NOVEMBER 23, 1978

GALLIUM ARSENIDE TO THE RESCUE IN SPACE DATA GLUT/94

Charts simplify fiber-optic design task / 135

Microprocessors in action: an adaptive-gain controller / 150

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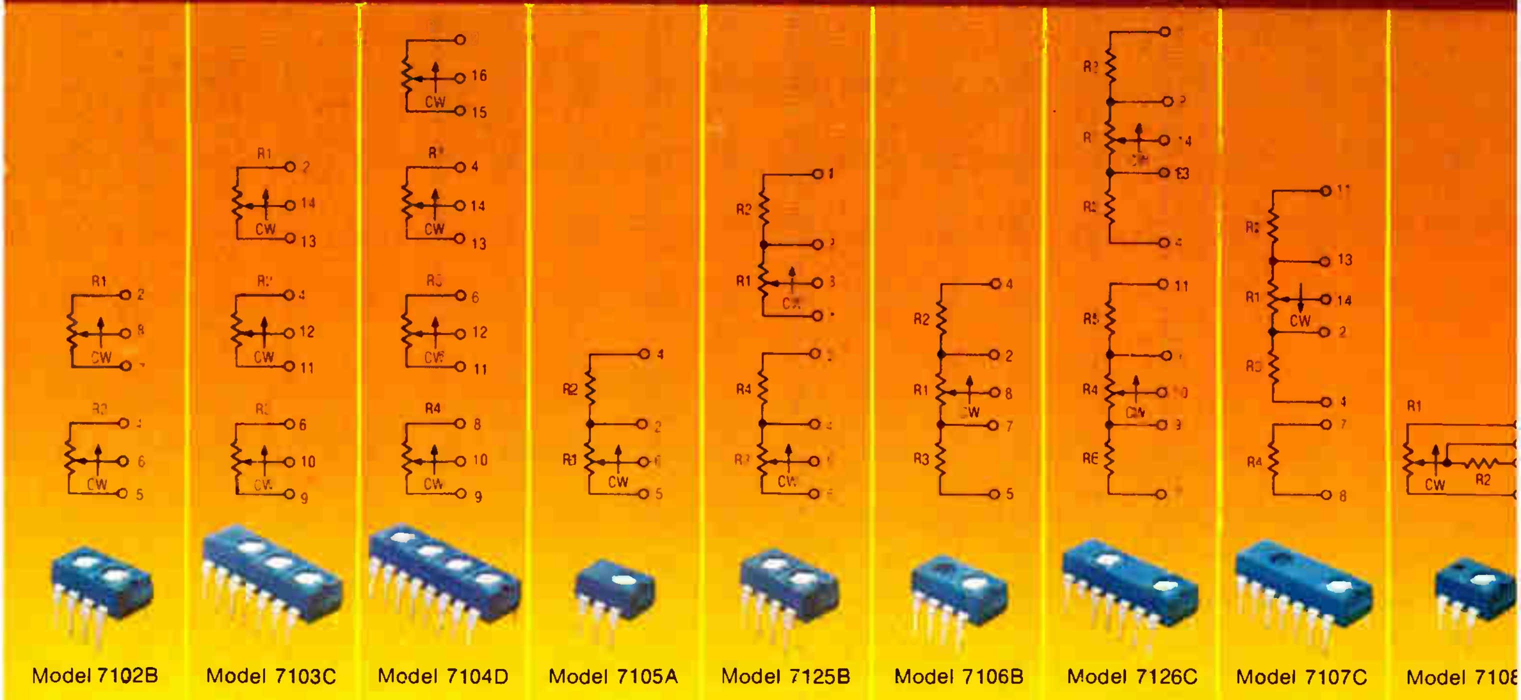

