING ROUTINE ADDRESS

(a)



(b)

3. Auto I/O. Dedicated control block (a) uses interrupts to perform auto-I/O operations. Auto-I/O instruction is placed in assigned memory control-block interrupt, and a second interrupt signals end of block. Flow chart (b) shows typical output sequence.

minicomputer manufacturers, who are highly sensitive to additional expenses, have restricted DMA interfaces to applications that require high-speed peripherals (Fig. 2a). The DMA-type interface provides excellent system performance, ease of programming, and high data throughput with little or no CPU overhead.

Direct memory access requires an "intelligent" I/O controller. The CPU initiates a data transfer by giving the controller a start command plus an address pointer or starting location in memory, and it indicates how many transfers are required. Upon receipt of the command, the controller automatically transfers all data between the peripheral device and memory without CPU intervention (Fig. 2b). The controller updates and keeps track of the memory address and transfer count, as well as formatting the data and checking for errors.

Enter auto I/O

Because none of the four basic types of I/O architecture solves all interfacing problems, some minicomputer manufacturers have exploited the best features of each to increase system throughput without boosting hardware costs and yet maintain software compatibility. Although programmed and interrupt I/O are not compatible with DMA, a variation of these two types can be made compatible.

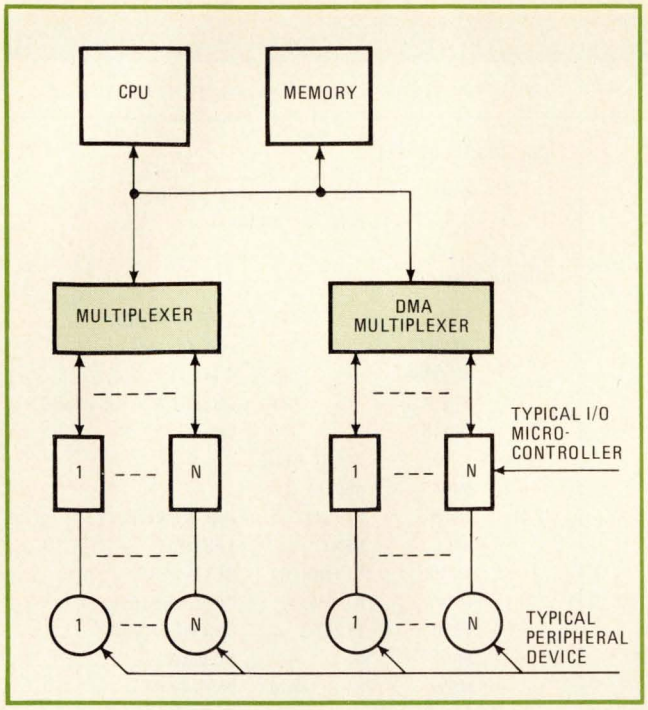
Each manufacturer has given this arrangement a name of his own, but the technique may be called automatic I/O. With auto I/O, specialized I/O instructions under interrupt control allow data transfer between the memory and peripherals without the need for computer hardware or software to save and restore operating registers or transfer control to an I/O subroutine to process each character. Instead, CPU firmware fetches and updates a dedicated control block in the memory that contains the operation to be performed, the device transfer count, and memory-address pointer.

Implementation of this technique, in addition to extending the uniformity of software, has approximately doubled the performance of a system that runs on conventional programmed I/O. A typical benchmark program that takes 50 bytes as an input from a teletypewriter and checks for the presence of a carriage return needed 1,010 microseconds, or only a third as long as a similar, but even faster type of CPU that used programmed I/O (see p. 104).

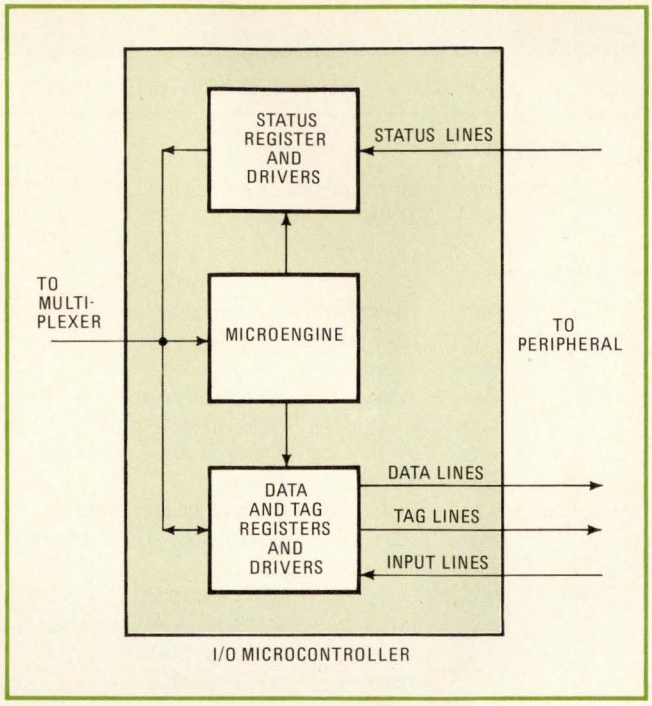
In implementing the auto architecture, the I/O controller generates a vectored interrupt, which goes to the CPU. The processor uses the interrupt-memory vector to fetch a control block containing the operations to be performed, a buffer-address pointer, and the number of bytes to be transferred. The CPU, which uses this control block to transfer data between the I/O controller and the memory, also updates the buffer-address pointer and transfer count, then finds out if there are any more bytes to be transferred. If the byte count is zero, the I/O controller is notified during the data transfer, and it generates an ending interrupt.

Auto I/O is limited to low-speed peripherals because it involves the CPU. The technique provides lower overall performance and task-isolation capabilities than the DMA method. However, these shortcomings can be surmounted by simulating the CPU's auto I/O in a DMA version of an I/O controller, which significantly improves all the I/O characteristics (Fig. 3).

With hardware, the DMA auto I/O controller can fetch



4. Architecture. Multiplexer, left, interfaces I/O device controllers with CPU and memory for programmed, interrupt, and auto I/O with throughput to 80 kilobytes per second. DMA multiplexer converts I/O microcontrollers to DMA at over 300 kilobytes/s.



5. I/O microcontroller. Microengine comprises microprocessor and ROM for instruction decoding and data manipulation; status devices synchronize data from peripheral to CPU and microengine; data and tag devices store and drive data between CPU and peripheral.

and store the dedicated control block from memory as soon as the peripheral starts operating. Then, when the I/O device interrupts through its own controller, the DMA controller, instead of passing the interrupt request on to the CPU, transfers the data between the device and the memory on a cycle-stealing basis. The DMA controller also provides all buffering addressing, transfer counting, and condition checking. When the I/O-device controller signals the end of an interrupt, the auto-I/O controller restores the updated dedicated control block in memory.

Lowering hardware costs

Conventional programmed I/O and interrupt I/O can also benefit from an adaption of the DMA controller. A multiplexer between several intelligent I/O controllers and the CPU-memory bus (Fig. 4) can supply the common CPU-memory interface, interrupt, decoding, and data-buffering logic. It can also provide a baud-clock generator and special character-detection logic for serial-type peripheral devices. Common circuitry minimizes cost, space requirements, component count, and power consumption.

Intelligent I/O controllers, microcoded to perform all unique device-interface protocol, data storage, formatting, and automatic checking for status and errors. They also provide task isolation and distribute the processing. This approach enables upgrading of a system from programmed-I/O to DMA capabilities without undue hardware cost.

Another type of multiplexer can be added to handle the DMA controller, which interfaces with the intelligent I/O controllers so that either DMA or non-DMA performance can be chosen as a function of the type of multiplexer employed. The DMA type must not only provide all the capability of a simple multiplexer, but it must also emulate the CPU's auto-I/O instructions, such as detecting data-service requests, transferring data between device and memory, and updating and storing address pointers and transfer counts.

Both DMA and non-DMA multiplexers can be configured to support programmed-I/O and interrupt-I/O operation. With such organization, a single multiplexer can operate with any I/O-device controller that handles programmed, interrupt, and auto I/O in mixed configurations. This concept enables a user to upgrade system performance without the need to rewrite costly software and without throwing away expensive I/O-controller hardware. In addition, low-speed peripheral devices can be operated with DMA.

Interfacing the system

Computer Automation's I/O interfacing system, based on these architectural concepts, consists of a multiplexer called an I/O distributor, a DMA multiplexer called a DMA I/O distributor, and a set of parallel "intelligent" cables, each of which contains an integrated microcontroller that is called a Picoprocessor. Shown in Fig. 5, the Picoprocessor is microcoded to allow it to handle the particular characteristics of the specific peripheral its cable serves.

This distributed system enables any member of the company's LSI family of minicomputers to communicate with a maximum of eight parallel or serial peripherals in any mix—all from one I/O distributor logic module. The I/O distributor, contained on a single printed-circuit

BENCHMARK: AUTO I/O VS PROGRAMMED I/O

COMPUTER AUTOMATION LSI-3/05 WITH AUTO I/O

```
(CALLING SEQUENCE)

        LDA     (BYTE ADDRESS OF BUFFER - 1)
        JST     TTYIN

(SUBROUTINE)

TYINT   EQU     (TELETYPE INTERRUPT LOCATION)
TDYEVA  EQU     (TELETYPE WRITER DEVICE ADDRESS)
        ABS     TYINT
        AIB     TYDEVA      AUTOMATIC INPUT
        DATA    $-$         ROOM FOR BYTE COUNT
        DATA    $-$         ROOM FOR BUFFER ADDRESS
        DATA    0           RESERVED
        JST     $+1         END-OF-BLOCK INTERRUPT
        DATA    EOB         CALLS END-OF-BLOCK ROUTINE
        REL     0
TTYIN   ENT                 ENTRY LOCATION
        STA     TYINT+2     SAVE BUFFER ADDRESS (*P-REL)
        LAM     50          BYTE COUNT (MAX)
        STA     TYINT+1     SAVE IT (*P-REL)
        LDA     =:1E18      MICROCONTROLLER COMMAND (LITERAL)
        OTA     TYDEVA+1    START INPUT
        EIN                 ENABLE INTERRUPTS
        JMP     $           WAIT HERE FOR CR OR 50 BYTES
EOB     ENT                 ENTRY LOCATION
        RTN     TTYIN       EXIT TO CALLER (*P-REL)
```

REQUIRES:

TIME – ≈1,010 μs
– 6.9 μs + (20.0 μs per input character)
DMA Version of Auto I/O is ≈ 160 μs

SIMILAR TYPE OF FAST CPU WITH PROGRAMMED I/O

```
(CALLING SEQUENCE)

        MOV     #MEMBVF, R0 BUFF -- R0
        JSR     PC,TTYIN GO DO IT

(SUBROUTINE)

        TTYSTI=         TTY     STATUS WORD
        TTYWDI=         TTY     INPUT PLACE
        TTYWDO=         TTY     OUTPUT PLACE
        TTYSTU=         TTY     OUTPUT STATUS PLACE
        CR=15                   CR
TTYIN=          START HERE
        MOV     #50.,R2
NEXT:   TSTB    TTYSTI      ARE WE READY?
        BPL     NEXT        YES-WAIT
        MOVB    TTYWDI, R1  GET A BYTE
        MOVB    R1, (R0)+   GIVE A BYTE
        TSTB    TTYSTO      CAN WE ECHO?
        BPL     4           NO-WAIT
        MOV     R1,TTYWDO   SEND BACK
        SUB     #CR, R1     IS IT A CR?
        BEQ     EXIT        YES-GO WAY
        SOB     R2, NEXT    IF NOT 50 GET NEXT ONE
EXIT:   RTS     PC          GO BACK HOME
```

REQUIRES:

TIME – ≈3,142 μs
– 10.15 μs + (62.65 μs per input character)

To demonstrate the effectiveness of automatic input/output, a Computer Automation LSI-3/05 minicomputer was set up to use auto I/O and was programmed to perform a simple operation: taking in 50 bytes from a teletypewriter and checking for a carriage return. Another similar, but even faster, minicomputer was set up to perform the same operations using programmed I/O. The two programs are shown side by side above.

The auto-I/O setup required a basic 6.9 microseconds plus 20 μs for each input character, while the programmed-I/O setup required 10.15 μs to get started and then 62.65 μs for each input character. The total time for the auto-I/O setup was thus only 1,010 μs, while the programmed setup required three times as much time to do the same job—3,142 μs.

Note that in the programmed-I/O subroutine, the CPU must execute an instruction for each byte and then test to see if a carriage return has occurred before it can go back take to the next byte.

However, in the case of the auto-I/O routine, byte count is set up, and the CPU simply waits until the total of 50 bytes has been input and the carriage return has occurred.

The process could have been speeded up even more if the direct-memory-access version of auto I/O had been used. In this case, the total would have been only about 160 μs, since the CPU would have participated even less in the process.

Note also that although it is not shown in the program, the auto-I/O setup allows some overlap of overhead processing, since the I/O controller performs some operations in parallel with the CPU. Such operations are not possible with the programmed-I/O setup, where the CPU participates in each step.

card, provides baud clocks and buffering for the eight intelligent cables, and it supports programmed, interrupt, and auto I/O.

A four-channel hardware- and software-compatible variation of the I/O distributor, called the DMA distributor, adds the DMA capability to each intelligent cable. It is compatible with programmed and interrupt I/O as well as the auto-I/O software written for the I/O distributor.

Each intelligent cable provides task isolation, interrupts, buffering, and automatic error checking, as well as controlling interface timing and protocol. Serial cables can interface such peripherals as teletypewriters, cathode-ray tubes, and modems. Parallel versions work with magnetic tapes, printers, paper-tape units, card reader, and IEEE-bus equipment, as well as other general-purpose interfaces. □

So you want to be a consultant . . .

. . . remember to keep in mind that the rewards can be great, but so can the penalties for failure

by James M. Williams, *Consultek Inc., Wellesley, Mass.*

☐ When the company parking lot begins to look gray and familiar, many electronics engineers start dreaming about challenge and diversity. They often come to feel that a good way to achieve independence is consulting—a way of life that also draws EEs who make the move at the outset of their careers, as well as those who are between jobs or have time to moonlight.

But deciding to be a consulting engineer is a lot easier than becoming one. Most prospective consultants are not aware of the range of potential jobs, much less how to get them. Nor are they familiar with the business side, especially fees and contracts, or with the special problems a consultant faces on the job.

Necessary traits

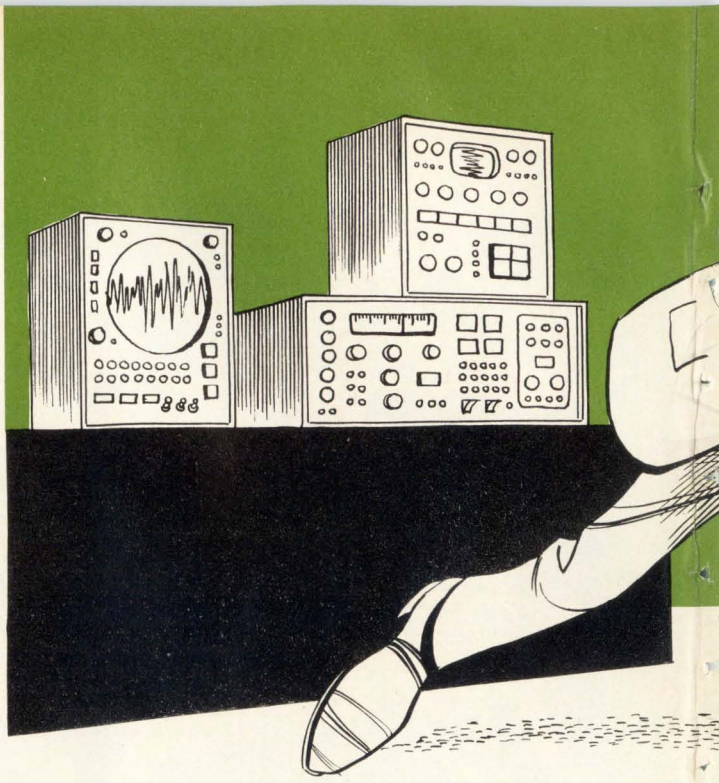
Engineering consulting can be challenging, profitable, and just plain fun. But it can also be a nightmarish conflict between the consultant and his clients involving lost time, overestimation of abilities, poor decisions, and worse. A sobering fact is the failure of the majority of engineers calling themselves consultants to establish a going business. Most of them should not have gone into consulting in the first place.

What separates the winners from the losers? Successful consultants all seem to have the ability to listen, the facility to think fast and clearly under pressure, self-confidence based on technical expertise and experience, a high level of motivation and interest in engineering, and salesmanship. Of course, these traits apply to almost any successful engineer, so you might say that a successful consulting engineer is first and foremost a fine engineer with a little something extra.

The vision of consultants as mental giants who should be able to do anything is wrong. In many situations, the consultant is part of a team effort; very often he and his client will augment each other's know-how. Therefore it is wise for a client to know from the beginning what the consultant can and cannot do.

A smart consultant does not promise the moon in an eager attempt to land a contract. Trying to con a client

One danger is getting caught between conflicting personalities in a company



into believing that you can do something you cannot deliver is simply asking for a damaged reputation, a lawsuit, or both.

The projects open to the consulting engineer vary widely. Usually a firm hires a consultant to provide a specialty it lacks or backup in technologies in which it is weak. I once worked for an optical-equipment manufacturer needing an oven that would cool down at a precise rate over several thousand hours. The firm could not buy it and did not know how to make it.

What consultants do

Many companies rely on outside help to get them started in a new product line while they develop in-house expertise. A good example is a project I did for a digital-equipment manufacturer. The firm wanted to come out with a line of low-level analog modules to plug into its existing digital systems. My duties included both startup design for the modules and interviewing candidates for the company's newly formed analog design team.

Electronics manufacturers often farm out specific tasks as well. For instance, I developed a production instrument for a maker of a certain type of environmental sensor. The sensor design itself was fine, but management wanted to add to the sales catalog an instrument designed around it. The firm was not willing to invest in a full-time engineer for a single new product.

Rescue operations are another form of consulting work. I once got a call from a firm where the senior engineer had died suddenly. He had been working on a new instrument, but had left almost no documentation, no specifications, no trimming procedures, no production tolerances, and no complete schematics.

It was a tight situation; time was short and cash flow limited, so the company needed a crash rescue operation. To finish the job, I sat down at the bench with what notes there were and the prototypes. From these I put together production schematics and created the other documentation required to get into production.

Another rescue involved a case where thousands of high-quality printed boards had been made up in advance for a circuit that did not work. These multilayer boards were tightly laid out, perfectly etched, precision-drilled, and very expensive. The problem was to get the circuit to work perfectly without altering the boards. In addition, there were restrictions on weight, power consumption, component size, and operating temperatures. And there could be no fudging on performance.

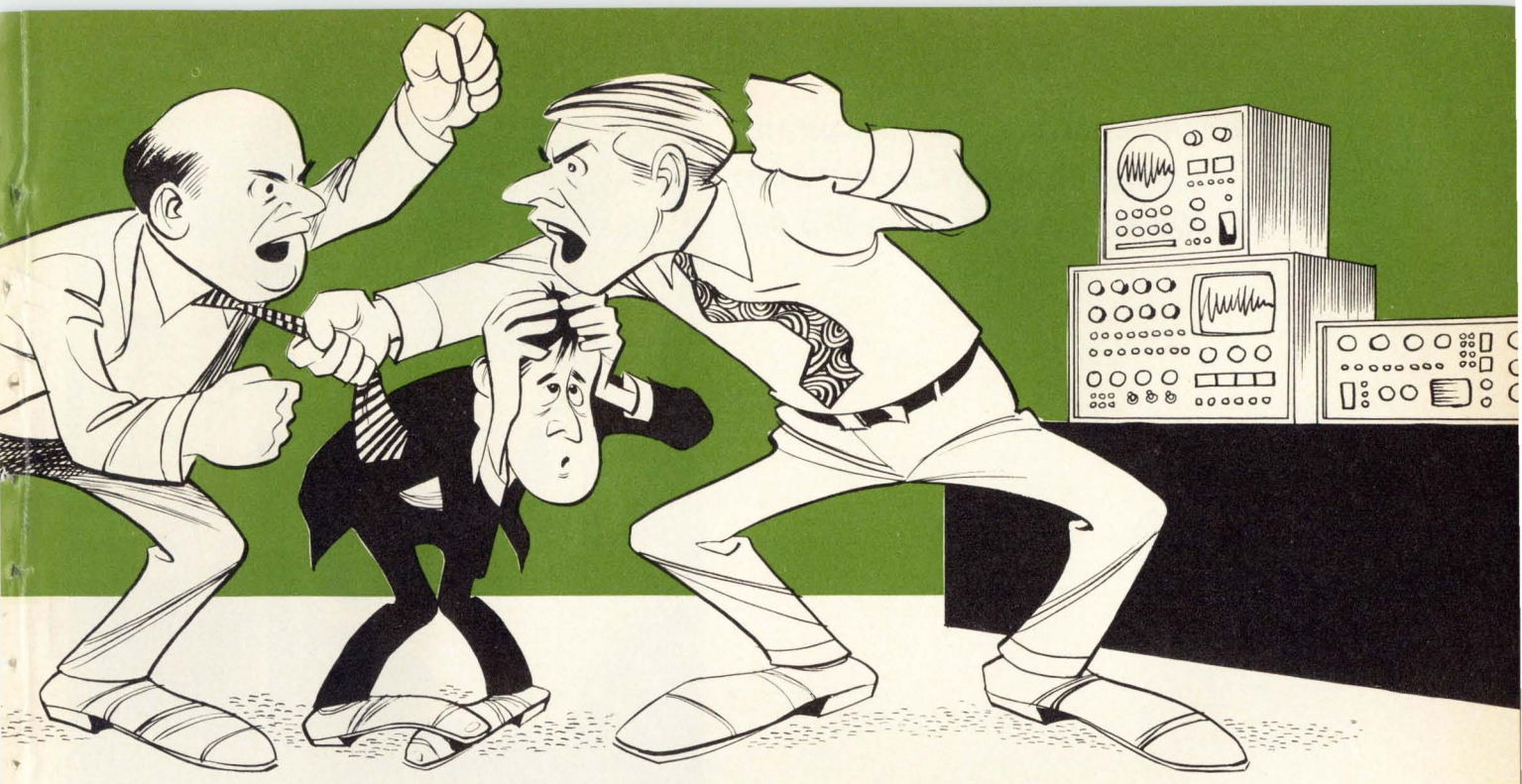
It was one of the most difficult assignments a consultant could get. The solution came down to analyzing the combination of functions and patterns that would perform to spec and conform to the board. It meant changing some components and changing values on others, a maddening procedure given the limits imposed.

Teaching is a possibility

Another possibility for a consultant is teaching special courses. Many companies prefer bringing the teacher to the students, rather than sending engineers to extension courses or night school. The advantages include lower cost, less time lost, and control over course content.

I have taught in-house courses in which the content was tailored to technologies the company was entering. One three-week course was a concentrated study of low-level analog circuits. Circuit performance and quality were the main concerns, with cost a secondary consideration. Another firm wanted its engineers to learn how to cut costs. So I taught a course on design shortcuts, such as one- and two-chip solutions to problems that appeared to require half a dozen integrated circuits.

Two other areas in which consultants sometimes work are technical writing and equipment-purchase recommendations. Data sheets, application notes, manuals, and even magazine articles are often farmed out in order to meet deadlines for the introduction of new products. As for purchasing recommendations, some firms hire a



consultant because their personnel have little background in electronics. Such a customer wants to make sure that it is spending money wisely in choosing test instruments and the like.

Along this line, I have also been asked to analyze competitive products. A circuit house, for instance, wanted to evaluate its high-grade chopper-stabilized amplifier against that of a competitor. The objective was to decide whether to expand its line to include models with features similar to the competitive unit.

Another form of consulting is developing a product design or patent independently and then selling it outright to a company that will manufacture it. The design effort can include anything from a black-box function to a complete instrument.

Finding work takes persistence

So much for the types of work available to the consultant. The next problem is how to land a job.

The key to getting work is mastering the art of thoughtful aggression—that is, spotting a potential opening and going after it. It means reading engineering periodicals to keep up to date on who is doing what. Is XYZ Inc. going into a new business? Do prices at ABC Corp. seem too high? Do product trends indicate an established firm is falling behind more progressive newcomers? Any one of these companies may be in the market for help from a consultant.