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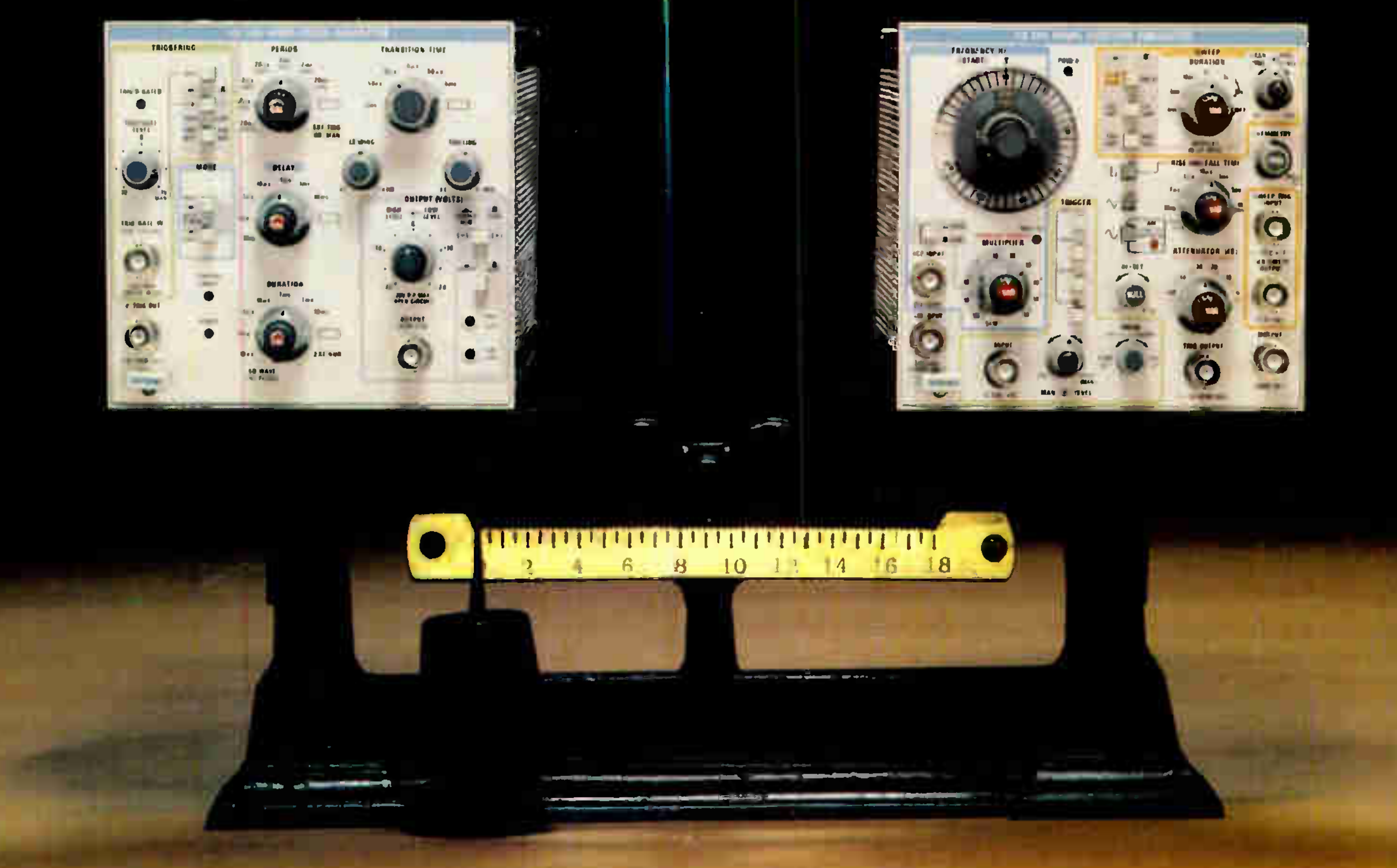

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Electronics
The International Magazine of Electronics Technology
Vol. 51, No. 24 • Nov. 23, 1978

Highlights

Cover: Work proceeds on VLSI, 111
There's no question that very large-scale integration is coming, but the complexity of the circuitry and the fine lines required mean that it will take longer to develop than did LSI. Semiconductor makers are deep into work on fabrication and testing problems.

Cover is by Sean Daly.

Will rising costs shrink the IC industry? 87
Equipment costs for the present generation of integrated circuits are skyrocketing, and VLSI promises to boost them even further. Couple that with the volume of research and development required, and the outcome may well be the end of the line for marginal chip manufacturers.

More powerful microcontrollers are here, 127
A second generation of intelligent peripheral control chips takes on dedicated-function tasks, thereby reducing demands on the central processing unit of a microcomputer system. The chips increase system throughput and reliability while simplifying design.

Charts speed fiber-optic design decisions, 135
To design fiber-optic data links, the engineer can take advantage of charts and graphs that permit initial component selection without in-depth knowledge. This is the second in a series; the third and final article will appear in the Dec. 21 issue.