Besides the engineering magazines, general business publications can also provide leads. Say Acme Shoe Co. reports it is planning to spend a few million dollars on automating production—an inquiry is in order. Or suppose Ajax Cardboard Corp. decides to diversify into data-processing products—business may be waiting.

Look at products you use yourself. Do they work well? Could you do a better design job? What about companion products, additional features, and the like? Are the data sheets or technical manuals clearly written and well illustrated? My first consulting project involved a premium product of top performance that I had been using. The data sheet was dull and poorly written, and the applications in it did not do justice to the product. I called and got the job of rewriting the data sheet.

Exposure on conference or symposium programs and in magazine articles is important too. The more work a consultant does, the more often other opportunities come his way by word of mouth.

Generally, though, the consultant has to approach the potential client—and this inquiry has to be well planned. A letter is one way to start, but a telephone call to the president or other high officer in the company is often better. It is always best to go to the top of a company first. Once you interest a key executive, the doors will open, whereas middle-echelon personnel may either feel threatened by a consultant or simply not have the authority to start the ball rolling.

The letter or telephone call should get straight to the point. The consultant describes who he is and how he thinks he can be of service in as specific terms as possible. Suggestions for a new product or a product upgrading should also be straightforward in order to provide the executive with enough information for evaluation without overwhelming him with details.

Very few consulting contracts are arranged without a meeting. Often a serious prospective client will offer to pay travel expenses for a preliminary get-together. However, once a contract is drawn up, travel expenses should be explicitly provided for or else lumped together with the total charge for the job.

When a company shows real interest, respond quickly. If you started with a telephone call, then a letter should follow, restating the conversation. If a letter spawned interest, then perhaps a telephone call is in order. The idea is to get negotiations moving quickly without becoming pushy. Sometimes a company simply cannot reply immediately because of size or internal communi-

For the established consultant, annual income can run from $30,000 all the way up to $75,000

cations difficulties. In any case, the consultant has to be ready to talk when the prospect is ready.

The period between initial approach and contract meeting is a good time for the consultant to get his case together. When the call comes, he will be ready with a plan and a fee to begin negotiations. After holding initial meetings, the consultant usually will write proposals, which are evaluated, discussed, and often revised.

Inventions: a special case

Finding a company to market an invention is probably harder than dreaming up the product. Knowing what design idea is saleable, to whom, when, and for what price are complex matters. And the lone engineering consultant trying to sell an idea is in a vulnerable position. Negotiations often resemble a poker game.

Some guidelines might be helpful, however. First, decide what the product is worth and do not sell for less. Of course, this decision involves considerable background research. You must estimate production costs, overhead, profit margin, marketability, and product life—all factors that the company probably knows quite well.

Negotiations over selling a product can go on for an incredibly long time and can appear fruitless. However, drawing out the discussions is often a tactic on the part of the company to shake the product loose from the disheartened inventor. So it is wise not to give into low bids or delaying tactics if you are confident that your product is a winner and if you have done your cost-analysis homework. Needless to say, competent legal advice should be sought before signing anything.

The business side of consulting is extremely important, yet it is surprising how sloppy many consultants are in this area. Only after listening to a prospective client's problem and making sure that it is understood, can a consultant come to a meaningful figure for the fee.

It is wise to enter a situation with a ballpark figure in mind, but the nature of the project may have changed since your initial approach, or else the project may not have been adequately communicated in the first place. It is important to look out for these stumbling blocks before discussing the fee.

In any case, the most common error of novice consultants is setting the fee too low. Two hundred dollars a day and up is a common figure these days. The main thing is to be paid a fair amount. Occasionally companies will offer a royalty arrangement in place of direct payment or some combination of the two.

Every so often a company is in a great hurry to get something done and is willing to pay anything, no questions asked. I once got a call from a California outfit. The president explained that his staff had underestimated the problems in building an oven to maintain a stable temperature of 65°C to within 25 microdegrees.

Speed means money

The company, a subcontractor, had built a large system, left the oven until last, and had a site inspection scheduled in four days. Afraid of losing all or part of the subcontract, the company offered a flat $5,000 fee to get a control system up and running. With a number of technicians and machinists helping, the control loop was running after 40 hours of nonstop work.

Whatever the fee agreement, it is important to draw up a contract. Some consultants are afraid of insulting a potential customer by insisting on a contract, but this fear is unfounded. A contract provides a record of the agreement to avoid any misunderstandings and to protect both parties. Managers understand this.

Some contracts call for all the work to be completed before payment is made. Others provide for partial payments as certain contractually defined phases of a project are completed. Still others provide a retainer payment before any work begins. Usually the client prepares the contract and sends it to the consultant, who edits it and returns it. A contract may go back and forth two or three times before both are ready to sign.

Most contracts are relatively simple and pose no problem. On very rare occasions, the consultant runs into a client who is dishonest and refuses to pay. If this happens, it is best to try to remind him, or to reach an understanding—but be firm. If the client does not respond, it may be necessary to retain a lawyer. However, a consultant should never threaten legal action as a bluff, since the client may call him on it.

Doing the job

Once a contract has been drawn up, work finally begins. At this point, the employer should have a clear idea of what the consultant's approach is and how he will solve a particular problem.

Above all, the consultant has to be prepared to recognize and correct a situation if it is not working out as planned. There is often a great deal of pressure from clients to get a project done on time within budget. It is difficult to walk into an unfamiliar situation and take charge immediately, yet clients want quick solutions, not excuses and complaints.

A potentially sticky problem arises when a consultant becomes caught between conflicting personalities in a company. Company politics, power struggles, petty games, jealousy, obstinacy, and plain stupidity often lurk in corporations and can easily trip up an unsuspecting consultant.

In one project, I worked for a company in which the test equipment was poor and out of calibration, the work area was poorly lit, the laboratory was a mess, and the so-called engineering staff did nothing but cash their paychecks. I did my work, made sure the firm was satisfied, and got out, glad to be free of the place.

However, if a consultant gets caught on a dead-end street, the best policy is to speak out plainly but tactfully. Discuss the problems with the managers involved to define who is in charge of what, who is responsible for the project, and where you fit into the picture.

Even though the circumstances may not be ideal, the main objective is to get the job done without blowing up or entering into pointless power struggles. There are exceptions to this policy. One group I worked with turned out to be willing to put products out the door that just were not ready to go. I did not want my reputation ruined by these bad products, so I resigned and told the company why.

Most jobs can be completed with minimal difficulty if you act professionally, provide first-rate documentation, and meet all deadlines. It is a good idea to call the client back several weeks after the project is completed to make sure he is still satisfied. This is an excellent way to drum up follow-on business, as well.

It is vital that a consultant maintain confidentiality. Many companies do not want it known that they hire consultants, much less what for. Sometimes a firm is reluctant to hire someone who has worked for a direct competitor. Much more troublesome are companies who want to find out what a consultant's former clients are doing. In the long run, it is in your best interest to tell them nothing, because word of unethical practices will get out eventually.

It can be done

Starting a consulting practice from scratch is difficult, but not impossible. If you are working for a company and thinking of going into consulting, cash savings will make the transition a lot less bumpy. There are some engineers who left companies, worked hard, and put together a consulting business from literally nothing.

Whether consulting becomes a transitional phase or the end point in a career is up to the individual. I have found it rewarding, challenging, and educational. It provides variety, independence, and opportunity to the engineer who seeks these rewards in his career. □

The pros and cons of consulting

Consulting offers a number of advantages to the electrical engineer. But there are also a number of drawbacks to keep in mind.

On the plus side, consulting offers broad exposure to engineering. A consultant is called upon to solve a variety of problems and can usually choose assignments that interest him.

In addition, the consultant works with a wide variety of people in a range of companies. In a month he may see the inside of more companies than the average engineer sees in a lifetime.

The consultant's professional life is relatively autonomous. He can set his own hours; that is, he can work the hours needed to do a job, rather than following a daily routine. Successful consultants take home more income than full-time engineers, set their own vacation schedule, and usually travel more than do most steadily employed engineers. Fees range from $25 an hour for beginners to $50 – $75 an hour for established consultants, with the very best getting $100 an hour. Annual income can run from $30,000 up to $75,000.

The consultant's life is probably riskier than the average engineer's. He must first of all dig up his own jobs, for there is no paycheck waiting for him if he has a bad month. And he has to be much more skilled in business management, law, and contract negotiations.

Fringe benefits, pension plans, and the like must be self-provided. Equipment and literature must be purchased, often money risked to land a contract.

In addition, prospective clients can drag out decisions for weeks or months, keeping a consultant on pins and needles. To justify his higher fees, a consultant must study more, work harder, and produce superior solutions faster than other engineers.

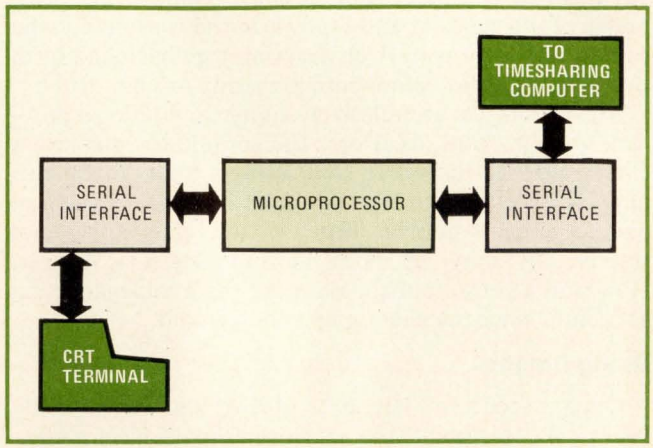
Salaried engineers who feel career insecurity, appreciate their fringe benefits and pensions, and fear technological obsolescence will make unhappy consultants. After all, the consulting engineer has the same economic concerns as everyone else—only more leeway in determining his fate.

Direct microprocessor link loads timeshared programs

by John Denker
APh Technological Consulting, Pasadena, Calif.

The development of optimized software for cross assembling is making timesharing systems more popular than microcomputer-based development stations. Now, by using 100 or 200 bytes of monitor programming on the microprocessor, you can link up directly to a central computer. The implementation of a direct communications link provides a much simpler, more elegant way to download, or transfer files from a timesharing system into a microprocessor memory, than the frequently used slow, noisy process of punching a paper tape and then reading it in. The setup, which requires two serial interfaces, is shown in Fig. 1.

Use of an inexpensive cross assembler such as this permits exploitation of the many attractive features of a timesharing system. A computer center provides cheap mass storage, speedy line printers, and other high-performance peripherals. It is especially attractive to users who do not want to spend the money for a full-blown development system or to limit themselves to a particular processor family.



1. Transparent microprocessor. Normally, all data passes through microprocessor unchanged. When command from the central computer is received, the processor loads a file; upon command from the terminal, control is transferred to downloaded program.

With this cross assembler, the microprocessor is normally transparent to the data—that is, it contains a monitor program that sends all characters from the central computer directly to the cathode-ray-tube screen and conversely, directs all data from the keyboard to the

2. Monitor program. Shown is part of a typical microprocessor program that requires at most a few hundred bytes to provide direct communications between timeshared computer and CRT console. When special character (CTLB) is received from central computer, a file is loaded; when CTLB is received from console, control is transferred to specified address—in this case, to MAID debug monitor.

```
MONITR.

                    213
                    214 * TRANSPARENT
                    215
                    216 * HANDLES COMMUNICATION BETWEEN THE COMPUTER CENTER
                    217 *  AND THE CONSOLE TERMINAL
                    218
                    219 *  THE CONSOLE APPEARS TO BE CONNECTED DIRECTLY TO THE
                    220 *  COMP CENTER.
                    221
                    222 *  A CTLB FROM THE CC CAUSES US TO LOAD A FILE
                    223 *  (RETURNS TO TRANSP AFTER LOADED)
                    224
                    225 *  A CTLB FROM THE KEYBOARD TRANSFERS CONTROL TO MAID
                    226
          =0002     227 CTLB     =        2
          =F0F9     228 MAID     =        $F0F9
                    229
2020 8E FF80        230 TRANSP:  LDS      #STACK          *HERE AFTER RESET
2023 BD 1129        231          JSR      INITIO          *SET DATA DIRECTIONS, ETC
                    232 *
                    233 * MAIN LOOP FOR TRANSP MODE
                    234 * FIRST, CHECK FOR CHARS FROM KEYBOARD
2026 BD 1028        235 UPLINK:  JSR      GETCRT          *RETURNS CHAR IN AC A
2029 24 0A=35       236          BCC      DNLINK          *C=0 MEANS NO CHAR AVAIL
202B 81 02          237          CMPA     #CTLB           *MAGIC CHARACTER?
202D 26 03=32       238          BNE      UPCHAR          *BRANCH IF NOT
202F 7E F0F9        239          JMP      MAID            *AHA! JUMP TO DEBUG MONITOR
                    240
                    241 * HERE IF ORDINARY CHAR
2032 BD 103F        242 UPCHAR:  JSR      PUTLNK          *SEND UP TO COMP CENTER
                    243
                    244 * NOW TO DO THE SAME THINGS FOR THE OTHER DIRECTION
                    245 *  SEE IF ANY CHARS FROM COMP CENTER TO CRT
                    246
2035 BD 1060        247 DNLINK:  JSR      GETLNK          *CHAR, IF ANY, IN AC A
2038 24 FC=26       248          BCC      UPLINK          *IF NONE, GO CHECK OTHER LINK
203A 81 02          249          CMPA     #CTLB           *MAGIC CHAR?
203C 26 05=43       250          BNE      DNCHAR          *NO
203E BD 2137        251          JSR      LOADER          *YES! LOAD FILE FOLLOWS
2041 20 F3=26       252          BRA      UPLINK          *WHEN LOADER FINISHED
                    253
                    254 * HERE IF ORDINARY CHAR TO TERMINAL
2043 BD 1000        255 DNCHAR:  JSR      PUTCRT
2046 20 DE=26       256          BRA      UPLINK          *REPEAT UNTIL COWS COME HOME
                    257
```

timesharing system; therefore the terminal appears to be attached directly to the large computer.

To download the processor, the user instructs the computer to write the object file on his terminal. The data to be loaded is preceded by a control character that is recognized by the monitor program in the microprocessor. The processor then transfers control to a downloader program, which accepts the object file coming down the link. After downloading, the processor returns to its transparent state.

Once the program is loaded in memory, execution is simple. The user types a control character at the terminal, and when the microprocessor receives this character, it jumps to a predetermined address. The address could be a 0, or if the microprocessor system has a debug monitor, such as MAID, Fair-bug, or TIM, the program would be transferred there instead.

This type of link requires no sophisticated circuits or difficult programming. Part of a typical monitor program for the software-controlled link is shown in Fig. 2. In this example, the control character is CTLB, and the transfer is made to the debug monitor, MAID. □

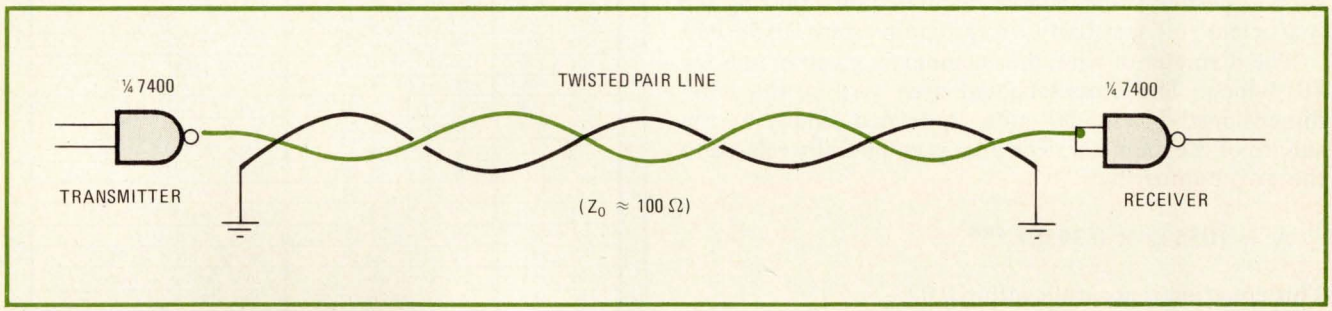
TTL gates drive twisted-pair lines

by William A. Palm
Magnetic Peripherals Inc., Minneapolis, Minn.

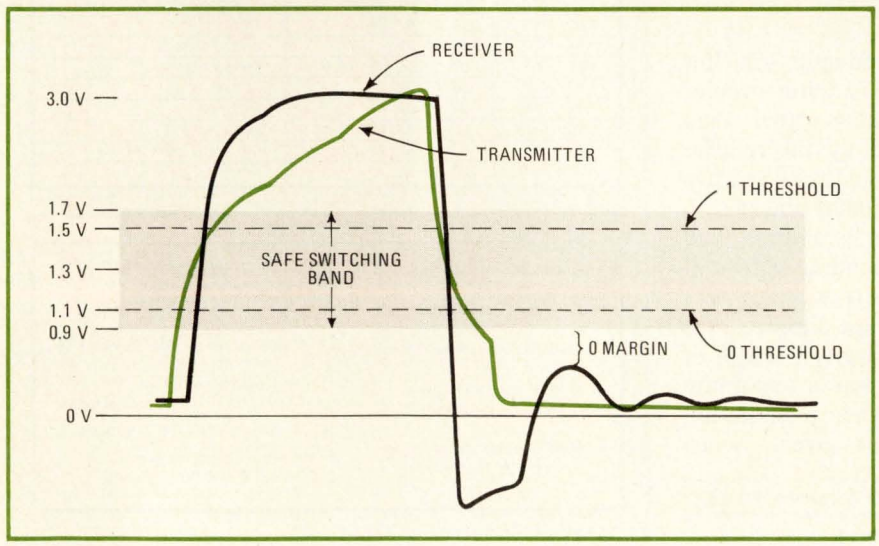
Though line drivers are usually used for sending data over twisted-pair lines, common transistor-transistor-logic gates may be adequate. In fact, TTL gates can drive input/output lines 200 feet long or longer if extremely high reliability is not required and the system can tolerate an occasional noise transient.

Figure 1 shows a twisted-pair transmitter/receiver configuration using two-input NAND gates. It is a good idea to observe the waveforms at either end of the line, to ensure that the switching is fast enough and there is an adequate safety margin between logic levels. Since most TTL families switch at a level of about 1.3 volts, a margin of 0.4 V on either side of this point defines a safe switching band which should be traversed in less than 100 ns.

Typical waveforms at the transmitter and receiver are shown in Fig. 2. If the ringing does not allow a sufficient zero margin, it can be reduced somewhat. Inserting a 100-ohm resistor in series with the signal line at the transmitting-gate output will match the transmitter impedance to the line impedance in the negative region—about 100 ohms for a twisted pair. This resistor also helps to protect the driver from grounding differ-



1. TTL-gate line driver. Two NAND gates can be used as transmitter and receiver for driving a twisted-pair line. Though grounding one of the wires at both ends may seem unnecessary, it is required to give line a characteristic impedance of about 100 ohms.



2. Switching waveforms. Signals at transmitter and receiver ends of line, though distorted, must traverse TTL safe-switching band at high speed. Ringing must leave adequate zero margin. Inflection points of transmitter waveform, caused by changes in drive impedance with amplitude, must occur outside safety band for good reliability.

ences between transmitter and receiver and from transients. On the other hand, the circuit now exhibits an increased pull-high impedance and a decreased safe switching band, since the receiver-gate current through the 100-Ω resistor raises the 0 level about 0.1 v.

A few precautions will aid in designing with TTL-gate drivers and receivers. First, do not use the transmitter to drive any other inputs. Second, make sure there are no ground differences between the chassis at either end of the line, or the gates may be burned out. To protect the receiver, place a diode from the input to the +5-v supply so that it is normally reverse-biased.

If the common-mode voltage caused by chassis potential differences cannot be reduced with ground straps, or if noise or transients are intolerable, it is necessary to use differential line drivers and receivers. □

Calculator notes

SR-52 program calculates AWG wire characteristics

by Fredric N. Fish III
Tempe, Ariz.

Once you have stored this wire-design program in your SR-52 calculator, you can forget about looking through wire-gauge tables. Not only does the program calculate the dimensions for a given American wire-gauge (AWG) number, but it yields the linear resistance and current capability as well.

The program handles any size of wire with AWG numbers from 0 up. All the data needed to design with solid copper wire can be found with the 209-step program shown in the table. For metals other than copper, desired values can be calculated by adjusting the coefficient of resistivity in program steps 055−060.

The diameter of wire, d, is commonly given in mils, or 10^{-3} inch. The cross-sectional area (A) of the wire, dimensioned in circular mils, is defined simply as the square of the diameter. The area is empirically related to the AWG number by:

$$A = 105532 \times 0.79304^{AWG}$$

This equation is accurate within 0.02%.

The resistance of a wire of length l is calculated by:

$$R = \rho l / A$$

where ρ is the resistivity of the conductor—in this program, the value for copper, 10.575 ohm-circular mils/foot, has been entered. For metals other than copper, this figure must be multiplied by the relative resistance. For example, aluminum, which has a relative resistance of 1.64, has a $\rho = 17.34$ Ω-circular mils/ft.

To use the routine, the AWG number is entered, and keying B through D yields the corresponding values of diameter, area, and resistance per 1,000 ft. Keys B′, C′, and A are used to find a maximum gauge allowable for a maximum permissable resistance of a given length of wire. Keys D′, E′ and A′ are used to find a maximum allowable gauge for a given current when a minimum ratio of cross-sectional area to amperage is given. □

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.

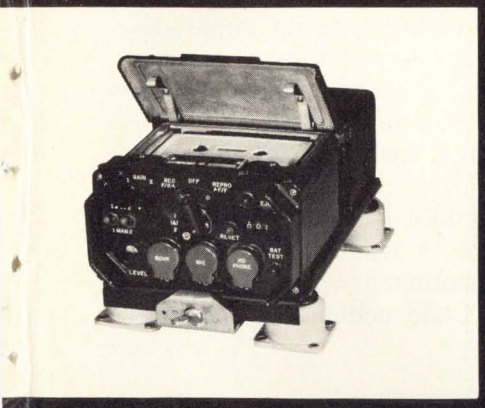
SR-52 WIRE-GAUGE PROGRAM

LOCATIONS	CODES	KEYS
000	56	*rtn
001 − 002	46 11	*LBL A
003 − 005	42 01 09	STO 19
006 − 007	50 00	*st flg 0
008	56	*rtn
009 − 010	46 12	*LBL B
011 − 016	13 30 46 87 52 95	C *√x *LBL *1′ EE =
017 − 021	57 03 52 22 52	*fix 3 EE INV EE
022 − 024	22 57 56	INV *fix *rtn
025 − 030	46 13 22 60 00 88	*LBL C INV *if flg 0 *2′
031 − 036	93 07 09 03 00 04	.79304
037 − 040	42 01 02 45	STO 12 y^x
041 − 044	43 01 09 65	RCL 19 ×
045 − 050	01 00 05 05 03 02	105532
051 − 052	41 87	GTO *1′
053 − 054	46 14	*LBL D
055 − 060	01 00 93 05 07 05	10.575
061 − 066	42 01 04 52 03 55	STO 14 EE 3 ÷
067 − 071	53 13 54 41 87	(C) GTO *1′
072 − 075	46 15 47 86	*LBL E *CMs *rset
076 − 081	46 16 22 60 03 89	*LBL *A′ INV *if flg 3 *3′
082 − 085	22 60 04 89	INV *if flg 4 *3′
086 − 089	43 01 05 65	RCL 15 ×
090 − 095	43 01 06 54 41 77	RCL 16) GTO *4′
096 − 100	46 17 42 01 08	*LBL *B′ STO 18
101 − 105	50 01 22 50 03	*st flg 1 INV *st flg 3
106 − 109	22 50 04 56	INV *st flg 4 *rtn
110 − 114	46 18 42 01 07	*LBL *C′ STO 17
115 − 119	50 02 22 50 03	*st flg 2 INV *st flg 3
120 − 123	22 50 04 56	INV *st flg 4 *rtn
124 − 128	46 19 42 01 06	*LBL *D′ STO 16
129 − 133	50 03 22 50 01	*st flg 3 INV *st flg 1
134 − 137	22 50 02 56	INV *st flg 2 *rtn
138 − 142	46 10 42 01 05	*LBL *E′ STO 15
143 − 147	50 04 22 50 01	*st flg 4 INV *st flg 1
148 − 151	22 50 02 56	INV *st flg 2 *rtn
152 − 157	46 88 00 20 00 56	*LBL *2′ 0 *1/x 0 *rtn
158 − 163	46 89 22 60 01 88	*LBL *3′ INV *if flg 1 *2′
164 − 167	22 60 02 88	INV *if flg 2 *2′
168 − 170	43 01 04	RCL 14
171 − 175	65 43 01 08 55	× RCL 18 ÷
176 − 179	43 01 07 54	RCL 17)
180 − 182	46 77 55	*LBL *4′ ÷
183 − 188	01 00 05 05 03 02	105532
189 − 191	54 28 55	) *log ÷
192 − 194	43 01 02	RCL 12
195 − 200	28 54 75 93 05 54	*log) − .5)
201 − 205	57 00 52 22 52	*fix 0 EE INV EE
206 − 208	22 57 56	INV *fix *rtn

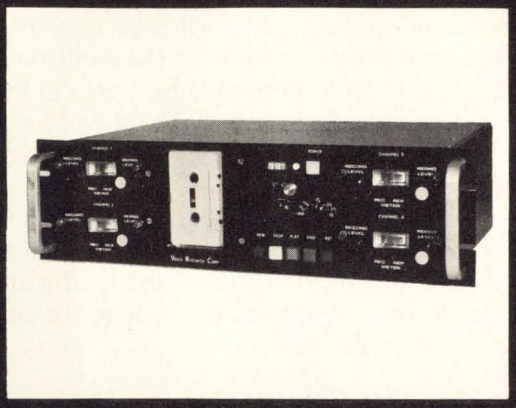
INSTRUCTIONS

1. Initialization: *Press [E]*
2. Enter wire size: *[AWG], [A]*
3. Find diameter: *Press [B] mils*
4. Find cross-sectional area: *Press [C] circular mils*
5. Find linear resistance: *Press [D] Ω/1,000 ft*
6. Enter wire length: *[ℓ], [*B′] ft*
   Enter maximum resistance: *[R], [*C′] Ω*
   Find smallest usable AWG: *Press [*A′]*
7. Enter desired area/current: *[A/I], [*D′] circular mils/ampere*
   Enter current: *[I], [*E′] amperes*
   Find minimum usable gauge: *Press [*A′] AWG number*

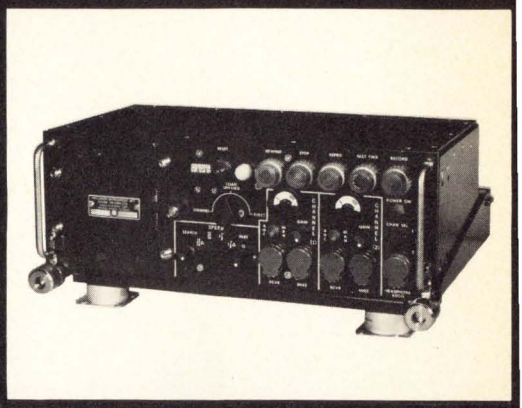
Everyone's going cassettes!