And in the next issue . . .
All about distributed processing . . . a look at the International Electron Devices Meeting . . . designing a microprocessor-controlled alphanumeric display,

Electronics

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Publisher's letter

As **the electronics** industries move into the era of very large-scale integration, one fact has become inescapable: it's going to be an expensive move. This point is amplified in our special report (p. 111) and the Probing the News story (p. 87) on VLSI.

Opinions vary on how the costs will alter the semiconductor industry. On one side, there are predictions of a major shakeout, leaving only a few large companies that are able to foot the bills. But there are others who contend that the transition will be no harder than the move into LSI.

"I'm sort of in the middle," says solid state editor Ray Capece, who prepared the special report. "VLSI will not be the only thing the industry is building in the future. Just because a company is not in VLSI does not mean it's doomed."

Nevertheless, the costs and related design considerations are pressing problems. It is not unusual for a semiconductor company to commit as much as 20% of its sales revenue to VLSI research and development and equipment, Ray points out. In addition, companies are grappling with applications decisions—how to specify the functions to be performed—as well as how to test the complex circuits.

"Since fabrication does not appear to be as difficult a barrier as expected, the trend will be to use chip space to solve other problems—by designing in test circuits or using gate arrays to simplify circuit designs. As for functions, the first VLSI products will be fixed-function devices like voice processors. By the mid-1980s, we will see a general-purpose, programmable device that marries hardware and software," Ray predicts.

U. S. producers are no longer as jittery about Japanese VLSI competition as they once were. The Japanese goals are no more ambitious than those of the Americans, and the funds they are working with are no greater than those the U. S. companies are spending, according to Ray.

San Francisco regional bureau manager Bill Arnold writes in the related Probing the News that some industry experts believe the soaring price tags of production equipment, together with huge R&D outlays, may drive marginal companies out of the market. In a future in which the semiconductor industry may repeat what happened in the automobile industry, there is concern for the fate of small companies.

While the big are getting bigger, the small may have to become quicker. They'll have to be faster at recognizing and filling the niches in the market left by the giants.

Meanwhile, the equipment makers are beginning to share the financial burden for demonstrating production lines with the big companies. It is now incumbent on the equipment vendors to prove the benefits of the new lines, even to the point of running some of the processes at their own expense, Bill points out. So the high cost of VLSI seems likely to hit everybody.

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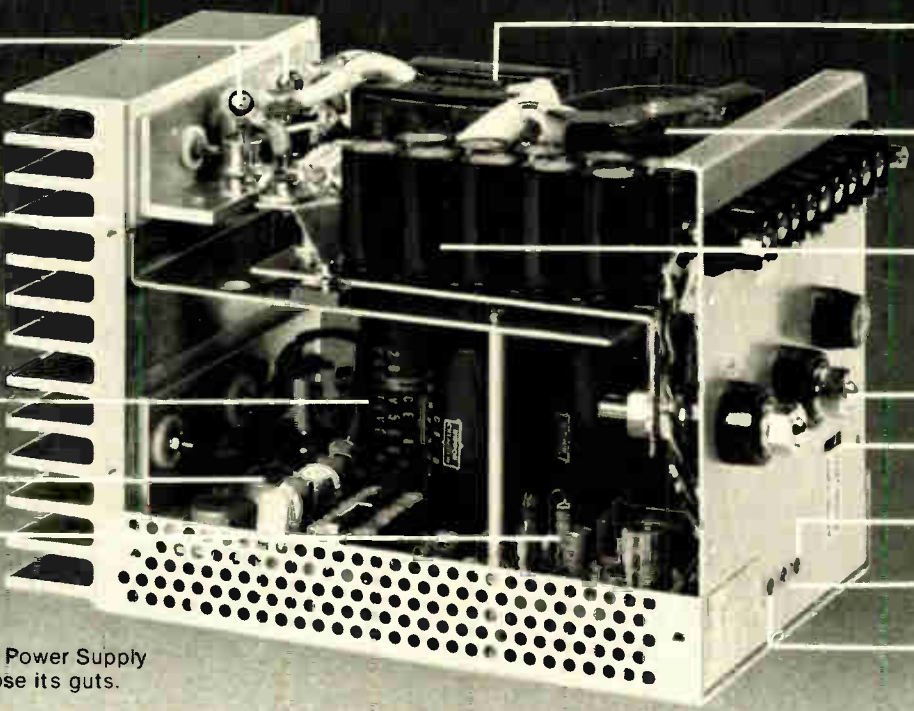

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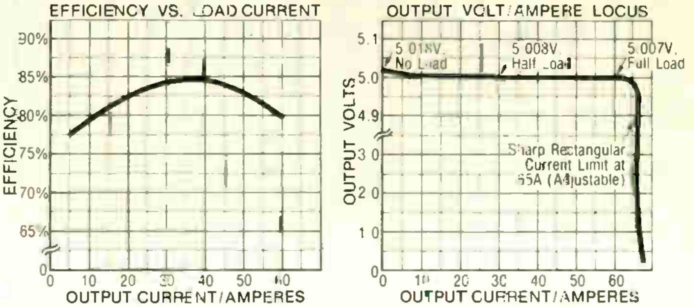

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Circle 5 on reader service card

Readers' comments

Whose assessment?

To the Editor: Concerning the item in your Sept. 28 Washington Newsletter, "Pentagon chills NATO adoption of standard" [p. 61], it would have been better to find out what Cenelec's principles are and what the Cenelec Electronic Components Committee (abbreviated to CECC) does before publishing this piece, as well as a previous Washington Commentary [Nov. 10, 1977, p. 50].

Leaving aside the big influence the U. S. Pentagon has on the North Atlantic Treaty Organization, we know very well the preoccupations of the Electronic Industries Association regarding the operation of the CECC's system for quality assessment of electronic components.

From your item, one could get the impression that NATO had wanted to introduce something unknown, created by some unknown people, in an unknown place in Europe. Fortunately, in particular for the new International Electrotechnical Commission quality assessment system (IECQ), that is not the case.

The CECC system is operated by 11 electrotechnical committees of European countries that are also members of the IEC and that will play a very important part in the future operation of IECQ as well. Thanks to the experience gained when setting up the CECC system and drawing up the necessary rules of procedure, the IECQ could get a much faster start.

In contrast, as can be seen from last November's Washington Commentary, the U. S. electronics industry was not at all interested in such a scheme.

The success of the CECC system prompted the move for the IECQ, but in no way will the CECC and the IEC systems compete once the latter is operating. On the contrary, they will fruitfully complement each other, since it is a well-established Cenelec principle to take over as much from the IEC as possible.

It is to be hoped that the relevant NATO officials will have a second chance to reconsider the use of CECC specifications for electronic components and that it will not unnecessarily delay the introduction of a good quality assessment system, which will be worldwide, because of political and economic pressure.

H. K. Tronnier
Comité Européen de
Normalisation Electrotechnique
Brussels, Belgium

Clarity: a life-or-death issue

To the Editor: Once before I wrote about the poor audio quality extant in aircraft communications. The responses ranged from "overstated" to "ho-hum."

But as anyone who has heard the tapes from the San Diego disaster knows, the situation has not improved. To the average listener, these tapes are completely unintelligible. When they were used on television, it was necessary not only to have someone repeat the conversations, but also to print an overlay of subtitles.

I cannot believe these scarcely understandable communications are not at least partly responsible for accidents and near-misses. In this day and time, such a total lack of fidelity is inexcusable, if not criminal. (To the degree that I've not heard the Air Line Pilots Association complain, it must share in the responsibility.)

Why is this state of affairs tolerated and never mentioned or cited as a problem?

Richard G. Devaney
Kingsport, Tenn.

'Medium' vs 'media'

To the Editor: There seems to be a lot of confusion in the engineering fraternity about the terms "medium" and "media," especially as they pertain to the recording of data. The terms are often used interchangeably, and in particular, "media" is frequently used where "medium" is meant. "Medium," according to my dictionary, means [among other things] "a means of conveying something" or "a mode of communication." "Media" is the plural form of "medium." Thus it doesn't make sense to say "the floppy disk as a recording media."

Dale Hileman
Woodland Hills, Calif.