IRBORNE AN/UNH-16A
channel audio recorder/reproducer, Mil Spec
l the way.



LABORATORY Model IDC-IIA
4 channels - 6 speeds, records up to 4 hours per side, direct or FM - Great for voice logging too.



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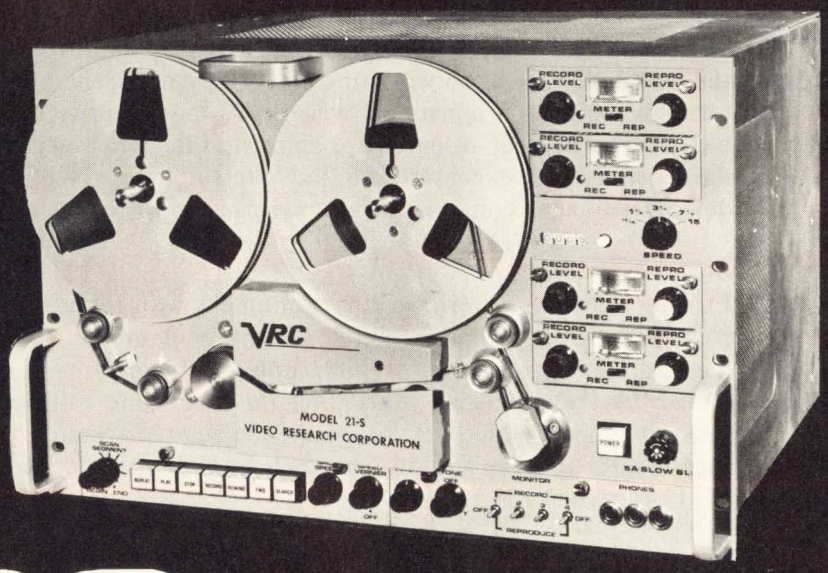

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Circle 113 on reader service card

Engineer's newsletter

Detect false receiver signals with your ears

Here's a simple, but often forgotten, way for you to determine whether the signal to which your communications receiver is tuned is the primary one or a false one, caused by imaging or some other spurious response. First, loosely couple a variable oscillator to the receiver's antenna input, then tune in the suspect signal with the receiver, and switch on its amplitude-modulation detector. Next, set the oscillator frequency close to the receiver frequency, so as to produce a beat note in the speaker. Now slowly wobble the receiver's main tuning dial back and forth through the tuned setting. **If the sound of the beat note changes, the signal is spurious; if it stays the same, the signal is true.**

The method works because a spurious signal does not maintain the same frequency relationship to a local oscillator as a true signal when the receiver is off-tuned slightly. First used with continuous-wave signals, this technique may be applied to any mode of amplitude modulation, as long as you're a good listener.

Synthesizing sine waves from triangles

The next time you must synthesize a sine wave, remember that a clipped triangular waveform can approximate a sine wave with fairly low total harmonic distortion, says Mike Callahan, who's with Mostek Corp., Carrollton, Texas. Sometimes it's easier to go the triangular route, he points out, rather than fuss with tuned LC or RC circuits, especially if you do not really require less than 1% distortion. A pure triangle wave has 11% total harmonic distortion, which can be cut to about 6% by hard-clipping the waveform so that its peaks are truncated. However, soft-clipping it (merely rounding the peaks a bit) **produces an even better approximation, with distortion down to around 3.5%**—which is good enough for many general-purpose testing requirements.

New monolithic converters to partner microprocessors

Designers of data-acquisition systems should keep a sharp eye out for the coming crop of monolithic data converters. Because of advances in linear processing and trimming techniques, as well as improved circuit designs, the next half year or so will bring an entirely new generation of devices—not only 12-bit d-a converters with 0.01% nonlinearity, but also **system-like microprocessor-oriented a-d chips that include everything needed for data acquisition except the digital control logic.** Needless to say, the devices will mean considerable cost savings and easier design development.

Learn how to design marketability into a product

Probably the most overlooked part of an engineer's education is the major role that marketing plays in the success of a product—its performance alone doesn't ensure profitability. But **a new softbound 127-page book called "A Handbook on Marketing for Electronic Engineers"** may help you get your product designs off on the right marketing track and keep them there. It costs $25.50 from Schoonmaker Associates, P.O. Drawer M, Coram, N.Y. 11727.

From mils to millimeters and vice versa

Besides tabulating conversion factors, the latest revision of "Metric Units of Measure and Style Guide" **provides style and abbreviation guidelines.** The 16-page paperback costs $1, dropping to 35¢ for 100 or more. Order from the U. S. Metric Association, Sugarloaf Star Route, Boulder, Colo. 80302.

Lucinda Mattera

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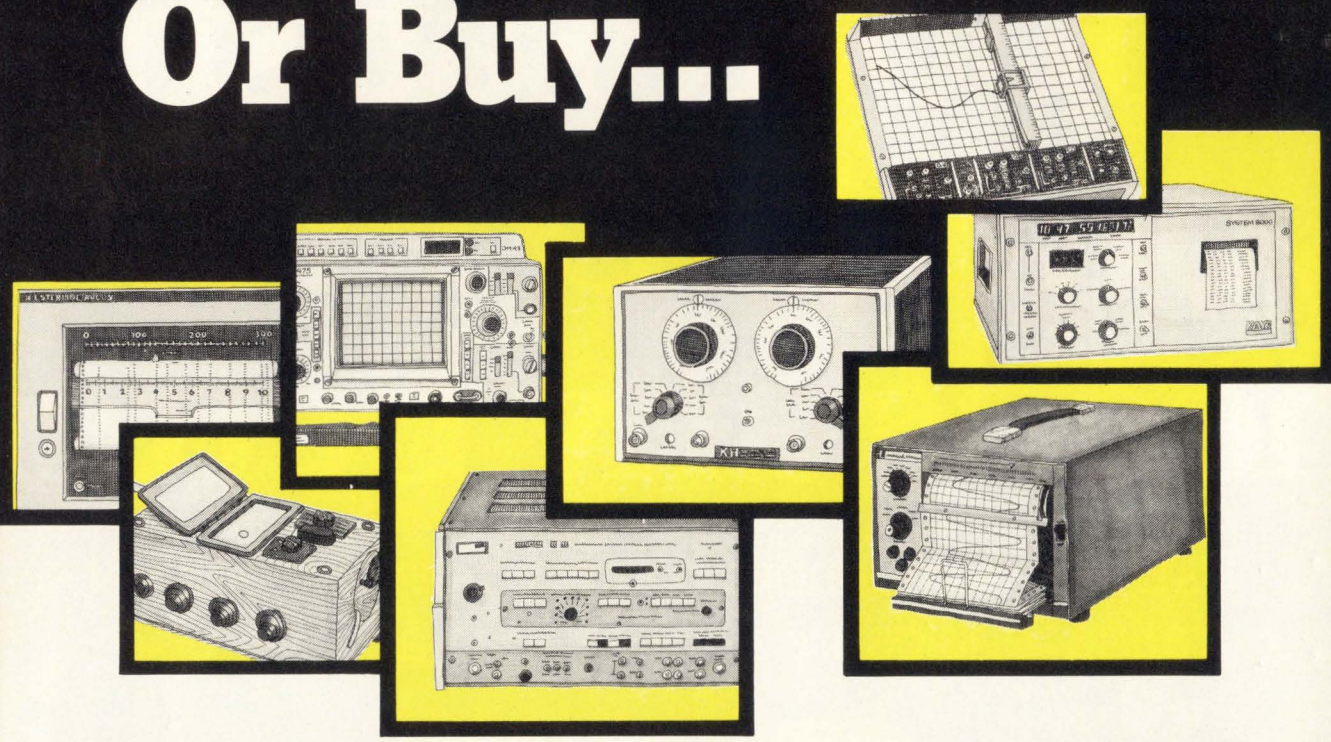

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Philips adds three 4½-digit DMMs

Company extends digital multimeter family with accurate fast-autoranging units that can measure temperature

by John Gosch, Frankfurt bureau manager

The engineer looking for versatility in a multimeter can find it in just about all price ranges. But if he wants fast autoranging and high resolution with commensurate high accuracy, the numbers on the price tag really climb. A trio of digital multimeters from Philips in the Netherlands, though, aim to keep the price premium reasonable. The 4½-digit DMMs are being added to the already available PM2527 [*Electronics*, Oct. 16, 1975, p. 137] to round out the family.

The Philips 4½-digit DMM series now extends from the general-purpose portable PM2522A at the low end to the top-of-the-line multifunction meter PM2527 with its double-guarding system and general-purpose interface bus. In between are the PM2524 and PM2526, both with a 1-second autoranging circuit. Prices for the instruments will be roughly $500, $800, and $1,300 for the 2522A, 2524, and 2526 models, respectively.

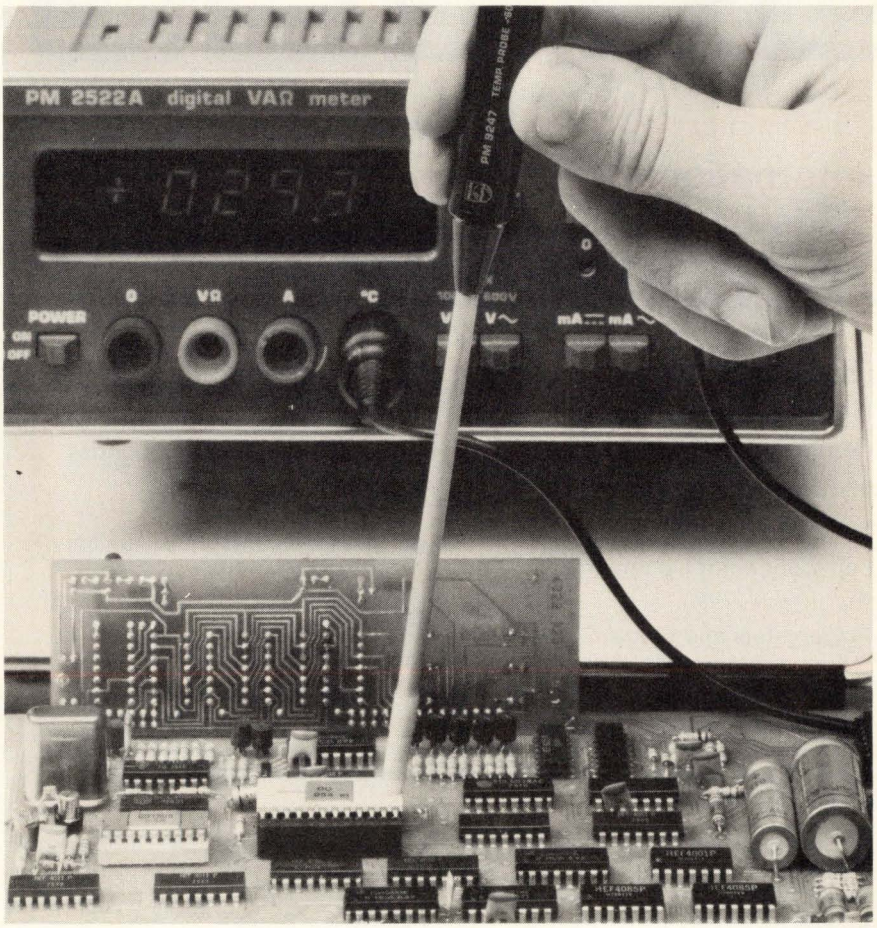
Besides autoranging and standard-bus interfacing, a number of other features demonstrate the versatility of the Philips DMM family. All models measure temperature and perform tests to international standards. Moreover, all have a hold facility that allows the last reading to be held for short-term reference.

Resolution. "Our new multimeters are real 4½-digit instruments," says Henk Onstee, a product manager in the Philips Industrial Equipment division in Eindhoven. He emphasizes "real" because it means that, in contrast to many other instruments, the circuitry is designed to exploit the additional resolution that comes with the last digit under all specified environmental conditions.

The four instruments measure temperatures within 0.1°C accuracy over a range from −60° to +200°C. With optionally supplied probes, it is possible to pick up 99% of the final temperature value in about 10 seconds, which is roughly one-tenth the time it takes currently available probes, Philips says.

A big improvement, Onstee points out, has been achieved in autoranging speed. An intelligent autoranging circuit in all models except the 2522A cuts the ranging time from the 300 milliseconds common for most instruments to only 80 ms. Within that time, the circuit detects whether or not the correct range is reached. If not, it switches up or down the next ranges in sequence. When the correct range is found, the circuit switches to the full 300-ms measuring cycle to provide a stable reading. Autoranging over all seven ranges would take 560 ms, which with settling time gives a 1-s total.

True rms. Of note also is the true-



New products

root-mean-square measuring capability of the new 2526 and older 2527 models. In true-rms measurements, a special Philips-designed integrated circuit [*Electronics*, Oct. 16, 1975, p. 94] is used to compare the heat generated by the applied ac signal with the heat produced by a dc reference voltage, both signals working into equal resistances. The dc reference voltage is controlled to produce the same amount of heat as the applied ac signal. Measuring the dc voltage then yields the ac voltage value.

This process, which causes practically no delay, allows high-precision measurements to be made of any ac signal, regardless of waveform or amount of distortion.

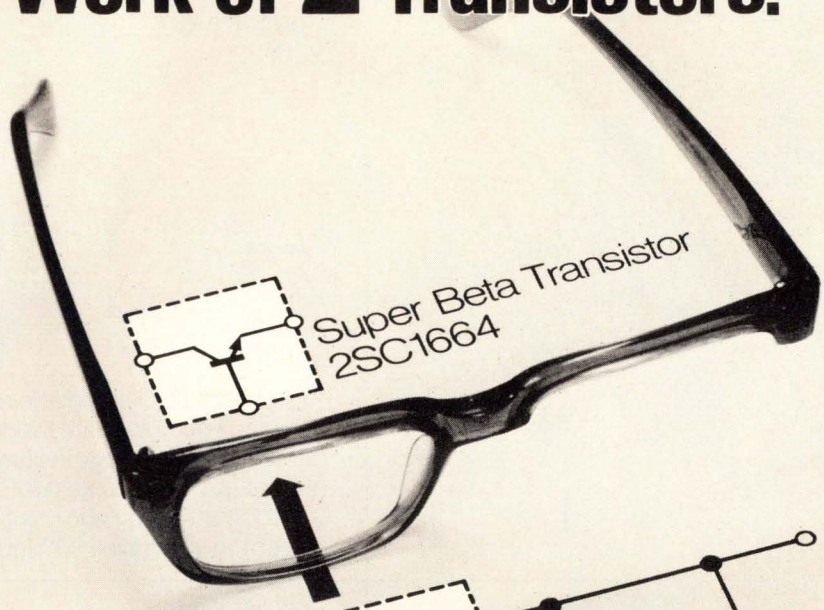
The PM2522A, the most economical model in the range, has a rechargeable-battery option. Its accuracy checks in at ±0.03% of reading plus 0.01% of range. The resolution is 100 microvolts. Like the other instruments in the family, the 2522A has an 11-millimeter-high light-emitting-diode display with polarity, decimal point, and overrange indication.

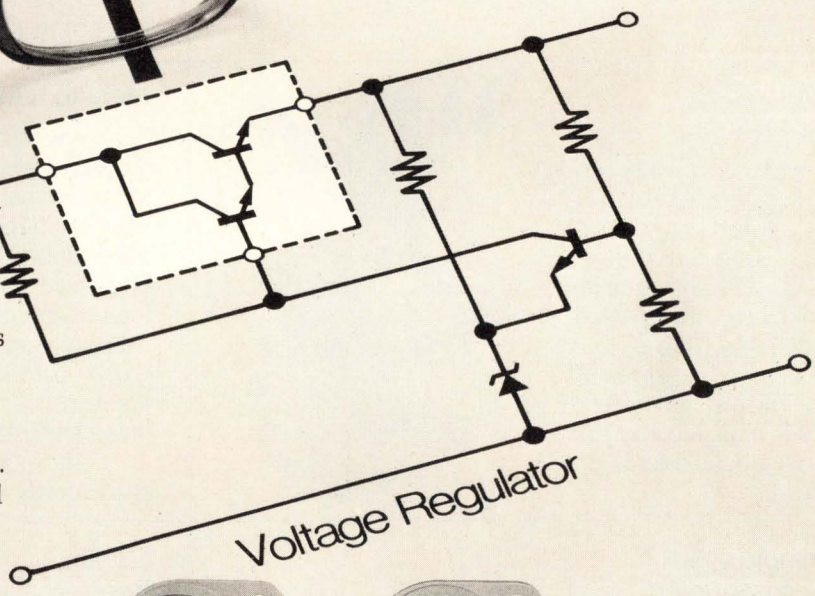
Higher accuracy. The next new member of the family, the PM2524, is built for portable or bench use and measures the same parameters as the 2522A—ac or dc voltage and current, resistance, and temperature—with a higher accuracy and resolution. On dc voltages, the accuracy is ±0.02% or reading plus 0.005% of range. Resolution is rated at 10 microvolts. The same accuracy and resolution ratings apply to the 2526 and 2527 models.

The last of the new additions, the PM2526, measures dc voltages, true-rms ac or true-rms ac plus dc voltages up to 100 kilohertz, and resistance from 10 milliohms to 20 megohms, thus making the instrument suitable for demanding tasks in research and development work. A radio-frequency signal-measuring facility is offered as an option. Like the 2527 model, the instrument has standard-bus interface or parallel BCD output for systems use.

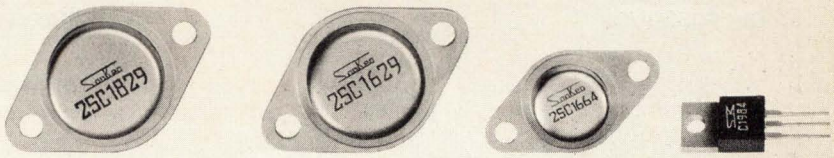
Philips Test and Measuring Instruments Inc.
85 McKee Dr., Mahwah, N.J. 07430 [338]

See How 1 Sanken Super Beta Transistor Does the Work of 2 Transistors.





Sanken's unique surface treatment gives these super beta power transistors the world's highest single transistor (non-Darlington) current gain. With **400 to 2500 current gain,** 1 does the work of 2. The result is lower production costs and simplified assembly in a wide range of power supply/consumer/industrial applications. Sanken super beta transistors possess excellent secondary breakdown characteristics and large current handling capabilities which are the outstanding features of Sanken power transistors. They are extensively used in color TV regulated power supply circuits and are well reputed for their advantages.
About 30% of Japanese color TV's currently employ these super beta transistors and this percentage will surely increase. Compared to Darlingtons, collector saturation voltage VCE (sat) is 0.6 to 0.7V lower and internal power loss is minimal.
Write for complete details.



NPN Type Number	V_{CBO} (V)	V_{CEO} (V)	I_C (A)	P_C (W)	Tstg (°C)	$V_{CE(sat)}$ (V) MAX.	@ I_C (A)	@ I_B (A)	f_T (MHz) TYP.	@ I_E (A)	@ V_{CE} (V)
2SC1829	200	150	5	100	−65~+150	2.0	1.5	0.05	15	−0.1	12
2SC1831	90	70	8	100	−65~+150	1.0	3	0.03	10	−0.5	12
2SC1629	90	70	6	50	−65~+150	1.0	3	0.06	10	−0.5	12
2SC1768	200	150	5	50	−65~+150	2.0	1.5	0.05	15	−0.1	12
2SC1664	70	60	6	40	−65~+150	1.0	3	0.06	10	−0.5	10
2SC1664A	100	80	6	40	−65~+150	1.0	3	0.06	10	−0.5	10
2SC1888	80	60	3	0.8	−65~+150	1.0	0.5	0.005	15	−0.1	5
2SC1889	100	80	3	0.8	−65~+150	1.0	0.5	0.005	15	−0.1	5
2SC1983	80	60	3	30	−55~+150	1.0	2	0.05	15	−0.2	12
2SC1984	100	80	3	30	−55~+150	1.0	2	0.05	15	−0.2	12
2SC2198	100	50	6	40	−65~+150	1.0	5	0.1	17	−0.5	10

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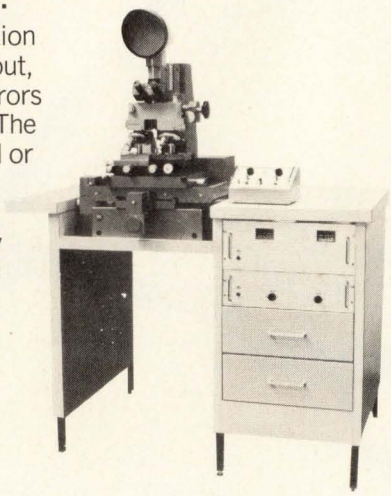
Circle 119 on reader service card

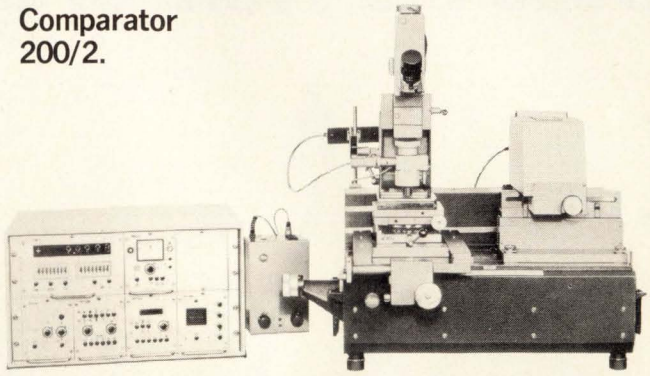
Six of the ways Leitz® puts optics to work in electronics production and quality control.

Overlay mask comparator.

For the inspection of mask sets for runout, rotation, stepping errors or missing patterns. The stage drive is manual or motorized. This instrument has a measuring capability with resolution of 10 micro-inches.



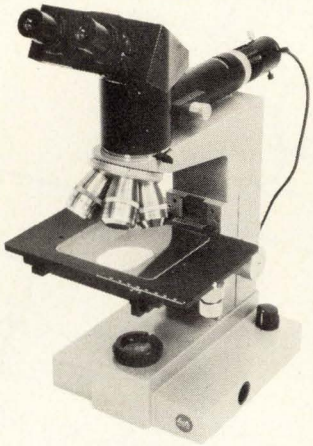
Comparator 200/2.



Linear, semi-automatic measuring machine for inspection of overall dimensions, stepping accuracy and run-out of photomasks. Features high through-put with readout resolution to .000005"; photoelectric edge detection and automatic compensation; 8" measuring range, 4" y-axis travel, 90° indexing.

SM-PQC microscope.

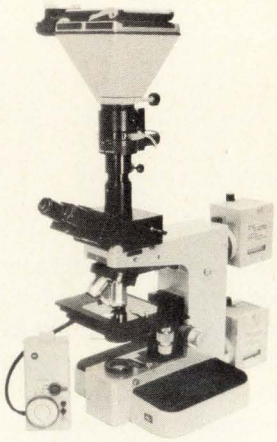
This is an inspection and quality control microscope with brightfield, darkfield, interference contrast illumination in reflected or transmitted light. It has a large scanning stage, up to 3¼" x 4". The instrument is "human-engineered" to avoid fatigue after hours of use.



Metalloplan.

A versatile microscope for R&D applications as well as failure analysis. The instrument can be equipped for observation in brightfield, brightfield/darkfield, interference contrast, photometric measurements, photomicrography, hardness testing, fluorescence and quantitative image analysis.

The Metalloplan offers an extremely wide field of view.



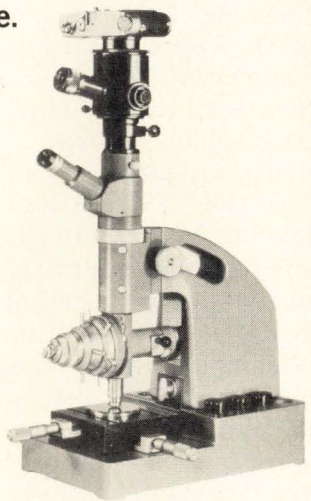
Ortholux TV microscope.

For the inspection of critical dimensions and micro-inch measurements, this microscope features illumination for transmitted or reflected light.

Digital readout from electronic micrometer takes advantage of full optical magnification on the monitor before measurement. Range of magnification to 5000x.

Linnick interference microscope.

Here is a measuring microscope for determining thickness of thinfilm depositions, oxide layers, diffusion depth by double beam interference. It shows surface irregularities and can also be used as an ordinary metallurgical microscope. The range of magnification is from 50x-1000x.



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Microprocessors

One-board unit has memory, I/O

Second in line of fully packaged computers has programmable interrupts

Looking more and more like a traditional computer house, Intel Corp. has begun production of its second completely packaged microcomputer, the System 80/20. This second-generation product is tailored specifically for distributed computing and multiprocessor control applications. What's more, in a major enlargement of its line of memory and I/O-expansion boards, the company is making five new members, aimed at significantly enhancing its single-board and completely packaged microcomputer systems (see following story).

Based on the SBC 80/20 single-board computer, the System 80/20 contains all the memory and I/O hardware required for such applications in industrial process control, test and instrumentation systems, communications systems, on-line data processing, word processing, smart terminals, and customized peripherals.

Two key features—its programmable interrupt control and its flexible I/O structure—make the computer ideal for distributed computing and multiprocessor control applications, says Wayne Gertin, product-marketing manager.

Programmable interrupt control is important in such applications as real-time control, where high-priority programs are frequently based on external events, elapsed time, or time of day without affecting any background processing like data reduction. This capability is implemented in the System 80/20 by an eight-level programmable interrupt controller and two internal timer/event counters.

The I/O flexibility necessary to handle binary input information, such as switch closures or encoded keyboards, is provided by 48 lines of programmable parallel I/O. The system software is used to configure the I/O structure of each port, and the I/O lines are routed in groups of four to sockets that allow interchangeable terminators to be installed. Gertin says the software, which can be developed for specific OEM applications, may be stored either in nonvolatile read-only or random-access memory.

The System 80/20 is aimed primarily at OEMs, system-software suppliers, users who want to do their own programming, and other low- to moderate-volume users. It is available from stock at $1,795, but in OEM quantities, the price drops below $1,200.

Heart of the system is the SBC 80/20, which contains the 8080A central processor, system clock, 2 kilobytes of read/write data memory in static RAMs, up to 4 kilobytes of erasable reprogrammable or masked read-only memory, programmable I/O ports, programmable serial data-communications interface, multimaster bus-arbitration logic, and bus-expansion drivers.

The 48 parallel I/O lines are provided via two 8255 programmable peripheral interfaces organized as six 8-bit ports. The programmable communications interface is provided via the 8251, a universal synchronous/asynchronous receiver/transmitter with programmable data and control formats, parity, and other software-selectable features. The 80/20 provides three fully programmable and independent BCD and binary 16-bit interval timers/event counters utilizing an 8253 programmable interval timer. An 8259 programmable interrupt controller handles interrupt vectoring control for as many as eight levels.

The microcomputer is packaged in a 3½-inch-high housing compatible with standard 19-inch rack mounting and, in addition to the SBC 80/20, contains a card cage and back-plane assembly for up to three additional boards, power supply, cooling fans, ac power-line connector, on-off controls, and convenient cabling access.

Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051 [361]

Five boards enhance expansion-board line

Expanding its board family, Intel is introducing five boards that interface directly with any SBC 80 single-board computer or any System 80 packaged microcomputer via the system bus. Three boards, the SBC 104/108/116 series, are combination memory and I/O expansion boards containing 4, 8, and 16 kilobytes of RAM, respectively. The fourth, the SBC 517, is a combination I/O-expansion board containing 48 programmable I/O lines, with addressing and connectors directly compatible with the SBC 104/108/116 series. The last new board, the SBC 519, provides 72 programmable lines, which can be expanded via direct bus interface. Single unit prices are $775 for the 104, $975 for the 108, $1,375 for the 116, $425 for the 517, and $395 for the 519.

On 104/108/116 boards, the memory is implemented with Intel's dynamic random-access-memory components. On-board refresh hardware refreshes a portion of all eight RAM memory elements every 14 microseconds. If a read or write cycle is already in progress when a refresh cycle is scheduled to begin, the refresh cycle is postponed until the end of the cycle. Each refresh cycle uses memory for 590 nanoseconds. Typical RAM access time is 485 ns. Typical read/write cycle time is 560 ns. Sockets for up to 4 kilobytes of nonvolatile read-only memory reside on the boards.

Both the 104/108/116 series and the 517 I/O board contain 48 programmable I/O lines implemented with two Intel 8255 programmable peripheral interfaces. In each case, the system software is used to configure the lines to meet a wide variety of system peripheral requirements.

New products

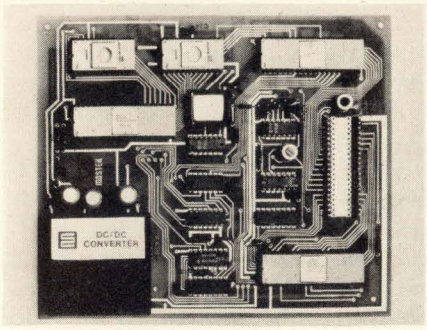
A programmable RS-232-C communications interface is provided on each board by an Intel 8251 universal synchronous/asynchronous receiver/transmitter to allow virtually any serial data transmission technique. Each board also contains a jumper-selectable 1-millisecond interval and interface logic for eight interrupt-request lines.

However, to provide 72 programmable I/O lines for the 519, three 8255 devices with typical read-access times of 300 ns and typical read/write cycle times of 450 ns are used. Also provided is an interval timer, which may be used to generate real-time clocking in systems requiring the periodic monitoring of I/O functions.

Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051 [362]

Emulator board developed for 3870 one-chip computer

The EMU-70 emulator board is electrically equivalent to the MK 3870 single-chip microcomputer except that is field-programmable rather than mask-programmable. Thus it allows the user to verify his design before committing it to hardware. The EMU-70, which sells for $200 not counting 2,048 bytes of programmable read-only memory, is expected to find use as a low-volume logic replacement as well as an



emulator for the F8-compatible MK 3870. It provides 64 bytes of scratchpad random-access memory, four 8-bit TTL-compatible latched I/O ports, a software-programmable timer, and vectored interrupts. It

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Mostek Corp., 1215 W. Crosby Rd., Carrollton, Texas 75006. Phone (214) 242-0444 [363]

National adds circuits to 8080A microprocessor line

National Semiconductor is adding five interface and support circuits plus two high-performance versions of the basic microprocessor chip to its 8080A microprocessor family. The new interface devices include three built using Schottky bipolar technology. These are the DP8212 8-bit input-output port, the DP8224 clock generator and driver, and the DP8228 system controller and bus driver. The other two interface circuits are the DP8301 microprocessor interface latch element, which is fabricated by a silicon-gate C-MOS process, and a low-power Schottky 8-bit bidirectional bus transceiver—the DP8304.

The new high-performance CPUs are the 8080A-1, which has a 1.3-microsecond cycle time, and the 8080A-2, which is rated at 1.5 μs. The original 8080A is specified at 2 μs.
National Semiconductor Corp., 2900 Semiconductor Drive, Santa Clara, Calif. 95051. Phone Chuck Troiani at (408) 737-5873 [364]

Video RAM can be externally synchronized

Like its predecessors, the MTX-1632SL video random-access memory supplies a character-generating interface between a microprocessor and a TV monitor. What makes the new device different is its ability to accept external horizontal and vertical sync pulses. This allows it to be used in applications where video mixing is required—adding text to the output of a television camera, for example.

On the input side the device connects directly to bus-organized

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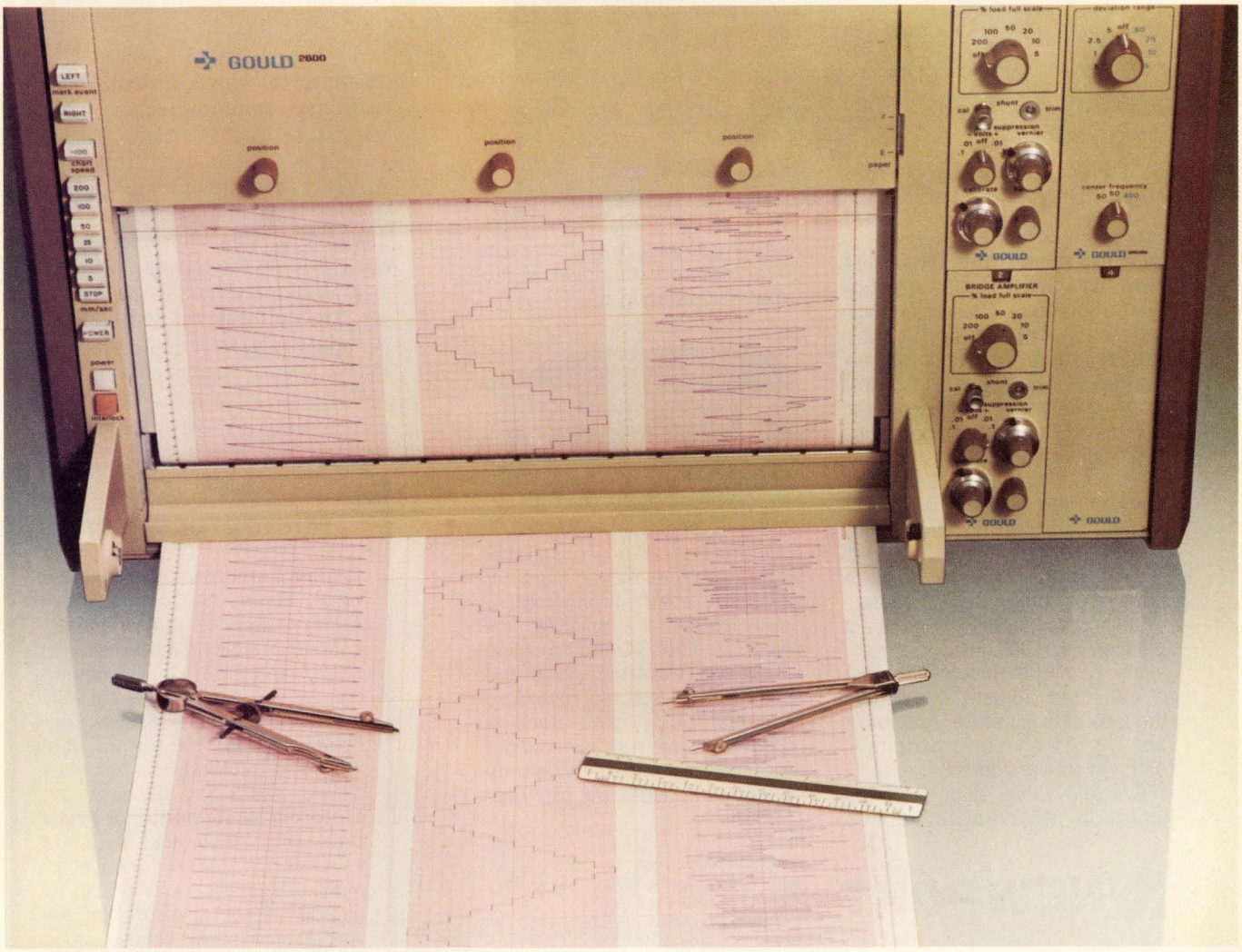

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Circle 125 on reader service card 125

New products

systems to which it looks like an ordinary random-access memory consisting of 512 8-bit words. Its output is a video signal that directly drives a TV monitor to provide a display consisting of 16 lines of 32 characters. The characters, formed on a 5-by-7-dot matrix, include the 128 alphanumerics of the full ASCII set. The unit sells for $225 in singles, dropping to $169 in hundreds.

Matrox Electronic Systems, P.O. Box 56, Ahuntsic Station, Montreal, Que. H3L 3N5 Canada. Phone (514) 481-6838 [365]

TOPICS

Microprocessors

Digital Equipment Corp., Maynard, Mass., has announced a series of input/output and applications-interfacing modules for its LSI-11 and PDP-11/03 computers. Among the modules are units for direct memory access, optically isolated I/O, bus interfacing, and high-density user-designed interfacing circuitry. . . . **Motorola Semiconductor Products Inc., Phoenix, Ariz.,** is increasing its support of development of systems built around its M6800 microprocessor with the introduction of two chassis, two card cages, and a power supply for its Micromodule products. . . . **Tychon Inc., Blacksburg, Va.,** is selling a slide-rule-like device to aid in the development and debugging of 8080 software. The octal code card is priced at $2.95. . . . **Johnson Computer Co., Medina, Ohio,** has developed a resident assembler for the MOS Technology MCS 6502. The assembler, which is now available for the KIM-1 microcomputer, occupies about 4.5 kilobytes of memory.

AUGAT ANNOUNCES THE PC BREAKTHRU OF THE DECADE

The card you're looking at is an ordinary printed wiring board with an extraordinary difference. There's not a solder joint anywhere. Every component is plugged into place.

It's this simple: Augat has invented a way to turn plated-through holes into plug-in sockets.

Think what that means: all the benefits of component

plugability with no need for sockets or the headaches of soldering. You get socketed components with card spacing as low as .400"!

And the cost? Less than the total soldered cost of typical inexpensive sockets.

Intriguing, yes? So is the way it works. At the heart of our new method, (which we call the Augat Holtite™ system), is a special adaptation of the long-proven, beryllium copper precision contact that we've turned out by the billions over the past decade for reliable component lead interconnections.

You simply insert the contacts into your plated-through holes, press them into place...

and just like that you've got a component "socket" built right into your board. It's that simple.

Another thing you'll like: switching to our new Holtite system is totally painless. You continue to use the same artwork, drill tapes and process specs. Simply drill the holes to the recommended diameter.

As to mass loading the contacts into your boards, that's easy too. We lease you a machine that does it automatically at a rate of 30,000 con-

tacts an hour, which includes pressing them into place using a standard hydraulic press.

We're confident our Holtite system is going to revolutionize PC component socketing, and we invite you to be a part of it.

To get started, order one of our Holtite prototyping kits (for $94.50) from your Augat distributor, or from us. It has everything you need (1,200 contacts, tools, instructions and test report) to try out our idea firsthand on your own boards. Give it a whirl—this week!

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Augat Inc., 33 Perry Avenue, P.O. Box 779, Attleboro, Mass. 02703. Tel. (617) 222-2202.

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Augat interconnection products, Isotronic microcircuit packaging, and Alco subminiature switches.

Circle 127 on reader service card

New products

Semiconductors

FIFO works two ways

First-in, first-out memory can handle both serial and parallel data streams

Applying its Isoplanar integrated-injection-logic technology to the problem of data storage in high-speed communications systems, Fairchild Camera and Instrument Corp. has developed a 64-by-4-bit first-in, first-out memory.

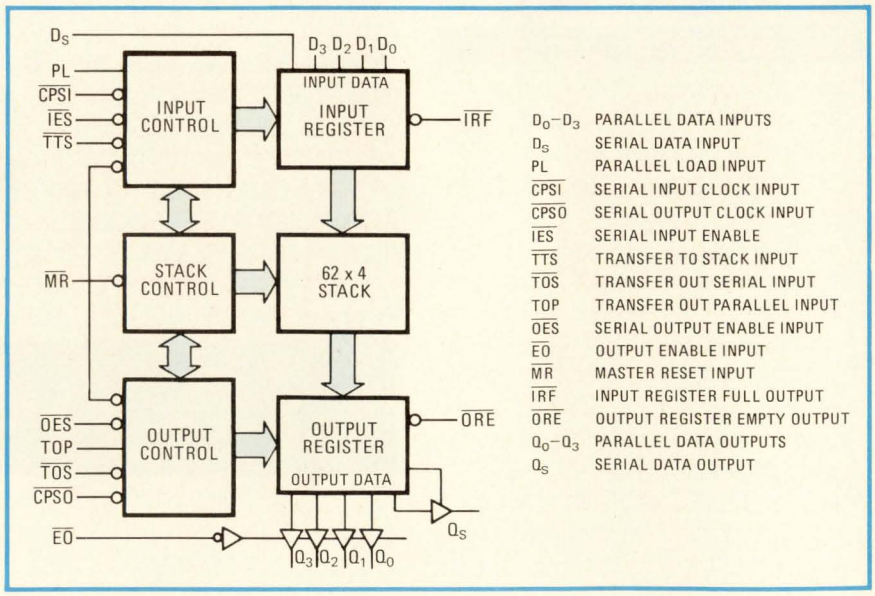
Unlike devices that can handle either parallel or serial data but not both, the 118-by-120-mil 9423 FIFO can handle both and handle them at the same time. Instead of just one input pin that can pass parallel or serial data, the 9423 takes advantage of the added density it gains from I^3L to dedicate separate pins to each function, with each having its specialized logic.

The I^3L FIFO contains an input register with parallel and serial inputs, as well as control inputs and outputs for input handshaking and expansion; a 4-bit-wide, 62-word-deep fall-through stack with self-contained control logic; an output register with parallel and serial data outputs, and control inputs and outputs for output handshaking and expansion.

According to Kris Rallapalli, advanced products manager, the 9423 also can be vertically expanded to store more words or horizontally expanded to store longer words without external logic. What's more, he says, the expansion scheme fully preserves the parallel/serial data features.

Another novel feature is an automatic priority scheme. Most conventional FIFO designs provide status signs analogous to "input-register-full" or "output-register-empty" signals. However, when these are operated in arrays, unit-to-unit delay variations require additional external gating to avoid transient false-status indications. This condition is referred to as composite status-signal generation, Rallapalli says. The design of the 9423, however, eliminates this problem. An automatic priority feature has been built in to assure that slow signals will automatically predominate, regardless of location in the array.

The I^3L FIFO is designed primarily for data-communications applications as a local buffer, an elastic store, or a sector buffer, as well as for high-speed disk or tape controllers. The 9423 has a 10-mega-



THE ONLY LOGIC TESTER DESIGNED FOR MICROPROCESSOR BOARDS.

A fresh start for logic board testing.

Microprocessors are here.

If you are like most electronic manufacturers, you're either using μP's or you plan on using them soon. But how do you test your boards so you can ship a dependable microprocessor-based product?

With the new Fluke Trendar 3040A.

For a fraction of the cost, it does what other systems can't do. It fully tests microprocessor boards with either user-defined bit-by-bit test patterns or automatically-generated patterns, interchangeably, via simple push-button commands. A unique new interface allows the necessary handshaking between μP board and tester. Any type of advanced digital logic board can be tested at system operating speeds. Diagnosis can be made by an operator using the guided clip/probe option.

And it not only performs higher confidence tests, it cuts your costs. It eliminates the programming delays and complexities of minicomputers and their peripherals. Editing is on-line. The effect of a program change on circuit behavior is instantly displayed. Programs are done in a fraction of the time.

All this at a price you can afford.

For data out today, dial (415) 965-0350. Fluke Trendar, a subsidiary of John Fluke Mfg. Co., Inc., 630 Clyde Avenue, Mountain View, CA 94043.

Fluke (Nederland) B.V., P.O. Box 5053, Tilburg, The Netherlands. Phone: (013) 673-973. Telex: 52237.

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Circle 129 on reader service card

hertz serial or parallel data rate and three-state outputs. Packaged in a 24-pin configuration, it is powered by a single +5-volt supply. Sample quantities will be available in July.

Fairchild Camera and Instrument Corp., 464 Ellis Street, Mountain View, Calif. 94042 [410]

Monolithic 12-bit d-a converter is fast and highly linear

Monolithic data converters are now routinely servicing 8- and 10-bit applications, but hybrids and modules still dominate those jobs involving 12 bits or more of resolution. However, a number of semiconductor manufacturers, among them some of the major houses, are about to crack that 12-bit barrier. In fact, samples of the first truly monolithic 12-bit digital-to-analog converter are already being supplied by Precision Monolithics Inc.

Dubbed the DAC-12, the device is a bipolar chip that offers the same pinout as Analog Devices' AD562, a popular 12-bit two-chip design. Besides holding linearity error to within ± 0.25 least significant bit, the DAC-12 is fast, with an output settling time of only 300 nanoseconds to 0.01% of final value.

Unlike other converter devices, the DAC-12 is trimmed after it has been packaged and tested. The firm uses a zener-zap technique, in which on-chip zener diodes are selectively short-circuited to produce discrete correctional currents. Right on the chip, the company builds a current programming network, which occupies about 40% of the area. After trimming is complete, this network is locked out to prevent further zener shorting. The programming network also permits the manufacturer to change the bit currents from binary to binary-coded-decimal weighting.

The DAC-12 operates over a power-supply range of +4.5 to +18 v and −10 to −18 v, with a power consumption of 150 milliwatts at +5 and −15 v. It is housed in a 24-pin ceramic dual in-line package and operates in conjunction with an

THE BEST VOLTMETER YOU CAN BUY ISN'T A VOLTMETER.

The Fluke 8500A is an advanced measurement system, but most people buy it because it's the finest high speed 10 ppm voltmeter built.

So why make a distinction?

Simply because all other digital voltmeters have been nothing more than that, voltmeters. As quickly as technology advanced or needs changed, the unit became obsolete. Not so with the 8500A.

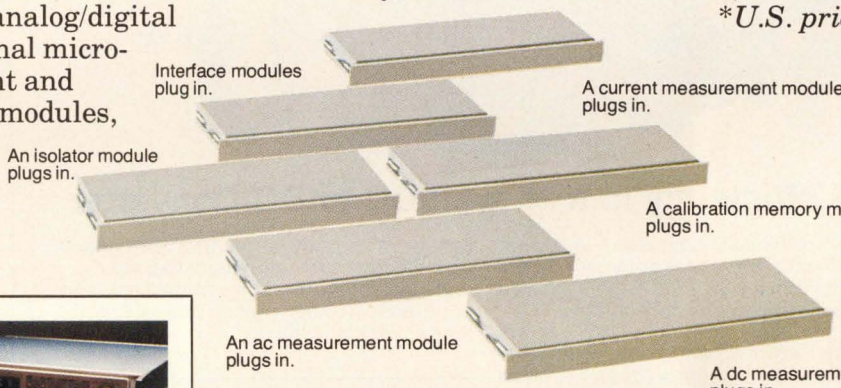
The 8500A employs a unique analog/digital bus in conjunction with an internal microprocessor to control measurement and interface modules. The function modules, such as resistance, current, IEEE-488 interface, etc., can be plugged into any available slot in the bus by the user. The controller then senses the module and measures the new parameter or performs the new function.