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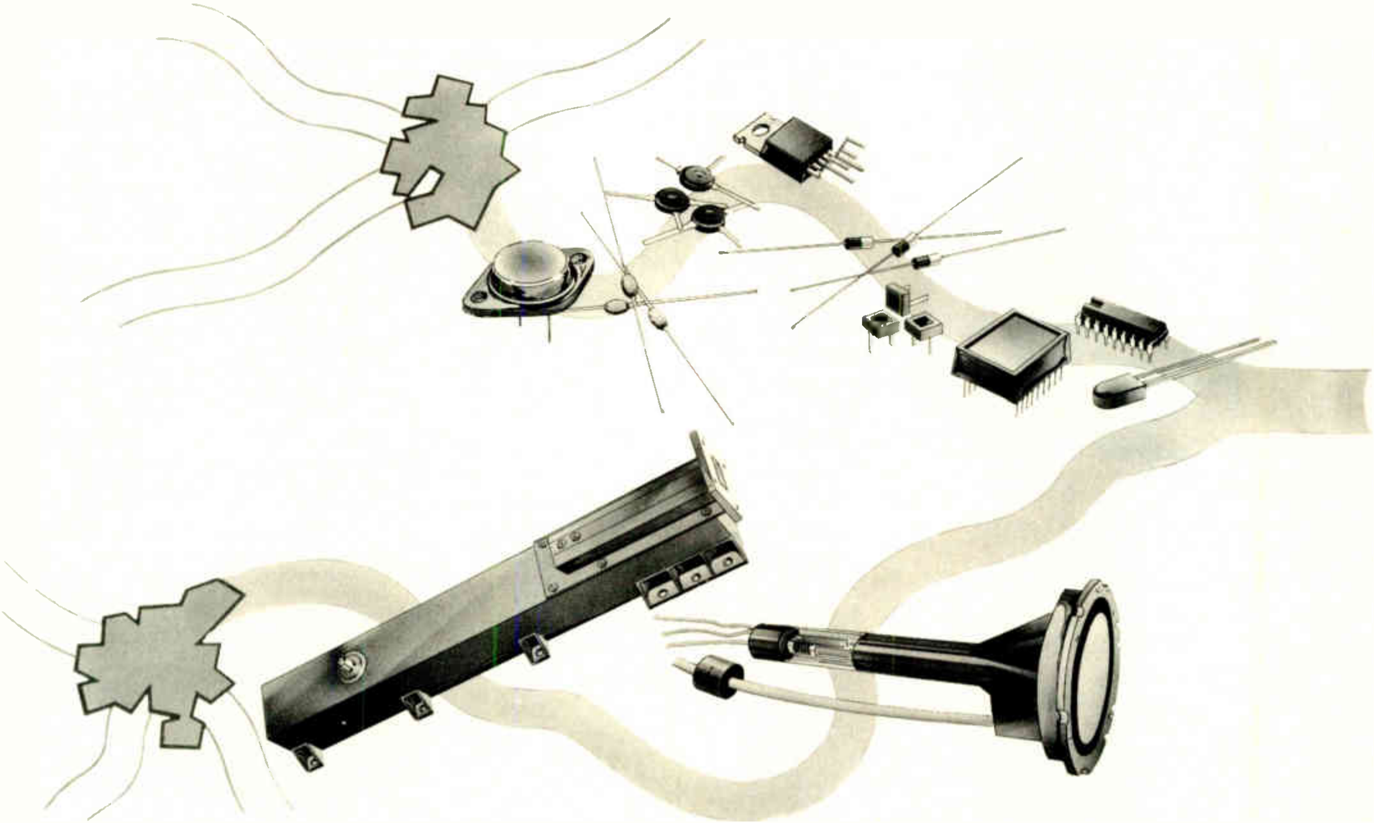

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News update

■ There will be a little bit of Chicago in Atlanta beginning in 1980, when the Bell System will install its first standard light-wave communications system for voice and data in the southern city. Chicago is where American Telephone & Telegraph Corp. conducted its successful one-year trial of a fiber-optic link between two switching offices [*Electronics*, Dec. 22, 1977, p. 43].

The Atlanta system will initially involve three central offices and will be the forerunner of other standard metropolitan trunk systems that will be made available to Bell operating companies by Western Electric. Connecticut, Florida, and Arizona are on the light-wave schedule, with the sites in Florida and Arizona near power stations. The fiber cables are immune to the severe electrical interference of such locations.

Bell uses laser sources rather than light-emitting diodes. The Chicago link operated at 44.7 megabits per second over 1.5 miles of 24-fiber cable serving as a trunk between two downtown exchanges and as a customer loop to an office building. It carried voice traffic for all three, and data and video between one exchange and the building. **Harvey J. Hindin**

■ The Sony Corp. has stretched the playing time of its pulse-code-modulated audio disk to 2½ hours. As demonstrated in prototype form early this month at the Audio Engineering Society's convention in New York, Sony's latest optical system, the DAD-1X, differs from last year's 30-minute model [*Electronics*, Sept. 29, 1977, p. 42] in two ways: it rotates more slowly (450 vs 1,800 revolutions per minute) and has a higher recording density.