So as technology or your needs change, so does the 8500A. You won't be stuck with a dead-ended instrument.

All for a basic system price of $2,695*.

Obviously, there's a lot more to tell. For data out today, dial our toll-free hotline, 800-426-0361.

**U.S. price only.*



The world's finest dc measuring system.

The world's finest dc and ac measuring system.

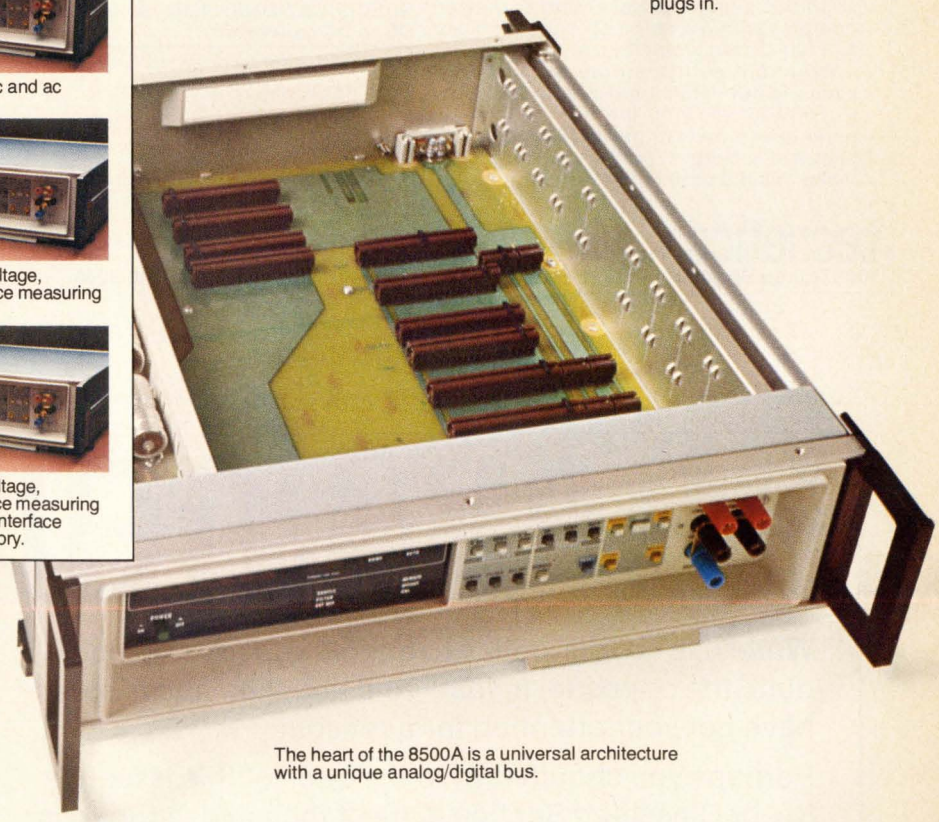
The world's finest voltage and current measuring system.

The world's finest voltage, current and resistance measuring system.

The world's finest voltage, current and resistance measuring system with remote interface.

The world's finest voltage, current and resistance measuring system with remote interface and calibration memory.

The 8500A can be whatever you want it to be, so it's never obsolete.



The heart of the 8500A is a universal architecture with a unique analog/digital bus.

John Fluke Mfg. Co., Inc., P.O. Box 43210, Mountlake Terrace, WA 98043
Fluke (Nederland) B.V., P.O. Box 5053, Tilburg, The Netherlands. Phone: (013) 673-973 Telex: 52237

FLUKE®

For demonstration circle 131 on reader service card

For literature circle 208 on reader service card

external voltage reference.

The firm plans to have the DAC-12 in full production by the summer. Price is in the $20 range.

Precision Monolithics Inc., 1500 Space Park Drive, Santa Clara, Calif. 95050. Phone 408-246-9222 [412]

Schottky diodes have low forward voltage drop

Besides offering extremely fast switching speeds, Schottky diodes hold power losses to a minimum because their forward voltage drop is about half that of junction devices. But a new pair of ion-implanted diodes from Solid State Devices may well be challenging Schottky devices for applications in switching power supplies at frequencies of up to 100 kilohertz. Made with the firm's proprietary Epion ion-implantation process, the 1N6097E and 1N6098E provide a maximum forward drop of 0.86 v and a reverse recovery time of 75 ns maximum, 50 ns typical.

Either device can handle an average half-wave rectified forward current of 50 amperes. Dc blocking voltage is 30 v for the 1N6097E, 40 v for the 1N6098E. They have an operating temperature range of −65°C to +175°C and a thermal resistance of 0.8°C/watt, with no temperature derating up to 125°C, says the company. At rated voltage, reverse leakage current is 100 microamperes at 25°C and 2 milliamperes at 125°C.

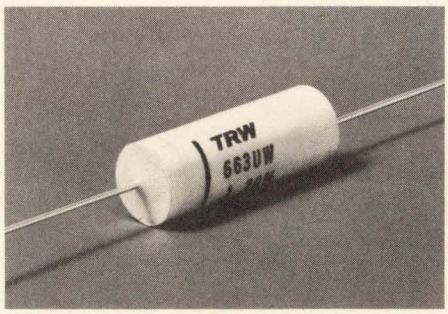
In 100-unit quantities, the 1N6097E is priced at $11.25 each, the 1N6098E at $3.50 each. Delivery is from stock to within four weeks.

Solid State Devices Inc., 14830 Valley View Ave., La Mirada, Calif. 90638. Phone 213-921-9660 [411]

Timer counts hours, minutes, or seconds

Designed for industrial applications that range from keeping track of time charges on telephone calls to

Check the specs on this one



...when you need a subminiature capacitor offering "instrument" quality

With its skin-tight plastic case, TRW's Type 663UW Mylar* dielectric capacitors offer you major space savings with *no* compromise on life or reliability.

Use these TRW 663UW capacitors for high-density circuitry in computers, instruments, MIL applications. *Conservatively* rated to assure trouble-free performance in your equipment.

Complete specs on 663UW capacitors—along with a look at TRW's overall Mylar/foil capability—available on request. Write TRW Capacitors, an Electronic Components Division of TRW, Inc., Box 1000, Ogallala, Neb. 69153. (308) 284-3611.

DF: less than 1.0% at 1000 ±20 Hz

IR: greater than 70,000 megohm-microfarads at 25°C (5X paper dielectric capacitors)

Dielectric strength: twice rated voltage for one min.

Temp. range: −55°C to +85°C (to +125°C with derating)

Stability: easily pass 10,000 hr. test with negligible drift in capacitance and IF

Tolerances: to ±1%

*Du Pont T.M. for polyester film.

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Circle 133 on reader service card

time-and-motion studies in production plants, a complementary-MOS precision decade timer has its oscillator, divider, and decoder-drivers integrated on a single chip.

The ICM 7045A decade timer, made by Intersil, is an upgraded device derived from the company's C-MOS stopwatch family. The selection of the oscillator frequency alone determines whether the timer is used for counting seconds (1.31072 megahertz); minutes (2.184533 MHz), or hours (3.640889 MHz).

The 7045A, which uses a 3.6-v supply, is guaranteed to operate over a range of 2.5 to 4.5 v. The peak output current drive is rated at 18 milliamperes, with a 12.5% duty cycle. Operating range is −20°C to 70°C.

Price of the ICM 7045A in a 28-pin epoxy dual in-line package is $29.75 for 1 to 24, $23.80 for 25 to 99, and $19.85 for 100 to 999. Delivery is from stock.

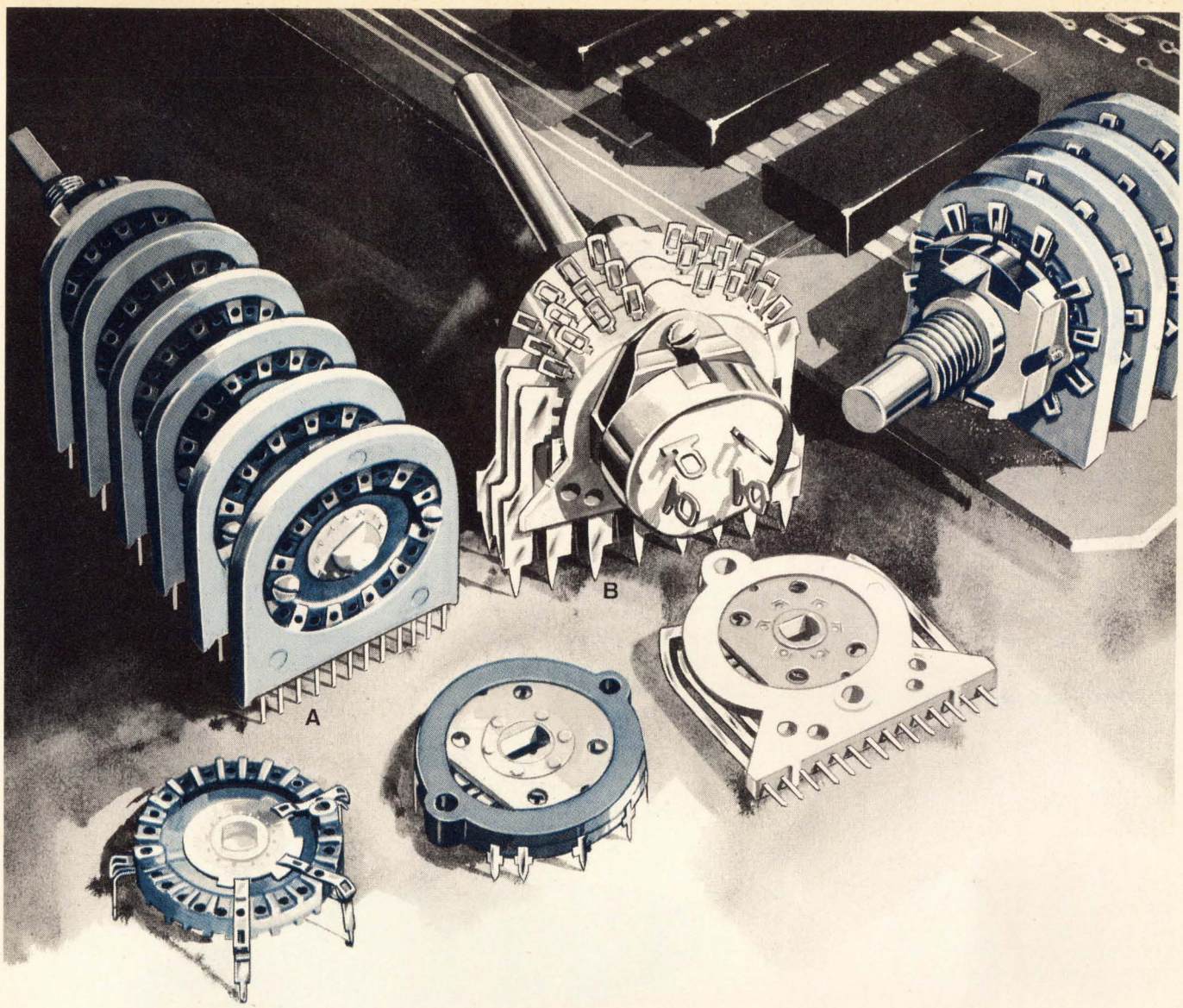
Intersil Inc., 10900 N. Tantau Ave., Cupertino, Calif. 95014 [413]

Transient absorption zener diode responds in 1 ps

Featuring an extremely fast response time of 1 picosecond, the TAZ transient-absorption zener diode is intended to protect components, instruments, and systems against transients induced by lightning or the switching of inductive loads. Available in models that range from 6.2 to 200 volts, the TAZ line is well suited for use as a low-level protection device in conjunction with gas-filled surge voltage protectors in telecommunications applications. It is also expected to prove useful in computers and medical equipment.

Housed in hermetic DO-13 cases, the TAZ devices are designated IN5555 through IN5558, IN5629 through IN5665A, and IN5907. Typical price for the IN5555 is $3.35 in quantities of 250. Samples are available from stock.

Components Group, Siemens Corp., 186 Wood Ave. South, Iselin, N.J. 08830. Phone (201) 494-1000 [416]



Handle most PC needs with rugged, compact CTS rotary switches.

Specify CTS and satisfy nearly every printed circuit switch mounting requirement. Cut production time, too. And at lower cost than with conventional wiring.

Choose from thousands of variations of shorting, nonshorting or mixed circuitry; plus a wide selection of index assemblies and wafer constructions for either perpendicular or parallel PCB mounting. Available in combination with AC power switches and variable resistors. You get a one-source supply for the complete switch package.

Two popular choices include the new CTS Series 223 parallel mount style (view A) measuring only 1 5/16" wide by 1 3/8" above the PC board permitting 12 PC terminals on .100" centers; up to 1-pole, 11-position circuitry. An optional 13th PC or solder lug terminal gives a full 12-position switching capacity. Shown at (B) above is the CTS Series 227 rotary selector switch, which provides years of virtual problem-free performance in all kinds of applications. Parallel mount ...single or multiple wafer constructions...compact 1 11/16" wide by 1 11/32" above PC board. One and two wafer designs are also available with shaft axis perpendicular to board. Ask about our NEW 14-terminal 1-pole, 12-position or 2-pole, 6-position PC switches, too.

Made to your exact specifications CTS switches assure proven reliability, design flexibility and MIL quality. Call your CTS representative or write **CTS Corporation,** 905 N. West Blvd., Elkhart, IN 46514. Phone: (219) 293-7511.

CTS CORPORATION
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Circle 135 on reader service card 135

Instruments

Analog meter has LED display

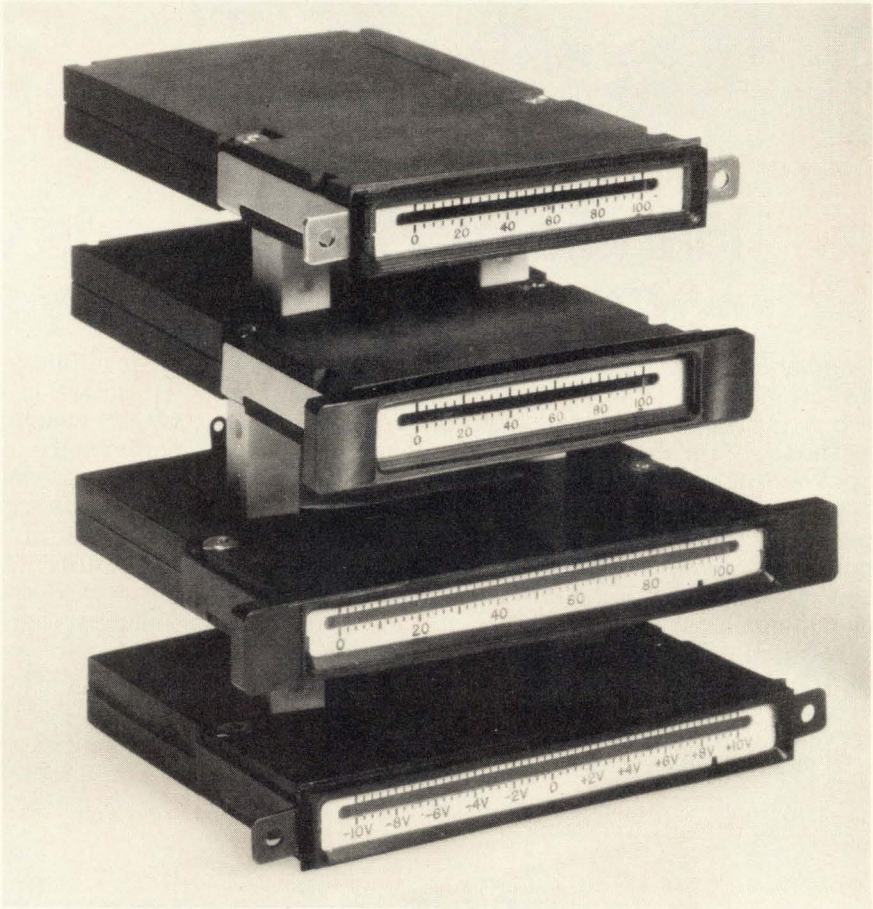
Aimed at jobs in hostile environments, panel unit has no moving parts

Conventional electromechanical analog panel meters can suffer performance loss in environments with a lot of vibration or dirt. With those applications in mind, engineers at Bowmar-Ali Inc. have developed a solid-state light-emitting-diode meter that fits standard front-panel cutout holes and reads in volts, amperes, pounds per square inch, or whatever unit the user needs.

The meter, designated the APM-3, comes in two versions: one with a row of 100 LED segments is accurate to 1%, and a 50-segment unit is accurate to 2%. Charles Krakauer, president, says their performance is not affected by vibration in such applications as avionics, where extra-cost shock mounts are usually required with analog displays. Nor would the dust and grime in a mine be a problem, because there are no moving parts to clog.

Since it generates its own light, the APM-3 is also ideal for use where ambient light is low, Krakauer says. He looks for it to compete well against Panaplex-type displays because it will be cheaper and requires less drive voltage. "I also suspect that there are many applications for which people are using digital panel meters, simply because it's the 'in' thing to do, where we can compete," he says. "We've asked potential users if they would use a solid-state analog panel meter if they could get it, and they have said 'yes.' "

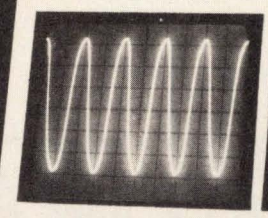
Because it is completely solid-

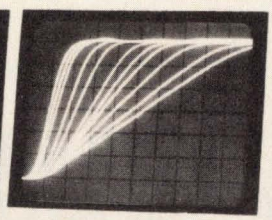


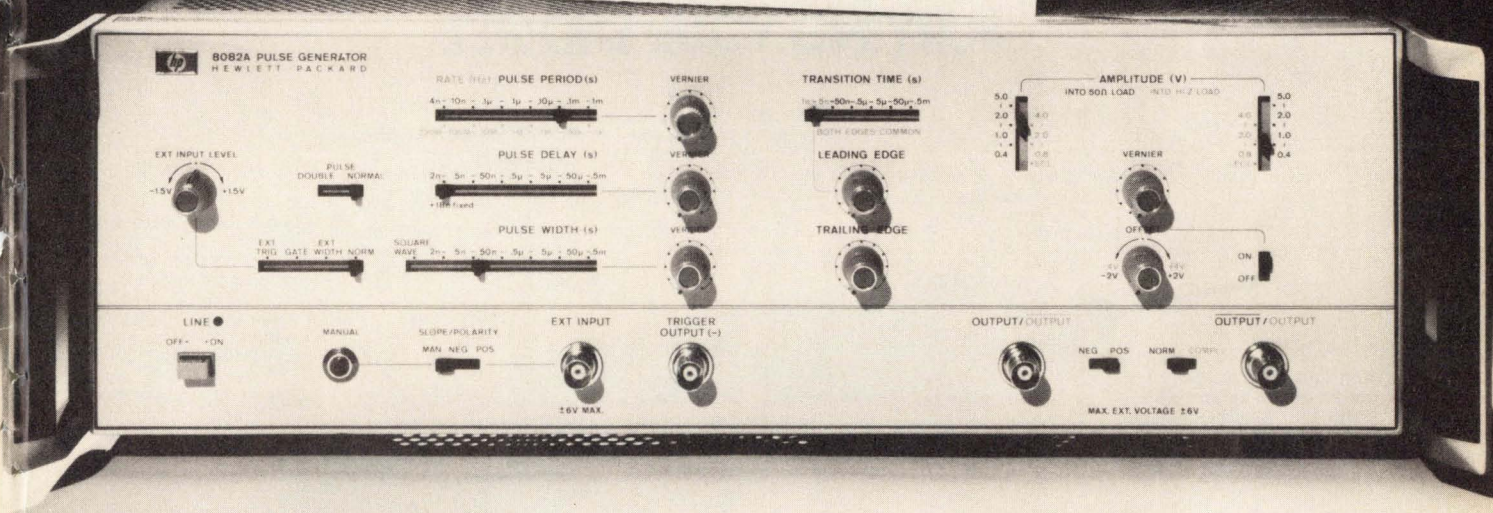
Meaningful ECL testing demands both:

Rep rates to 250 MHz.

Variable transition times to 1 nsec.







Instrument is shown with optional handles

Only HP's 8082A Pulse Generator delivers both.

In ECL testing, high rep rates and fast transitions aren't enough. You also need variable transition times to 1 nsec for meaningful results. And, HP's 8082A Pulse Generator gives you variable transition times and more.

Now you can match the manufacturer's specified conditions for propagation delay measurements. That means more accurate results for both device testing and qualification, and breadboard testing. The ability to vary transition time between 1 nsec and 0.5 msec also gives you a way to test for worst-case conditions. And it lets you use this pulser for Schottky TTL and general-purpose TTL testing too.

What's more, HP's 8082A gives you a precise 50 ohm, low-reactance source impedance for excellent pulse shape without an external termination. That means simplified setups. And, to further simplify operation, the 8082A has an ECL output switch that automatically sets amplitude and offset to specified ECL levels; complementary outputs; and switch selectable polarity.

The 8082A also provides variable pulse delay for easy scope triggering at the right instant; a double-pulse mode with variable spacing to 2 nsec for measuring data set-up times or simulating radar pulses; and external triggering which extends the rep rate range to dc. Priced at $3675*, the 8082A is the logical choice for both meaningful and convenient ECL testing.

And for the designer doing *state-of-the-art* logic development, HP has a new 300 MHz to 1 GHz pulse/word generator system, the 8080. This modular system can be configured either as a pulse generator or a word generator. Now, a single GHz pulser gives you dual outputs with frequency division and precise inter-channel delay for convenient and economical testing of the fastest available IC logic families.

For complete details on these versatile pulse generators, contact your local HP field engineer.

*Domestic U.S.A. price only.

087/6

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THE LOGICAL CHOICE—First in a series

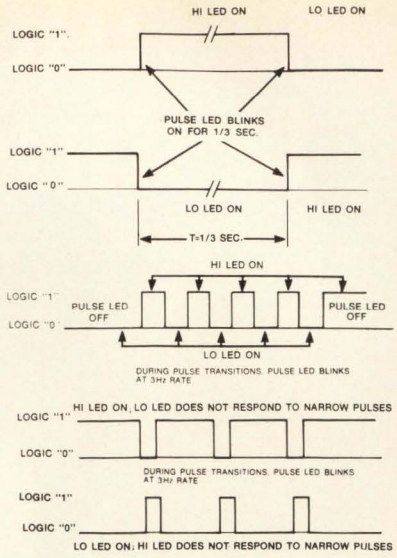
Logic Probe 1 is a compact, enormously versatile design, test and troubleshooting tool for all types of digital applications. By simply connecting the clip leads to the circuit's power supply, setting a switch to the proper logic family and touching the probe tip to the node under test, you get an instant picture of circuit conditions.

LP-1's unique circuitry—which combines the functions of level detector, pulse detector, pulse stretcher and memory—makes one-shot, low-rep-rate, narrow pulses—nearly impossible to see, even with a fast scope—easily detectable and visible. HI LED indicates logic "1", LO LED, logic "0", and all pulse transitions—positive *and* negative as narrow as 50 nanoseconds—are stretched to ⅓ second and displayed on the PULSE LED.

By setting the PULSE/MEMORY switch to MEMORY, single-shot events as well as low-rep-rate events can be stored indefinitely.

While high-frequency (5-10MHz) signals cause the "pulse" LED to blink at a 3Hz rate, there is an additional indication with unsymmetrical pulses: with duty cycles of less than 30%, the LO LED will light, while duty cycles over 70% will light the HI LED.

In all modes, high input impedance (100K) virtually eliminates loading problems, and impedance is constant for all states. LP-1 also features over-voltage and reverse-polarity protection. Housed in a rugged, high-impact plastic case with strain-relieved power cables, it's built to provide reliable day-in, day-out service for years to come.



CSC'S MULTI-FAMILY LOGIC PROBE 1. AT $44.95, IT DIGS UP A LOT OF INFORMATION WITHOUT BURYING YOUR BUDGET.