According to Toshi Doi, a scientist at Sony's Audio Technology Center in Tokyo, the company is investigating two more refinements. One would replace the player's helium-neon pickup laser with a solid-state version; the other would slow the disk as the pickup moves toward the outer tracks, increasing playing time another 50%. **John Javetski**

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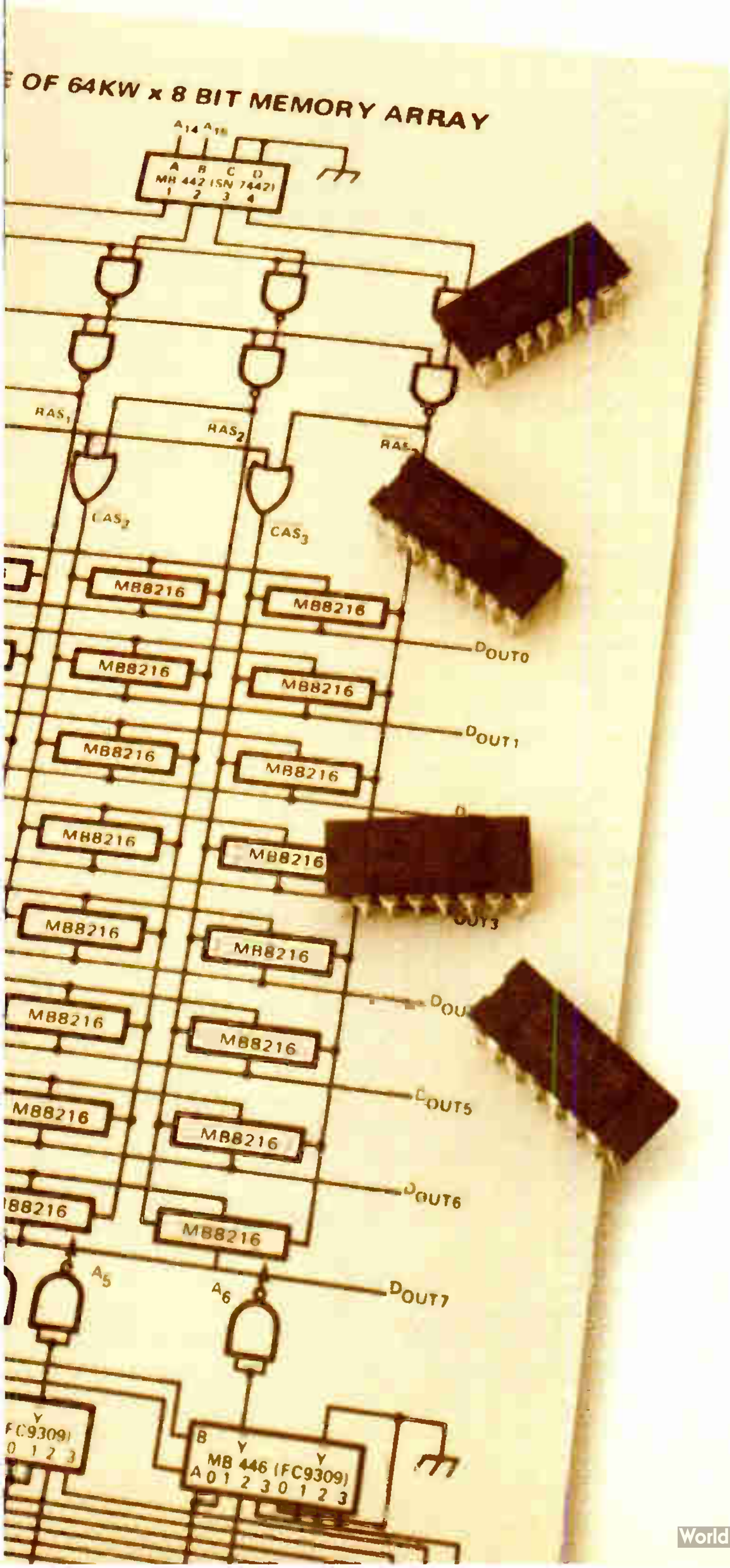