HI/LO LED's—Display level (HI-logic "1", LO-logic "0") of signal activity at node under test

PULSE LED—Lets you know what's going on—and off. Indicates positive *and* negative pulse and level transitions. LP-1 stretches pulses as narrow as 50 nanoseconds to full ⅓ sec. (3Hz pulse rate)

PULSE/MEMORY Switch— PULSE position detects and stretches pulses as narrow as 50 nanoseconds to ⅓ sec. Switch to MEMORY and it stores single shot and low-rep-rate events indefinitely; HI/LO LED's remain active

Logic Family Switch— TTL/DTL or CMOS matches Logic "1" and "0" levels, for greater versatility. High Input Impedance—100K virtually eliminates circuit loading problems and is constant in both "0" and "1" states. CMOS position also compatible with HTL, HiNIL and MOS logic

Non-corrosive nickel-plated probe tip and clip leads—For reliable contacts and maximum life

Rugged high impact plastic case—Built to take it . . . in the lab or in the field

Protected—Features built-in reverse polarity and over-voltage protection; strain-relieved power cable

$44.95 Price tag—Costs so little it can be *your* personal property

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state, he says, it outperforms electromechanical meters, not only in accuracy, but in response time (100 microseconds), input impedance (100 kilohms) and reliability. Standard faceplate scales are in units of 0-1, 0-5, 1-10, and 1-100, with custom scales available. The front panel also includes underrange and overrange indicators.

The price will be from $75 to $85, and quantity deliveries will begin in 120 days.

Instrument Division, Bowmar/Ali Inc., 531 Main St., Acton, Mass. 01720. Phone (617) 263-8365 [351]

Digital voltmeter resolves 7½ digits with integration time of 8.3 seconds

The model 9577 precision digital voltmeter is a variable-resolution instrument that can display up to 7½ digits (14 million counts). In its highest-resolution mode, the meter has an integration time of 8.3 seconds. Its four other modes provide integration times as short as 0.83 millisecond and corresponding resolutions down to 3½ digits.

When measuring dc voltage, the DVM has an input resistance in excess of 1,000 gigohms, a drift of 20 ppm/year, and an accuracy that varies with range, resolution, temperature, and time. Typical of its performance is a maximum error of 15 ppm of reading plus 35 microvolts for the 10-volt range at a resolution of 7½ digits, a temperature of 18°C to 28°C, and a calibration interval of six months. The meter has six dc voltage ranges with full-scale voltages from 10 millivolts to 1 kilovolt. Since the instrument cannot resolve voltages smaller than 1 microvolt, its ranges from 10 mV through 1 V do not actually provide 7½-digit performance.

In addition to measuring dc voltage, the 9577 measures true-rms ac voltage, voltage ratio (dc-to-dc and dc-to-ac), and resistance. It is a systems-oriented instrument that can make as many as 500 measurements per second. Features that enhance the meter's accuracy and flexibility are a front-panel control to null out external thermal emfs and an instant-start capability.

The meter, which will be shown at Electro 77, sells for $3,995. A wide variety of available options includes Kelvin clip leads ($250), parallel BCD system interface ($450), five-terminal input lead ($50), and a low-emf lead kit ($110). An IEEE-488 interface will be available in the middle of this year.

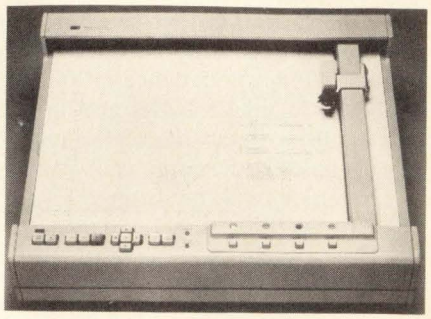
Guildline Instruments Inc., 1997 Palmer Ave., Larchmont, N.Y. 10538. Phone (914) 834-8100 [353]

Microprocessor-based plotter draws in four colors

An XY plotter designed to work with the HP 9825 and 9831 desktop computers contains four different colored pens that the plotting arm can automatically select,

Circle 139 on reader service card →

New products



under program control, to enhance the readability of complex plots. The model 9872A microprocessor-based plotter also uses techniques other than color differences to make plots easier to interpret. It has seven dashed-line fonts, five built-in character fonts, provision for user-defined characters, and symbol-mode plotting.

The microprocessor is programmed with 38 instructions to provide such features as point digitizing, labeling, and character sizing. The unit also provides error-free handling of off-scale data. If a plot runs off the scale, the plotter will calculate the vector's mechanical intercept and proceed to that point, ready to begin plotting as soon as the data comes back on scale.

Deliveries of the 9872A, which sells for $4,200, will begin in April.
Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, California 94304 [354]

Quartz-crystal analyzer spans 1 to 60 megahertz

The model 150A solid-state quartz-crystal analyzer, which operates over the frequency range from 1 to 60 megahertz, makes five basic measur-

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PROCESS COMPUTER SYSTEMS, INC.
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313-429-4971 TWX: 810-223-8153

Circle 141 on reader service card

ements: series resonant frequency, loaded resonant frequency (loading is provided by a user-adjustable capacitor), series resonant resistance, load capacitance, and power-drive level. The power, which can be set from about 50 to 5,000 microwatts, remains constant, despite changes in crystal resistance.

Priced at $1,600, the 150A has a delivery time of two to four weeks.

Saunders and Associates Inc., 7440 East Karen Dr., Scottsdale, Ariz. 85260. Phone (602) 991-9250 [355]

Multichannel tape recorders operate almost anywhere

Because they can be powered by an ac line, by rechargeable batteries, or by external 12- or 24-volt dc sources, tape recorders in the SE 84 series can be used almost anywhere—in the laboratory, on the factory floor, and in moving vehicles, to cite three examples. The four-channel units, which use 0.25-inch tape, and the eight-channel machines, which use 0.5-in. tape, use plug-in modules for each channel. Thus any channel can be equipped with either fm or direct-analog recording circuitry. The direct-recording bandwidth is greater than 60 kilohertz at 15 inches per second while the fm bandwidth extends from dc to 5 kHz at that speed.

Three speeds are provided in each recorder. One of the speeds must be 15 in./s; the others may be chosen from the following: 15/16, 1 7/8, 3 3/4, 7 1/2, and 30 in./s. The 30- and 15/16-in./s speeds are not available in the same machine.

The recorders contain complete built-in calibration systems, including two crystal-controlled calibration frequencies, measurement of power-supply voltages, and dc/peak-ac measurement of input and output levels. They weigh only 25 pounds (four-channel unit) or 30 lb (eight channels) and sell for $5,473 to $8,582 each.

EMI Technology Inc., P.O. Box 1264, Danbury, Conn. 06810. Phone Peter Simmons at (203) 744-3500 [356]

INTRODUCING THE BOARD TESTER YOU'VE ALWAYS WANTED.

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Introducing the GR 1795-HD logic circuit tester.

It's the board tester you've always wanted, if what you've wanted was a GR 1792-A. And who wouldn't.

With its unrivalled programming flexibility, fault simulation, and high speed automatic diagnostics, the 1792-A has been the industry's recognized leader.

And now, in the 1795-HD, you can get all this for 30% less money – with prices starting at under $50,000.

In addition to 1792 capability, the 1795-HD actually gives you even greater capacity. Thanks to its large hard disk storage and unique driver/sensor board design, it can handle boards with up to 480 pins.

Of course, if you want to save even more money, we still offer our original 1795 with floppy disk drives. And you can always upgrade the 1795 to a 1795-HD.

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Circle 143 on reader service card

Subassemblies

Video op amp does not ring

Hybrid thin-film device comes in 14-pin DIP, is guaranteed to 500 MHz

Engineers working in the uhf region often have to build their own operational amplifiers, and they usually must use discrete components to reach ultrahigh frequencies. Designers at Teledyne Philbrick are changing all that with a hybrid thin-film true-differential op amp that fits in a 14-pin hermetically sealed DIP and is intended for precision amplification of complex waveforms with frequency components from dc to 500 megahertz.

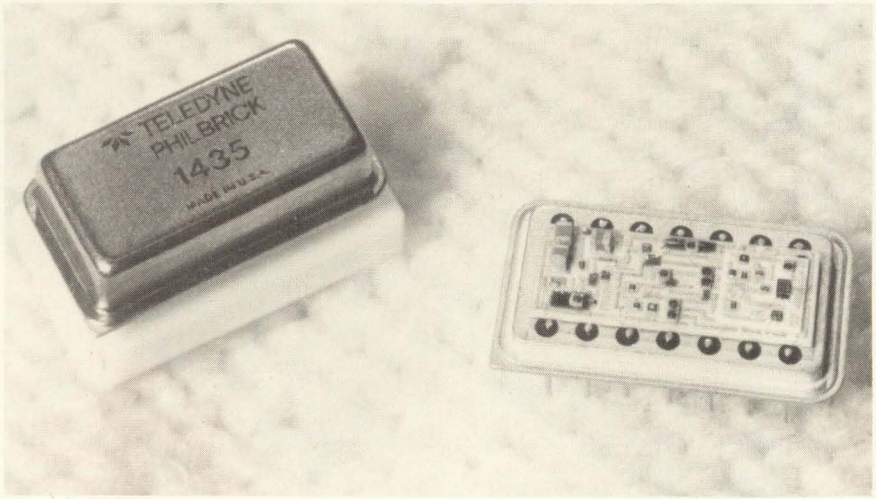
The model 1435 has a typical gain-bandwidth product of 1 GHz, with 700 megahertz guaranteed. Its unity-gain bandwidth is a minimum of 500 MHz. Frank Goodenough, product specialist, says that is about 10 times the gain-bandwidth product of anything else on the market. Further, the precision of the 1435 is reflected in its settling time of 75 nanoseconds to an accuracy of 0.01% for a 10-volt output step. Before this unit, Goodenough says, the best comparable performance was 200 ns to within 0.01% of final value for the company's own model 1430.

In addition, the 1435 does not present the ringing problems often associated with fast-settling op amps because of their high slew rates. "This one is guaranteed at 250 v per microsecond, compared to a lot of others that are at about 2,000 v per microsecond," Goodenough explains. "This one is nicely damped, so that we're stressing that overshoot is less than 1% of output-pulse amplitude, instead of stressing slew rate by itself. This way, we get fast settling time, with a nice, smooth rise, instead of getting ringing."

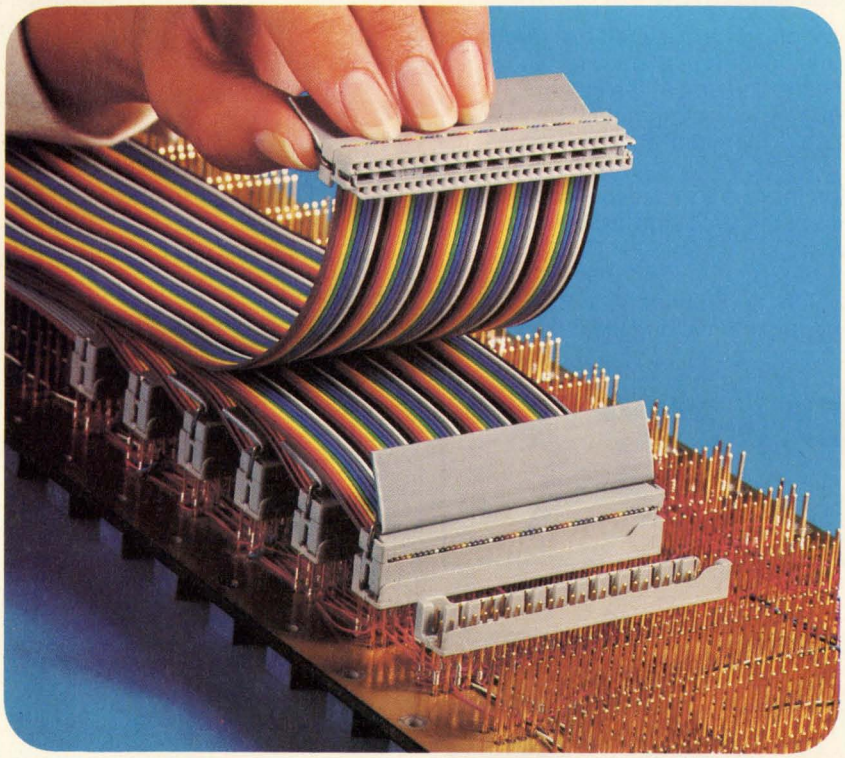
Likely users, he says, may want to modulate microwave transmitting tubes, for example, in electronic-countermeasures applications. It could also be used to handle video signals for graphic cathode-ray-tube displays or in radar and sonar signal processing. Then, too, it is a good tool for building other kinds of circuits, such as peak detectors, sample-and-hold units, and video analog-to-digital converters.

The 1435 has a common-mode rejection ratio of 60 decibels at 1 MHz. "And at 10 MHz, we still have a common-mode rejection ratio of about 40 dB, so that it can be used differentially in an electrical environment with a lot of logic signals with no error on the output," Goodenough adds.

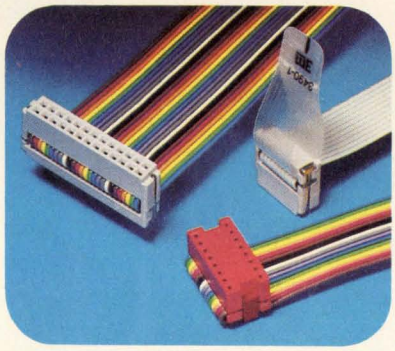
Delivery is from stock, and the 1435, which will be displayed at both Electro 77 and the components show in Paris, is priced at $127 in quanti-



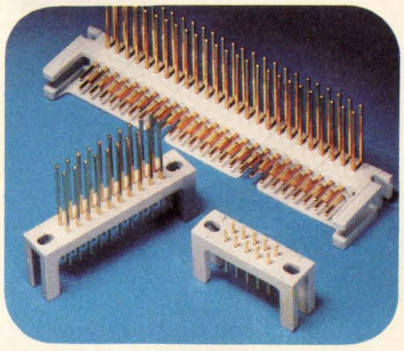
Want simpler backplane connections? Come to the source.



Now, a unique Scotchflex brand Socket Connector and Keying Header system lets you interface directly with backplane wrap pins and provides for easy, positive polarization and keying. The header design allows for thousands of unduplicated polarizing combinations without loss of backplane pins. The 50-position connector mates with .025" square pins on .100" x .200" grid spacing. Header allows space for and protects two layers of wrap below it. System also provides polarizing keys and strain relief handles.



Need some other ways to simplify wiring and increase circuit density? 3M's Scotchflex line offers you a broad choice of mass terminating socket connectors, plus wrap tail or solder tail headers to suit your specific design problem. Keying capability is also provided.



There are several more things you can get only from 3M. The broadest range of flat cables and complete system components. Best off-the-shelf availability. Proven performance. And the unmatched experience of the people who pioneered this reliable mass termination system.

For more information on Scotchflex products call 612-733-3350.

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3M COMPANY

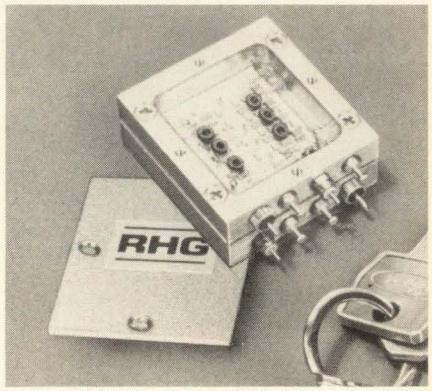
See our catalog in EEM, page 1056

ties of one to nine, or $123 from 10 to 24 units. A derivative of the unit, the 1435-83, is processed to military standard 883, class B, including 168 hours of burn-in. Its price is $169 each for 1 to 9, $164 for 10 to 24.

Teledyne Philbrick Inc., Allied Dr. at Rte. 128, Dedham, Mass. 02026. Phone Frank Goodenough at (617) 329-1600. [381]

Log amplifier takes up only 1.5 cubic inches

The UML miniature logarithmic amplifiers, which are available with center frequencies from 30 to 160 megahertz, are housed in packages that measure only 1.5 by 1.25 by 0.7 inches. The amplifiers have bandwidths as wide as 40 MHz and dynamic ranges to 65 decibels. A



typical unit, the UML6020, has a center frequency of 60 MHz, a bandwidth of 20 MHz, a dynamic range that extends from −60 dBm to +5 dBm, and a price of $775.

RHG Electronics Laboratory Inc., 161 East Industry Court, Deer Park, N. Y. 11729. Phone Sidney Wolin at (516) 242-1100 [384]

Cassette recorder includes interface electronics

Designed to relieve the user of the problem of interfacing a cassette recorder to his microcomputer or minicomputer, the STR-150 is a cassette recorder that contains its own interfacing circuitry. All the

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with people, ideas, products– whatever it takes to get the job done

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Wire, cable and cord sets usually cost less to buy than install. And poor performance can cut into your product's profitability deeper than potential savings on an initial buy. Belden is ready with whatever it takes to get the job done right.

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*Information available upon request.

BELDEN

Circle 147 on reader service card

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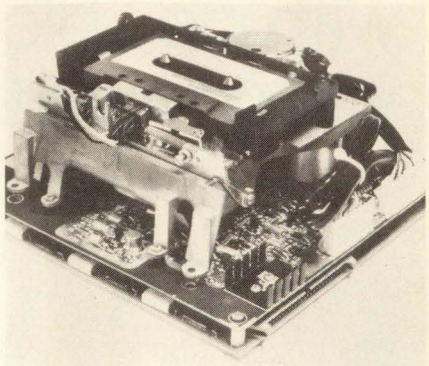
New products



user must provide are eight data input lines with a strobe, eight data output lines with a strobe, and a rewind line. No external clock is required. He need not concern himself with transport considerations such as start and stop times, leader length, and encoding and decoding.

Priced at $503 in small quantities and $376 in hundreds, the STR-150 uses EPI's speed-tolerant recording technique to virtually eliminate the effects of flutter, wow, and head misalignment—common problems with low-cost digital cassettes. The result is a soft-error rate of 1 in 10^7 and a hard-error rate of 1 in 10^8.

Electronic Processors Inc., 1265 W. Dartmouth Ave., Englewood, Colo. 80110. Phone Joe Voelker at (303) 761-8540 [383]

Synchro-to-digital converter resolves 12 bits, costs $199

Although it works off a single 5-volt power supply, weighs only 3 ounces, and sells for only $199 in small quantities, the SD402 is a 12-bit synchro-to-digital converter that is accurate to within 15 minutes of arc. The converter, which has a tracking rate of 10,800° per second, operates from 0 to 70°C. A version that operates over the range from −55 to 105°C is priced at $299.

Both versions of the SD402 accept either synchro or resolver inputs plus a reference. They are 400-hertz devices; for operation at 60 Hz, an external mating transformer must be used. The company plans to develop a third unit which will be made with components that meet MIL-STD-

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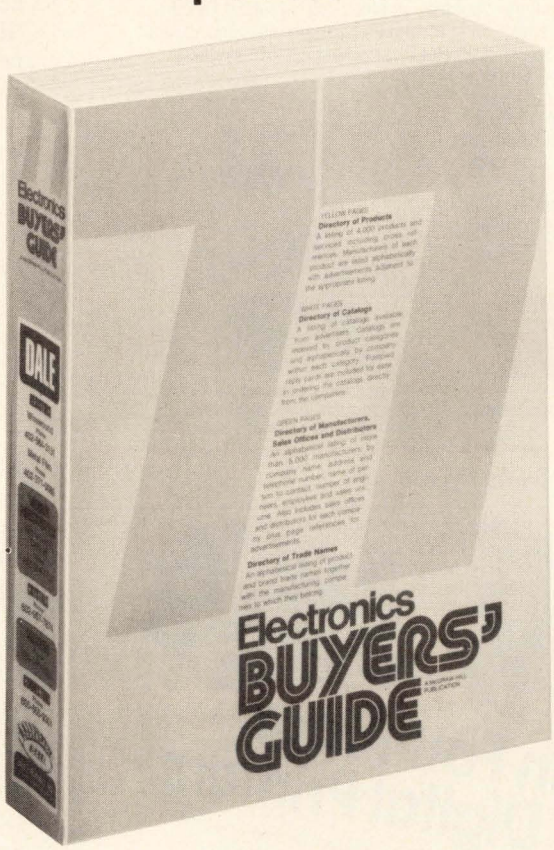

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New products

883 and will have an MTBF in excess of 250,000 hours. While working with any standard synchro or resolver, the SD402 consumes only 1.5 w.

In addition to the SD402, Natel has announced a two-speed s-d converter housed in a 2.6-by-3.1-by-0.82-inch module. Called the 2SD402, the two-speed converter is accurate to within 0.6 minute of arc at a speed ratio of 36:1. Like the SD402, it operates off a single 5-v power supply. In its commercial (0 to 70°C) version, the 2SD402 sells for $795 in small quantities. Both converters are available from stock to 45 days.

Natel Engineering Co., Inc. 8954 Mason Ave., Canoga Park, Calif. 91306. Phone Ed Berman at (213) 986-5060 [385]

14-bit s-d converter covers 50 to 400 Hz

Most synchro-to-digital converters are designed to operate at a specific reference frequency and a specific voltage. To deviate from these design parameters by more than about 10% typically involves making some wiring changes or adding an external transformer module. An exception to this general rule is the model 1651-24 autoranging s-d converter. This 14-bit tracking converter can operate from reference voltages of either 26 or 115 v root mean square and from frequencies in the range of 50 to 400 hertz. The converter automatically senses and responds to changes in voltage or frequency, so no user action is required.

Key specifications include accuracy to within 4 minutes of arc over the full operating temperature range, jitter-free tracking to 16 revolutions per second, and full transformer isolation. Models are available for operation from 0 to 70°C and for −55 to 85°C. Hermetic and high-reliability units are also offered. Small-quantity prices start at $640, with delivery from stock to four weeks.

Transmagnetics Inc., 210 Adams Blvd., Farmingdale, N.Y. 11735. Phone Fred Haber at (516) 293-3100 [386]

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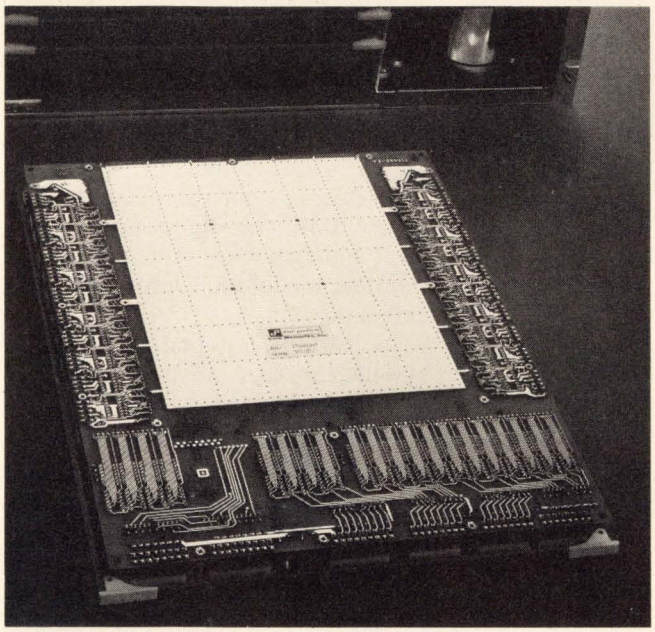
Dataproducts was first to design and manufacture 32K-word planar core memory modules in mass production.



And we have out-delivered the industry in 32K core memory systems.

One of those systems, the STORE/3220, delivers complete 32,768-word X 20-bit capacity or double the capacity of 16K systems, using the same size planar board.

And the compact 5¼" chassis of the STORE/3220 accommodates up to 131,072-words X 20-bits.

Leadership in the 32K marketplace is no accident for Dataproducts.

We were first to employ 16K sensing technology in 16K word modules.

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Our core memory systems are neither the most nor the least expensive.

They are the *most* cost-effective.

And if we don't make the exact system you need (for commercial or military use), ask us and we will.

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N. American Sales Hq: 6219 De Soto Ave.,Woodland Hills, Ca. 91365, Tel: (213) 887-8451, Telex: 69-8492.
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Communications

Tester checks phone lines fast

Calculator-based system makes up to eight precision measurements per second

To minimize and even eliminate customer complaints about poor-quality lines, one would like to check each of the thousands of channels in a typical telephone-system test room daily. But to make such routine measurements as pilot levels, carrier leakage, test-tone levels, channel noise, channel power, and supergroup out-of-band noise once a day is impossible—unless there is available to the tester a piece of highly automatic equipment.

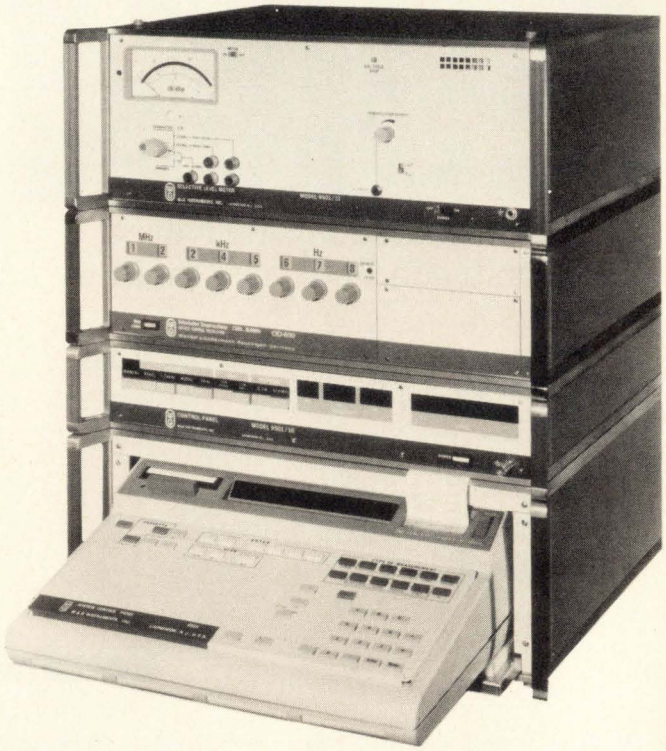
Such tests are all in a day's work for the model 9501 automatic measuring system from W & G Instruments. This calculator-controlled test set can make up to eight precision measurements per second, be they routine checks or special tests.

The system's standard software includes both Bell System and CCITT frequency plans. If, for example, one wants to measure all of the pilot tones in a multiplex package, the 9501 can handle that as a routine task.

The major advantage of the programmable calculator becomes evident when one wants to make a measurement that cannot be defined in terms of an FDM plan—the A and B equalizing tones on an L-4 carrier system, for example. In this case, the calculator programs the system's selective level meter to make the measurements and notes whether they are within tolerance or not.

The 9501, which covers the frequency range from 2 kilohertz to 18.6 megahertz, has four major components: a programmable version of the Wandel & Goltermann AT-611 (or AT-463) selective level meter, a programmable frequency synthesizer, a microprocessor-based control unit with digital displays for level and frequency, and a Hewlett-Packard model 9825 programmable calculator.

In its fully automatic mode, the system can scan all or part of the multiplex package for one or more



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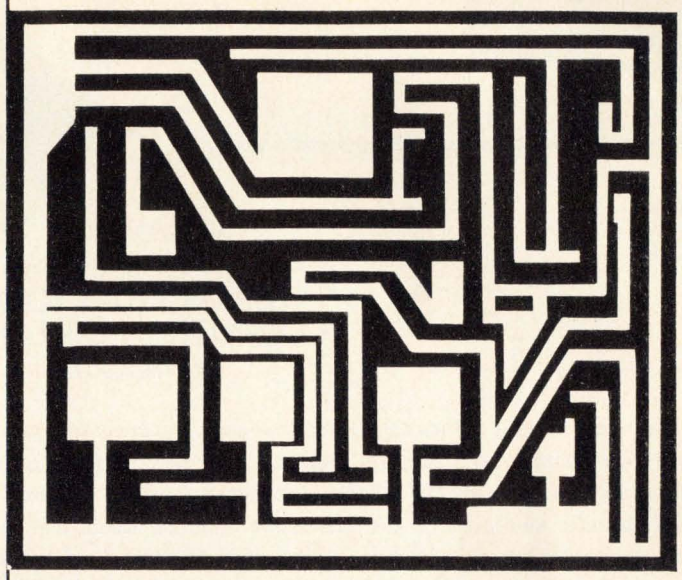

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CONTROL DATA CORPORATION

Circle 153 on reader service card 153

New products

parameters. It can log all data on the printer built into the calculator, or it can log only data that is out of tolerance. If desired, out-of-limit results can be made to trigger an alarm.

As a semiautomatic system, the 9501 is controlled by the operator from the keyboard. He keys in the kind of measurement to be made, such as carrier, tone, or noise, and specifies the master group, super group, group, and channel. The calculator computes the proper frequency, establishes it by means of the synthesizer, and makes the measurement.

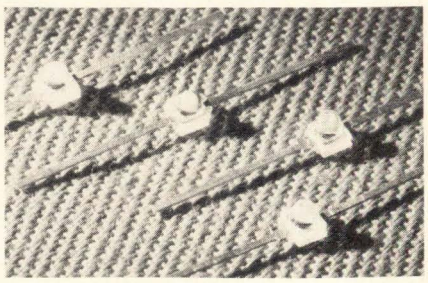
Selective filter bandwidth, measurement mode, and averaging time are all set automatically. The user is provided with a digital display of the parameter in question, together with the proper units of measurement. For most level measurements, the worst-case maximum error is 0.15 decibel.

The 9501, which sells for approximately $25,000, will be available during the second half of this year. Existing nonprogrammable AT-611 and AT-463 selective level meters can be retrofitted by the company's facility in New Jersey to lower the cost of automation.

Sales Dept., W & G Instruments Inc., 119 Naylon, Ave., Livingston, N.J. 07039. Phone (201) 994-0854 [401]

Near-infrared source is easy to align

Because its near-infrared output can be seen without special infrared viewing equipment, the HEMT-6000 light-emitting diode is extremely easy to align. Designed for maximum efficiency at a wavelength of 700 nanometers, the diode is in-



Automatic Frequency Counting and Display to 60MHz with 1Hz Resolution

B+K PRECISION MODEL 1801, $240

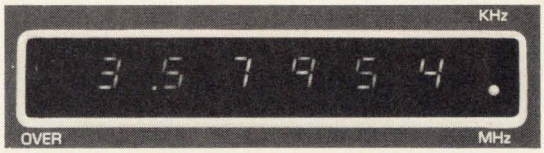
For laboratory, production line or maintenance applications, the Model 1801 will meet most requirements for sensitivity, ruggedness and dependability. With the Model 1801 you can *watch* oscillator adjustments, monitor RF and audio frequencies precisely, do fast production testing, check critical countdown chains, calibrate signal generators and check CB frequencies.

Automatic ranging 20Hz—40MHz is guaranteed. Ranging to 60MHz is typical. Reliable TTL circuitry updates the six-digit display five times per second. Resolution to 1Hz is obtained by switching to the 1SEC mode that suppresses the leading digits above 1MHz.

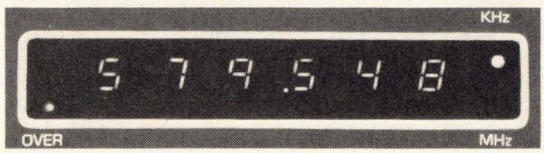
Specified accuracy better than 10PPM, 0-50° C. Maximum aging rate 10PPM/year.

The 1801 is compatible with prescalers that will extend its usability into the UHF range.

For detailed specifications and a no obligation, 10-day free trial, contact your local electronic distributor or B&K Precision.



MHz display of 3.579548 MHz input (AUTO mode)



KHz display of overflow of 3.579548 MHz input (1SEC mode)

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Circle 155 for product demonstration
Circle 195 for additional information

New products

tended for use in fiber-optic communications systems, smoke detectors, card readers, and the like. The device has a narrow beam angle to reduce crosstalk, and it can be coupled efficiently to a fiber-optic cable with a low numerical aperture. Typical axial radiant intensity is 250 microwatts per steradian. Bandwidth is dc to 5 megahertz. The HEMPT-6000 sells for $1.05 in small quantities, dropping to 75 cents in hundreds, and 60 cents in thousands. Delivery is from stock.

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [404]

Rf filter to aid color video games

To help manufacturers of color video games meet the requirements of FCC type-approval, Plessey has developed a surface-acoustic-wave filter for use on channels 3 (61.25 megahertz) and 4 (67.25 MHz). The model SW301 vestigial sideband filter actually contains two filters connected to a common output. Key features are a bandwidth of 6 MHz and the low drift that results from having a completely passive device. The filter, which is packaged in a low-profile TO-8 metal can, sells for $3.75 in lots of 1,000.

Plessey Semiconductors, 1674 McGaw Ave., Irvine, Calif. 92714. Phone Dennis Chant at (714) 540-9945 [403]

Unit mates fiber optics with emitters and detectors

The FOT-3 is an eight-channel fiber-optic termination device that accepts both glass and plastic cables and couples them to emitters and detectors in TO-18, TO-46, and certain T13/4 encapsulations. Made of aluminum, the FOT-3 is covered with Martin Hardcoat to provide electrical insulation between LEDs and detectors that are electrically connected to their cases.

Costs are minimized if the FOT-3 is used with plastic cable with an

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The Post Office Engineers' Conference
"Power electronics and power supply in postal services and telecommunications"
Date: 21st and 22nd April 1977

The Railway Engineers' Conference
"Integrated transport control on the German Federal Railway"
Date: 22nd April 1977

Components Symposium
"Optoelectronics"
Date: 26th April 1977

Something unique at trade fairs: EBI: the Electronic Visitors Information System gives you all the wanted information faster and more exactly. In the seven halls of the electrical group.

Make sure you use the latest information from 24 different branches of industry at the Hanover Fair. To help you prepare your visit we shall be glad to send you the Fair Diary with the programme of all branches and those sectors with the provisional exhibitors' list which interest you most.

Please return this coupon to

Deutsche Messe- und Ausstellungs-AG, Messegelände,
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ELS–3

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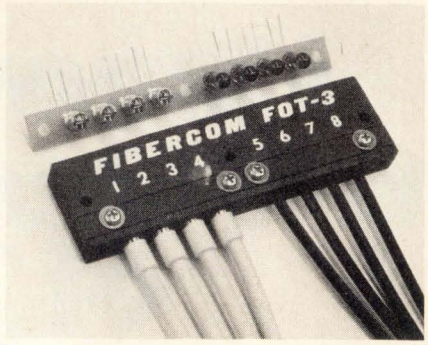
IHM 397/GB-INT

Hanover Fair '77
Wednesday, April 20 - Thursday, April 28

New products



outer diameter of 0.119 inch. If glass must be used for high data rates or long cable lengths, an accessory ferrule must be employed to encapsulate the fiber bundle and retain the jacket. The FOT-3 terminal sells for $40 in quantities of one to nine and $30 in lots of 10 to 49.

Radiation Devices Co., P.O. Box 8450, Baltimore, Md. 21234. Phone (301) 628-2240 [405]

Time-division multiplexer accommodates 16 channels

The M1318 Multitran multiplexer is a microprocessor-based device that can accommodate up to 16 synchronous or asynchronous digital data channels or any combination of both types. The time-division unit, which can be used for point-to-point communications between terminal clusters and central computers, is fully compatible with the manufacturer's M3200 network switching and management system.

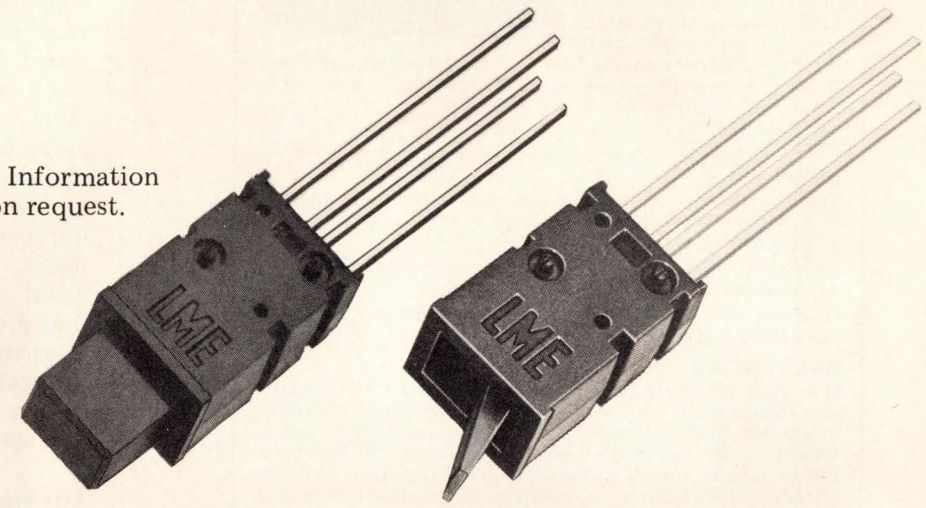
Automatic speed recognition, which the company calls Autobaud, makes it unnecessary to dedicate asynchronous channels to specific transmission speeds. Any asynchronous channel can handle data rates of 75, 110, 134.5, 150, 300, 600, and 1,200 bits per second. The multiplexer can accommodate synchronous transmission rates of 1,200, 2,400, 4,800, and 9,600 b/s. It may connect terminals via dial-up or dedicated modems, short-haul data sets, or direct EIA cabling.

Computer Transmission Corp., 2352 Utah Ave., El Segundo, Calif. 90245. Phone (213) 973-2222 [407]

New PCB contactless switches!

Contactless pushbutton and toggle switches are designed to a 1/10" module and are particularly suitable for printed circuit mounting. Two outlets of open collector type. Both switches included in the MBC-system consist of LED-units, mechanical pushbuttons, fuse holder and test jack unit.

Further Component Information
15-10 and 15-10.1 on request.



You will find the contactless switches at the Salon des Composants in Paris, Stand 68 under the name of Metox.

LM ERICSSON
TELEMATERIEL AB
Fack S-135 01 Tyresö SWEDEN

Circle 159 on reader service card

Meet the toughest in the shop.

Disc Model 702 shaft-position encoder just took the title away from Frank, the top machinist.

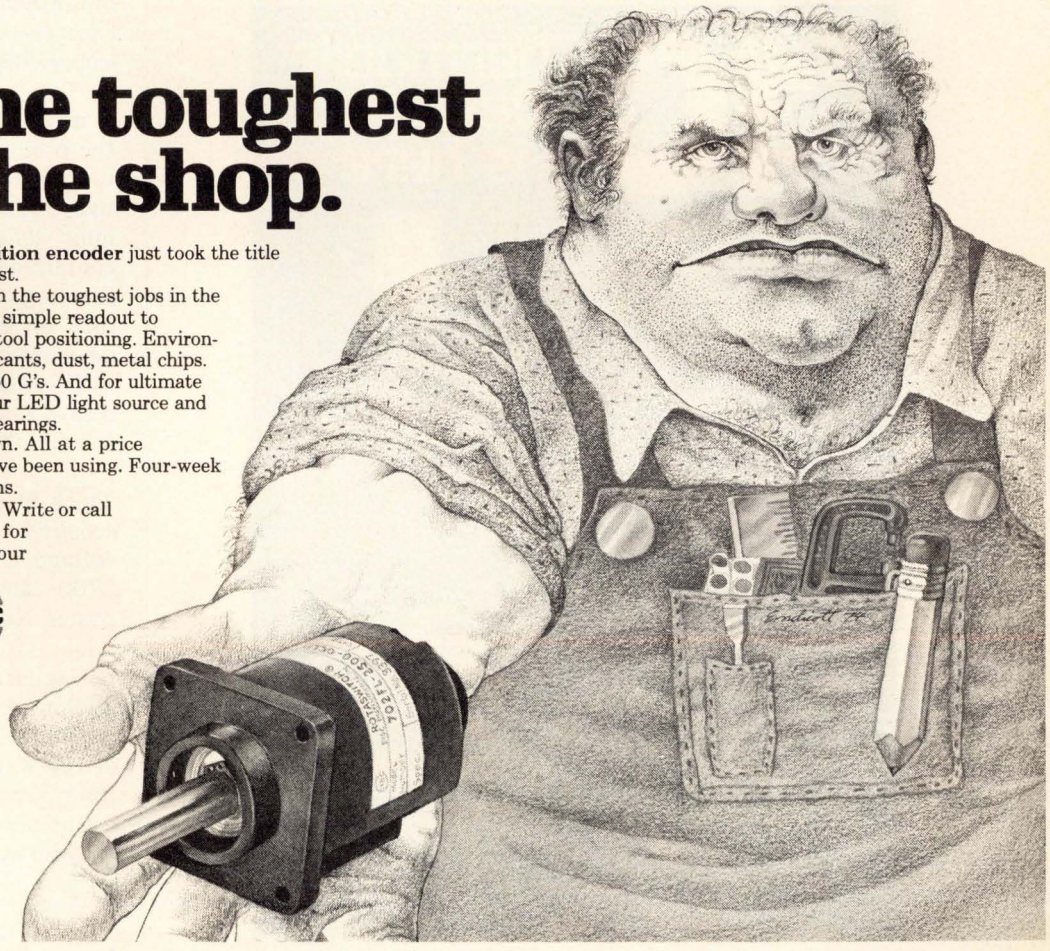
Our new champion takes on the toughest jobs in the toughest environments. Jobs from simple readout to sophisticated automatic machine tool positioning. Environments loaded with moisture, lubricants, dust, metal chips. Heavy vibration and shock up to 50 G's. And for ultimate reliability, it features a 100,000 hour LED light source and conservatively rated class 5 ball bearings.

It's 16 ounces of pure brawn. All at a price competitive with the encoder you've been using. Four-week delivery on all standard resolutions.

Find out how tough we are. Write or call our Machine Tool Encoder Dept. for details. And if you're an OEM, your letterhead request brings details on a free evaluation sample.

DISC

DISC Instruments, Inc.
102 E. Baker St.
Costa Mesa, Calif. 92626
Phone (714) 979-5300



See Disc Encorders: April 1-6, Composants electroniques 77/Paris
Syracuse Electronics Booth KR G 10, Bldg. NR 2

Circle 198 on reader service card

New products/materials

A conductive surface coating formulated for rf shielding applications is supplied in six-ounce aerosol cans for ease of application. Called Ecco-shield ES, the silver-based lacquer has a surface resistivity of no more than 1 ohm per square. Normal coverage for a 6-oz. can is about 30 square feet. Being sufficiently fluid to flow into cracks, the material can improve the shielding of joints, seams, and contacting surfaces of metal structures to the point where they provide more than 100 decibels of attenuation from 15 kilohertz to 10 gigahertz.

Emerson & Cuming Inc., Canton, Mass. 02021 [476]

An inexpensive casting resin for small electrical parts, EE0149 has been granted Underwriters Laboratories yellow-card recognition when tested for flammability under 94 VO. The material is intended for consumer-electronics applications in which a manufacturer wants to convert to a compound with flame-out properties without a cost rise.

Hysol Division, 15051 East Don Julian Rd., Industry, Calif. 91749 [477]

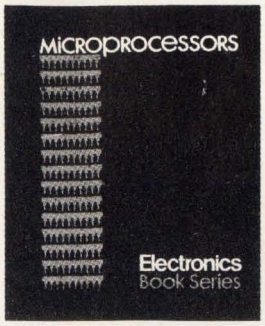
A non-ionic photoresist developer for the production of integrated circuits is compatible with all types of positive resists. The developer's non-ionic constituents eliminate surface contamination, thus potentially increasing circuit yields. At a temperature of 20° to 25°C, the material develops in only 10 seconds.

Micro-Image Technology Ltd., Greenhill Industrial Estate, Riddings, Derby DE5 4UB England [478]

Thick-film resistors that show low sensitivity to temperature, age, and voltage can be fabricated with the 2700 series of ruthenium-based pastes. Surface resistivities from 100 kilohms per square to 10 megohms per square are available. The 100-kilohm-per-square material changes less than 0.3% at a power dissipation of 100 watts per square inch at 70°C for 1,000 hours.

Electro-Science Laboratories Inc., 1601 Sherman Ave., Pennsauken, N.J. 08110 [479]

The Electronics Book Series offers you:



1
MICROPROCESSORS

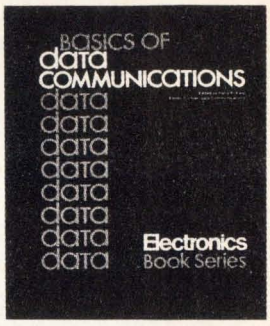
This book cuts through the confusion, presenting the design and application potential of this exciting technology in a manner that will appeal to the design engineer who needs to know how to use microprocessors as well as the system analyst who must assess the tradeoffs between microprocessors and other techniques to accomplish his system goals.

2
APPLYING MICROPROCESSORS

This new book completes the engineer's transition from the old methods of electronic design to the new world of microprocessor engineering. The book contains the up-to-date and ready-to-use information that every designer needs to know about the new technology.

3
LARGE SCALE INTEGRATION

"Large Scale Integration" deals with the entire range of design applications main memory systems, peripheral memories, memory controllers, on-line industrial controllers, data acquisition boards, communication systems, calculators, watches, etc.



4
BASICS OF DATA COMMUNICATIONS

Chances are you are going to be a part of the data communications market. There's no better place to start than getting a copy of "Basics of Data Communications"—a 316-page compilation of essential articles which have appeared in Data Communications magazine.

Use form below to order your copy. Prices on 10 copies or more, available upon request.

Electronics Book Series
1221 Avenue of the Americas, New York, New York 10020

1 ☐ Send me ____ copies of "Microprocessors" at $8.95 per copy.

2 ☐ Send me ____ copies of "Applying Microprocessors" at $9.95 per copy.

3 ☐ Send me ____ copies of "LSI" at $9.95 per copy.

4 ☐ Send me ____ copies of "Basics of Data Communications" at $12.50 per copy.

☐ Full payment must accompany my order.

I must be fully satisfied or you will refund full payment if the books are returned after ten-day trial examination.

Name _____ Title _____

Company _____

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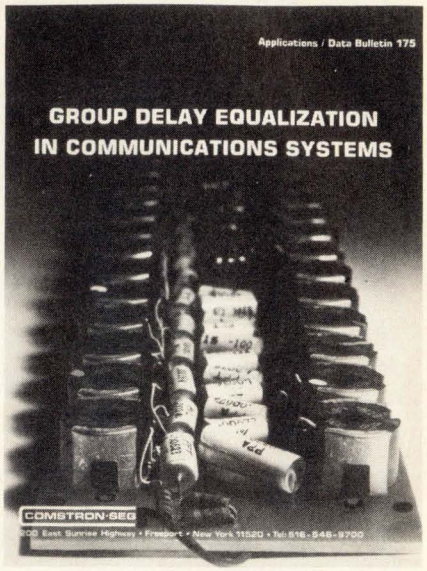
City _____ Country _____

Signature _____

New literature

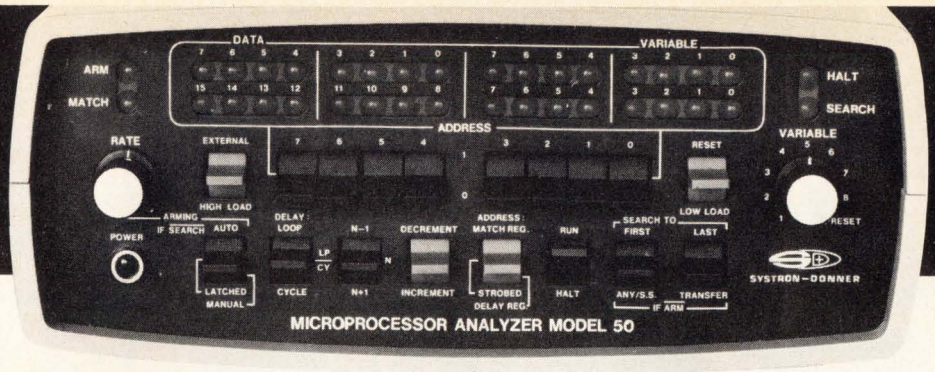


Group-delay equalization. A booklet on group-delay equalization in communications systems includes information on the specification of equalizers and equalized filters, as well as a tutorial look at the design of equalizers and their functions. The booklet defines group delay and discusses passive vs active designs, frequency effects, and computer optimization. Copies are available from Comstron-SEG, 200 East Sunrise Highway, Freeport, N.Y. 11520. Or circle reader service number 421.

Printer/plotters. A 24-page brochure from Varian, *Printer/Plotter Considerations*, describes various techniques and applications of all printer/plotters. Although the brochure covers a wide variety of techniques, the main emphasis is on electrostatic machines. Copies may be obtained from the Varian Graphics Division, 611 Hansen Way, Palo Alto, Calif. 94303 [422]

Nova 3 minicomputers. A 12-page brochure from Data General gives details on system use, software, and support for the Nova 3 minicomputer family. The document covers the Nova 3/4, the Nova 3/12, and the Nova 3/D. For a copy, write to Data General Corp., Dept. 6-58, Southboro, Mass. 01772 [427]

Vapor degreasing. To use vapor degreasers properly, one must con-



THE HOT NEW S-D MICROPROCESSOR ANALYZER

ONLY $865 but Model 50 does more than a 32-channel logic analyzer costing 3 times as much.

First Universal Analyzer: Useable with **all** microprocessor families that have accessible bus structure up to 16 bits data and 16 bits address.

Unique Search Modes: Identify the first and last instruction in a program loop, then step forward or backward through programs.

Passive or Interactive: Use as a passive real time monitor or interactive breakpoint generator.

Find out more about the time-saving (to put it mildly) Model 50 features such as delay by loops or cycles or combinations, single or multiple cycle or loop steps, dual clock, N−1/N+1 strobe, multiple unit capability, etc. Contact:

SYSTRON DONNER

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Circle 165 on reader service card

Problem:

You've designed a new instrument but it won't fit inside a standard enclosure.

Solution:

Call Bud. We'll modify one of our standard enclosures and it'll fit your product and budget to a T.

A modified Tilt-A-View houses control unit.

A modified Series 60 rack houses a viscometer unit.

A modified Compucab houses audiometer units.

We've designed and built thousands of special enclosures. Many have been modifications of our standard racks and cabinets. That means economies, delivery and the assurance of getting an enclosure that'll do a job, the right job for you. **YOUR PROBLEM IS SOLVED!**

Call toll free:

(800) 321-1764 for more facts. In Ohio, (800) 362-2265.

BUD

BUD RADIO, INC.
Willoughby, Ohio 44094

Circle 200 on reader service card

New literature

trol the boiling point (which changes as contamination increases) to prevent solvent breakdown and vaporization of contaminants. A handy, adhesive-backed chart, which is offered by Ramco Equipment Corp., 32 Montgomery St., Hillside, N.J. 07205, lists the critical temperature limits for five commonly used solvents. [423]

Liquid crystals. What is described as the most extensive list of liquid-crystal materials available today is covered by a set of data sheets that is available from Atomergic Chemetals Corp., 100 Fairchild Ave., Plainview, N.Y. 11803. Among the covered materials are Shiff bases, esters, nematic mixtures, smectic liquid crystals, cholesteryl liquid crystals, and miscellaneous chemicals that exhibit liquid-crystal properties. [424]

Power supplies. Datel's 1977 engineering-power-supply handbook is a 40-page compilation of modular sup-

plies (single, double, and triple output), dc-to-dc converters, modular high-voltage supplies, miniature supplies, open-frame supplies, and a new microcomputer supply. In addition, it contains a section on modern power-supply principles and practices and a glossary of power-supply terms. Copies are offered by Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021 [425]

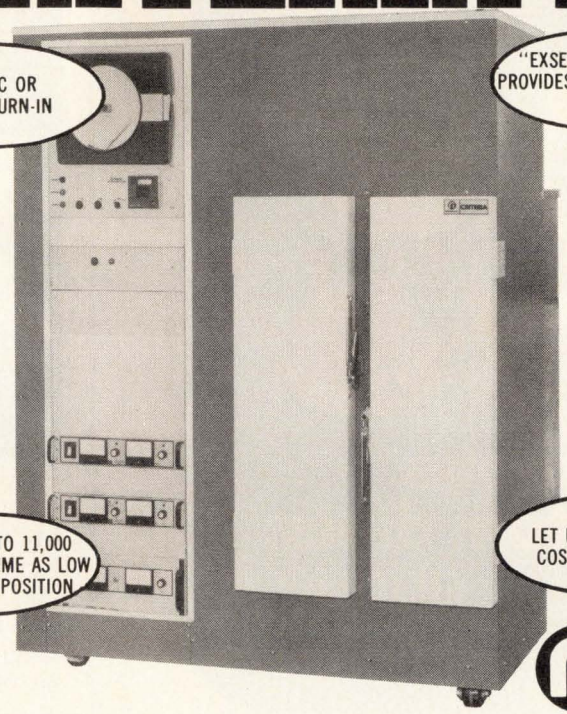
Motors. A condensed catalog of the electric motors made by Marathon

New system for dynamic burn-in of semiconductors achieves high temperatures via "Exsert Connection"

CRITERIA IV

DYNAMIC OR STATIC BURN-IN

"EXSERT CONNECTOR" PROVIDES DYNAMIC BURN-IN TO 200°C



Designed for production burn-in, the Criteria IV achieves 200°C dynamic capability by means of an "Exert Connection" (having the socket board extend through the oven wall). An externally connected driver cord generates all stimulation for the devices.

The inherent flexibility allows for simultaneous burn-in of any type of device. Typical system capacities vary from 11,000 4K RAM's to 18,000 14 pin IC's. Criteria equipment has over 10 billion device burn-in hours in Reliability's burn-in facility. Let this experience help in planning your burn-in capability.

Let Reliability, Inc. solve your burn-in needs. Our Houston burn-in facility has served major components manufacturers and OEM's with service on billions of items since 1970. Call or write today for full details.

BURN-IN UP TO 11,000 RAMS AT ONE TIME AS LOW AS $6.00 PER POSITION

LET US DEMONSTRATE COST-EFFECTIVENESS

Reliability, Inc.

P. O. Box 37409/Houston, Texas 77036
713/666-3261/TWX: 910-881-1739

Circle 167 on reader service card

When a customer wrote to tell us one of our oscillators failed, it wasn't to complain.

We have a letter that makes us proud. It confirms in writing what many people have been telling us over the phone: they love the dependability of our oscillators. We like phone calls too, but to have praise in black and white makes us feel even better.

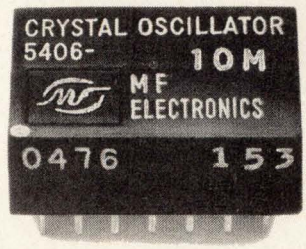
What happened was this:

An engineer from Stromberg-Carlson, one of our major customers, told us some pretty impressive facts about our Model 5406-4M Crystal Oscillator. Over the phone. Could he, we wondered put his experience in writing? We didn't ask for an endorsement. Just the facts objectively, his experience with our product. So he wrote to tell us this:

Our oscillators were used in an electronic telephone switching system, on a clock card assembly in the common control to provide primary timing signals for switching network and feature operation. Since the system was designed with a non-redundant single common control, reliability of the clock card and oscillator was essential.

Out of approximately 3,810,000 part-hours of crystal oscillator operations, ONLY ONE failure was identified. And since MF Electronics guarantees its oscillators, we even replaced that one.

What we won't replace is our determination that none of our oscillators will ever



fail. Why? Because we honestly believe no one makes a better quality oscillator at a better price than MF Electronics.

If you're in the market for high-performance, guaranteed oscillators, write or call us.

We welcome your business. As well as your letters.

Below, we have listed various types of the oscillators we make. Browse through it. If you are interested in a quality oscillator, MF Electronics makes it.

MF DIP CRYSTAL OSCILLATORS • 4-65 MHz

Series	Temperature of Operation	Frequency Accuracy, All Conditions
5406 / 5407	0 to +65 C	±.005% (±50 ppm)
5406-1 / 5407-1	0 to +65 C	±.0025%
5406-2 / 5407-2	−55 to +65 C	±.005%
5406-3 / 5407-3	0 to +85 C	±.005%
5406-4 / 5407-4	0 to +125 C	±.0075%
5406-5 / 5407-5	−55 to +85 C	±.005%
5406-6 / 5407-6	−55 to +125 C	±.0075%

SPECIFICATION OVER ALL TEMPERATURES, FULL LOAD 5406 / 5407 (All units)

	MINIMUM	TYPICAL	MAXIMUM	
Input Voltage	4.75	5.0	5.25	volt
Input Frequency	As Specified from 4 to 65 MHz			
Input Current 4 MHz to 10 MHz		20	40	ma.
Input Current Above 10 MHz to 65 MHz		25	50	ma.
Frequency Accuracy (All Conditions)	See Preceding Table			
Waveform Symmetry, measured at 1.5 v	40/60		60/40	
Rise Time, 4 MHz to 10 MHz, 0.8 to 2.4 volts		7	20	ns.
Fall Time, 4 MHz to 10 MHz, 2.4 to 0.8 volts		4	20	ns.
Rise Time over 10 MHz to 19.9999 MHz, 0.8 to 2.4 v		3.5	15	ns.
Fall Time over 10 MHz to 19.9999 MHz, 2.4 to 0.8 v		3	10	ns.
Rise Time from 20 MHz to 65 MHz, 0.8 to 2.4 volts		2.5	5	ns.
Fall Time from 20 MHz to 65 MHz, 2.4 to 0.8 volts		2	5	ns.

MF ELECTRONICS CORP.

118 E. 25th St., New York, N.Y. 10010 (212) 674-5360 TWX: 710-581-4109

Circle 202 on reader service card 167

New literature

Electric Mfg. Corp. can be obtained by writing to the company at Randolph and Cherry Streets, Wausau, Wis. 54401. Catalog SB-300 contains information on motors ranging from ⅙ horsepower to 250 hp. [426]

Microwave products. A 20-page illustrated booklet describes the broad line of microwave radio systems manufactured by GTE Lenkurt. Included in the catalog is information on the type 70F1 775 and 778 transmitter-receivers and the 700F1 repeater system. The document also provides basic information on FCC and CCIR frequency bands, as well as fundamentals of heterodyne, baseband, and rf repeater operation. For a copy, write to GTE Lenkurt Inc., Dept. C720, 1105 County Rd., San Carlos, Calif. 94070 [428]

Line printers. What is described as the largest selection of line printers in the world is covered in a six-page brochure put out by Digital Associates. Units with printing rates from 100 to 1,200 lines per minute are covered, as are a card reader and a line of interfaces. Available printers include matrix, solid-font, chain, and drum machines. The catalog lists 10 basic series of printers, with variations available on most of them. Copies of the brochure are offered by Digital Associates Corp., 1039 East Main St., Stamford, Conn. 06902 [429]

Why did Brunswick choose Wintek micro computer hardware?

For the same reasons as:

Monsanto
Mitre
Snap On Tools
CTS Electronics
Perkin Elmer
Naval Weapons
Master Specialties
Air Products and Chemicals
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Control module	$149.00
RAM module	$298.00
ROM module	$82.00
EROM programmer module	$195.00
Data acquisition module	$125.00

All Wince modules are standard 6½" X 4½" with standard 44 pin connectors.

For more information on why you should choose Wintek, call or write:

WINTEK
Wintek Corporation
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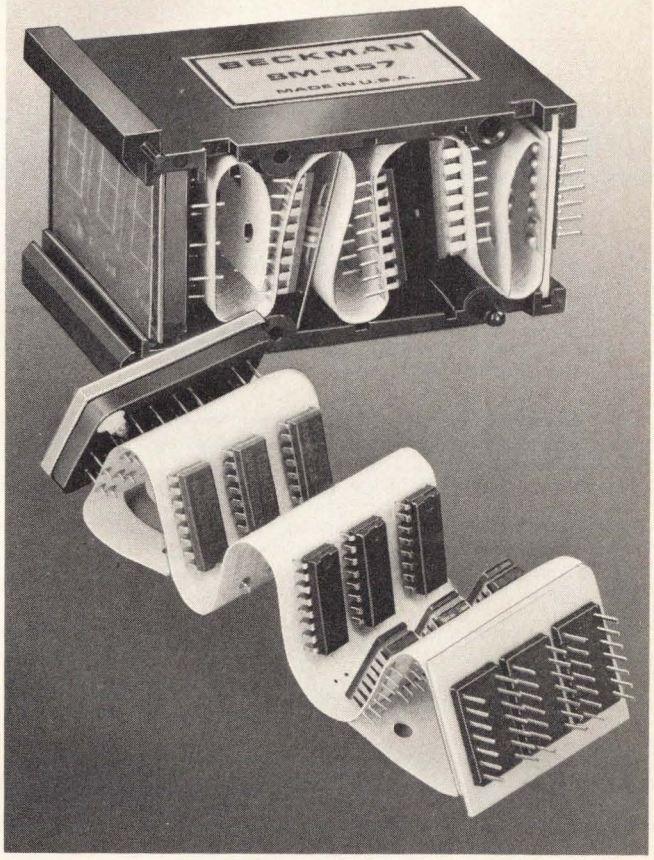
Lafayette, IN 47904
317/742-6802

Circle 169 on reader service card

FLEX CIRCUITS MEAN SECURITY



A new, exciting way to pack a lot of added security into your design.

R/flex circuits do several jobs at once and accordion fold to fit.

Heightened reliability and lowered costs assured by elimination of multiple circuit boards and jumpers. Labor savings, too, with components mounted directly on circuit—manually or automatically inserted. Stiffeners can be added where needed.

Can be made in one to six layers in a variety of shapes and sizes, with or without plated-through holes.

ROGERS CORPORATION
Chandler, AZ 85224 (602) 963-4584
EUROPE: Mektron NV, Ghent, Belgium JAPAN: Nippon Mektron, Tokyo

Circle 204 on reader service card

Classified section FOR ENGINEERING/TECHNICAL EMPLOYMENT OPPORTUNITIES

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Dallas . . . . . Mike Taylor . . 214/742-1747
Denver . . . . . Shirley Klotz . . 303/837-1010
Detroit . . . . . Mac Huestis . . . 313/873-7410
Houston . . . . Mike Taylor . . 713/659-8381
Los Angeles . Stan Kassin . . . 213/487-1160
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Pittsburgh . . . . Dan Ferro 412/391-1314
San Francisco. M.E. Kenny . . . 415/362-4600
Stamford . . . . . Holt Buchanan . 203/359-2860
XEROX 400 TELECOPIER . . 212/997-6800

Electrical Engineers

Listed below are current and immediate requirements of Local and National client companies. These openings represent a cross-section of industries, company sizes and applications. Most positions are multiple. If you have been thinking of investigating new opportunities, we urge you to contact us in confidence for individual discussions of particular opportunities in your career field, or to submit a confidential resume with salary information for review. Client companies assume all fees. For those who find it inconvenient to call during working hours, our office will be open until 7:30PM (E.S.T.)

Process Control Engineers – Degree in Engineering with background in Computer Sciences. 3-5 years of experience in the Application of Process Control Computers within the Petrochemical, Chemical, Pulp and Paper or Textile industries. **Salary to $16,000**

Test Equipment Design Engineers – BSEE with Digital Design experience in developing prototype test equipment within a Systems Environment. **Salary to $25,000**

Digital Logic & Circuit Design Engineers – BSEE and some experience in Logic & Circuit Design, including a familiarity with DDT, TTL, CMOS, etc. **Salary to $25,000**

Computer Architects – BS/MSEE and 3-5 years of experience in the definition and development of Minicomputer Systems. Will be a principal participant in developing a new family of computer systems. **Salary to $30,000**

Sr. Power Supply Design Engineers – BSEE and 3-5 years of Design and Development of regulated and non-regulated power supplies. The application of this work will be to build an in-house capability within a systems organization. **Salary to $25,000**

Microprocessor Design Engineers – BS/MSEE with detailed CPU architecture and software background. Position entails logic design simulation and prototyping. **Salary to $25,000**

Radar/Microwave Engineer – BSEE and a minimum of six years experience in the design of active microwave circuits involving radar transmitters and receivers. **Salary to $30,000**

Sonobuoy Engineers – BSEE and at least 5 years experience in design of low cost Miniaturized VHF/UHF Transmitter/Receivers. **Salary to $25,000**

Navy Fire Control System Engineers – BSEE and 3-5 years experience in modern Submarine Torpedo Fire Control Systems such as FCS MK 113, MK 117, MK 118. Will convert System Operational Requirements to System Functional Requirements. **Salary to $25,000**

Contact: Robert Norton

nk Norton, Kleven and Co., Inc.
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DIGITAL/ANALOG DESIGN ENGINEER
Salary area, $13,000 to $24,000
Houston's manufacturers of digital/analog systems, micro-processors and mini computers are expanding their products and markets and are in urgent need of Digital Design Engineers. Salaries range from $13,000 to $24,000 DOE.
For further information, contact **Warren Dunn at (713) 621-9050.**
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M. David Lowe
Personnel Services Inc.
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Houston, Texas 77002

POSITION VACANT

The Department of Electrical Engineering at Rutgers University invites applications for a regular faculty position at the Assistant Professor level beginning September 1977. Applications are invited from persons who can pursue a vigorous research program and teach undergraduate and graduate courses. Applicants with Ph.D. in Electrical Engineering or equivalent should have advanced experience in one of the following areas: discrete semiconducting devices, integrated circuits and microwave devices. Submit curriculum vitae to Professor B. Lalevic, Department of Electrical Engineering, College of Engineering, Rutgers University, P.O. Box 909, Piscataway, New Jersey 08854. Rutgers University is an Equal Opportunity/Affirmative Action Employer.

POSITIONS WANTED

Experienced Product Innovator and Engineering Administrator—Fifteen patents, several successful products and various publications. Admin. experience includes OD, product planning, resource allocation, etc. Searching for rapid growth or turnaround situation. Objective is to make meaningful contribution to significant technical programs. Ideally to participate in "State of the Art" advances in controls, instrumentation, or EDP technologies. PW-4051, Electronics.

POSITION VACANT

Engineers/Scientists: Over 800 firms in Eastern U.S. pay our fees to recruit Top-Caliber professionals in all technical areas. Send detailed resume, in confidence. Wallach Associates, Inc., 1010 Rockville Pike, Rockville, MD 20852.

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SIZES 7/8" to 10" deep in widths of one column (1 5/8"), two (3 3/8"), three (5 1/8"), and four (7").
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ISSUE DATE Every other Thursday.
AD ORDERS/BOX NUMBER ANSWERS Send to Electronics, Post Office Box 900, New York, N.Y. 10020.

Engineering Advanced Computer Peripherals

Calls for a mix of individual creativity and multidiscipline team work

Burroughs Peripheral Products Division is engaged in a series of continuing high technology programs involving advanced concepts in the design and manufacture of high speed document handling, reading, and printing devices. We have immediate openings for individuals with skills a cut above the average, and an interest in developing new ideas.

Electrical Engineers

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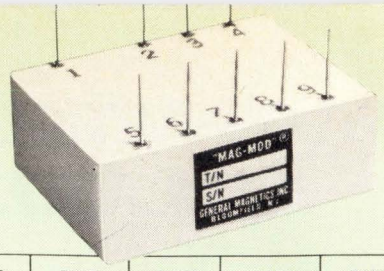

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FREQUENCY (Hz)	400	400	60	400	400	400	400	400	400	400	400	60
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OUTPUT IMPEDANCE	<1Ω	<1Ω	<1Ω	<1Ω	<1Ω	<1Ω	<1Ω	<10Ω	<1Ω	<1Ω	<1Ω	<1Ω
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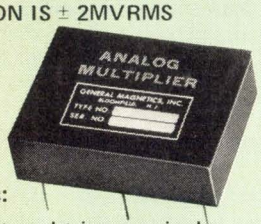
REFERENCE VOLTAGE (VRMS)	26	115	115	115	26	115	26	115	115	115	26	115
ACCURACY SIN/COS (+25°C)	±6MIN	±6MIN	±6MIN	±6MIN	±6MIN	±6MIN	±6MIN	±0.5%	±6MIN	±6MIN	±6MIN	±6MIN
FULL TEMPERATURE RANGE ACCURACY SIN / COS	±15MIN	±15MIN	±15MIN	±15MIN	±15MIN	±15MIN	±15MIN	±0.5%	±15MIN	±15MIN	±15MIN	±15MIN
D.C. SUPPLY (VDC)	±15	±15	±15	±15	±15	±15	±15	±15	±15	±15	±15	±15
D.C. SUPPLY CURRENT	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA
BANDWIDTH	>10Hz	>10Hz	external set	>20Hz	>5Hz	>10Hz	>10Hz	>10Hz	>2Hz	>40Hz	>5Hz	external set
SIZE	1.1x3.0 x1.1	2.0x2.25 x1.4	1.1x3.0 x1.1	1.5x1.5 x0.6	1.85x0.85 x0.5	2.01x2.25 x1.4	0.85x1.85 x0.5	2x2.25 x1.4	2x2.25 x1.4	2x2.25 x1.4	2.15x1.25 x0.5	1.1x3.0 x1.1
NOTES	–	dual channel unit	–	–	–	dual channel unit	–	dual sine output	dual channel unit	dual channel unit	–	–
TEMPERATURE RANGE	–40°C to +100°C	–40°C to +100°C	–40°C to +100°C	–40°C to +100°C	–40°C to +100°C	–40°C to +100°C	–40°C to +100°C	–40°C to +100°C	–40°C to +100°C	–40°C to +100°C	–40°C to +100°C	–40°C to +100°C

High Precision Analog Multipliers

PRODUCT ACCURACY (MCM 1519-1) ± ½% OF ALL THEORETICAL OUTPUT VALUES OVER FULL MILITARY TEMPERATURE RANGE OF –55°C TO +125°C. ZERO POINT ERROR FOR ANY INPUT COMBINATION IS ± 2MVRMS



Features:

- No external trims required
- Distortion free AC output over entire dynamic range
- Linearity, product accuracy and zero point virtually unaffected by temperature
- All units are hermetically sealed and are not affected by external fields
- High analog product accuracy and wave quality allows dual multiplier assemblies to be matched with 1% of point over the specified temperature range
- Full four quadrant operation
- Package size, power supply requirements and other specs. may be altered to your exact requirements at no extra cost.

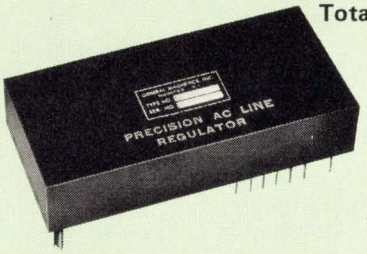
Specifications:

- Transfer equation: Eo=XY/10
- X & Y input signal ranges: 0 to ±10V PK
- Maximum zero point error (X=0; Y=0 or X=±10; Y=0 or X=0; Y=±10): 2MVRMS
- Input impedance: Both inputs 20K min.
- Full scale output: ±10V peak
- Minimum load resistance for full scale output: 2KΩ
- Output impedance: 1Ω
- Short circuit duration: 5 sec.
- Frequency response characteristics (both inputs) 1% amplitude error: DC to 1200 Hz (min.) 0.5 DB Amplitude error: DC to 3500 Hz min. 3 DB point: Approx. 10K hz Roll off rate: 18 DB/octave
- Noise Level: 5MV PK-PK @ 100K Hz approx.
- Operating temp. range: See chart
- Storage temperature range: -55°C to +125°C
- DC Power: ±15V ±1% @ 30MA
- Dimensions: 2" x 1.5" x .6"

Type No.	Product Accuracy	Operating Temperature Range
MCM 1519-1	± 0.5%	–55°C - +125°C
MCM 1519-2	± 0.5%	–25°C - +85°C
MCM 1519-3	± 0.5%	0°C - +70°C
MCM 1520-1	± 1.0%	–55°C - +125°C
MCM 1520-2	± 1.0%	–25°C - +85°C
MCM 1520-3	± 1.0%	0°C - +70°C

Precision AC Line Regulator

Total Regulation 0.15% Max.



Features:

- Low distortion sinusoidal output
- Regulation control better than ten times superior to commercial AC voltage regulators transformer product lines
- No active filters or tuned resonant circuits employed resulting in immunity to line frequency changes
- 6.5 watt output level
- Small size
- Output set to ±1% accuracy — this includes initial set point plus line, load, frequency and temperature changes
- Foldback short circuit protection provided resulting in protection against overloads and short circuits of any duration
- Low profile package with straight pins makes the unit suitable for PC board mountin (unit is hermetically sealed)
- Transformer isolation between all power inputs and the outputs.

*Other units available at different power levels. Information will be supplied upon request.

Specifications Model MLR 1476-2:

- AC input line voltage: 115V RMS ±20% @ 400 Hz ±20%
- Output: 26V RMS ±1% (for any condition)
- Load: 0 to 250 MA, RMS
- Total regulation: ±0.15% maximum (any combination of line, load or frequency)
- Distortion: 2% maximum
- AC input line current: 100 MA. max. at full load
- DC power: ±15 V DC ±5% @ 15 MA. max.
- Phase angle: 1° max.
- Temp. Range: -40°C to +85°C
- Case Material: High permeability nickel alloy
- Terminals: Glass to metal hermetic seal pins

Circle 182 on reader service card

GENERAL MAGNETICS • INC
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