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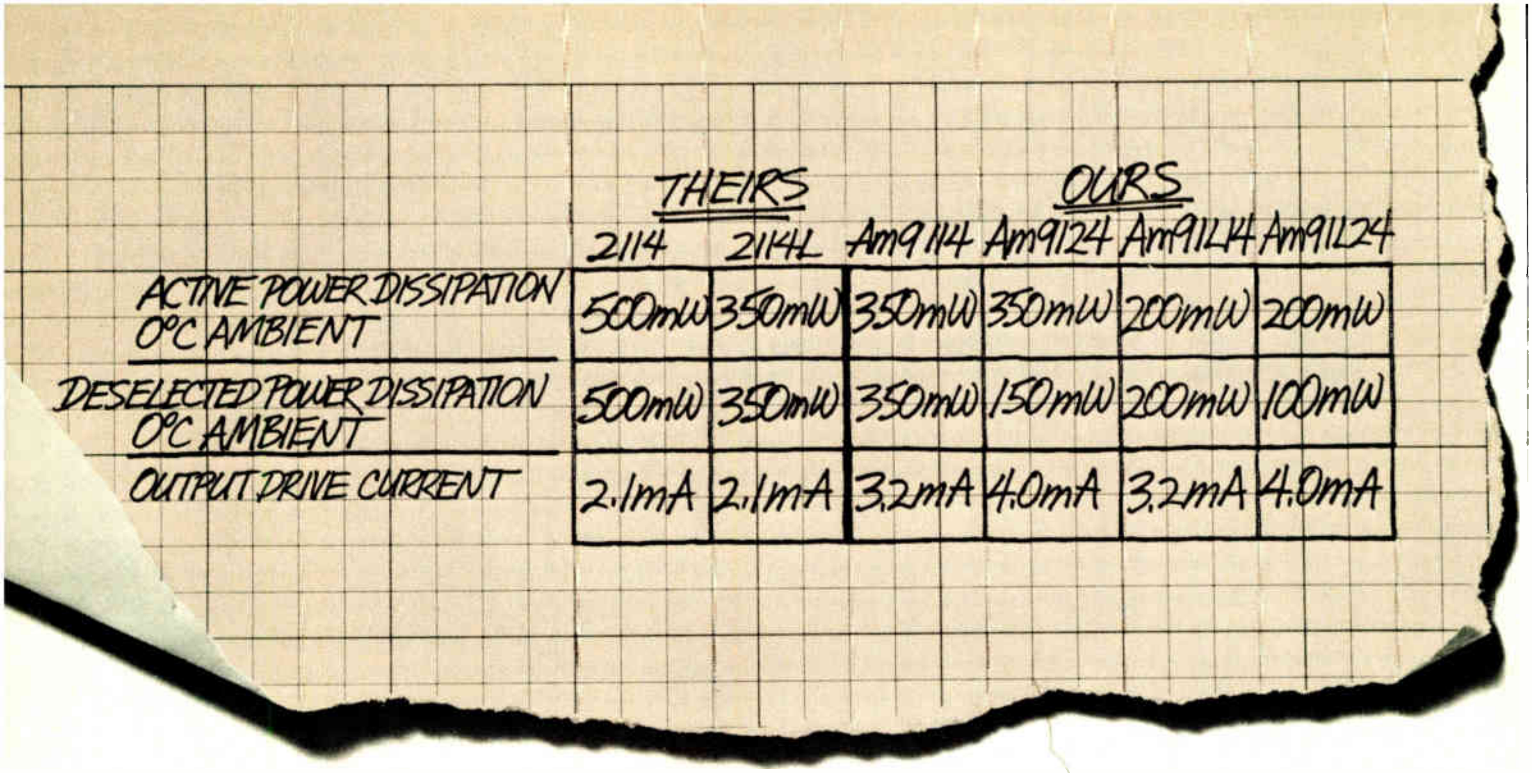

	THEIRS		OURS			
	2114	2114L	Am9114	Am9124	Am91L14	Am91L24
ACTIVE POWER DISSIPATION 0°C AMBIENT	500mW	350mW	350mW	350mW	200mW	200mW
DESELECTED POWER DISSIPATION 0°C AMBIENT	500mW	350mW	350mW	150mW	200mW	100mW
OUTPUT DRIVE CURRENT	2.1mA	2.1mA	3.2mA	4.0mA	3.2mA	4.0mA

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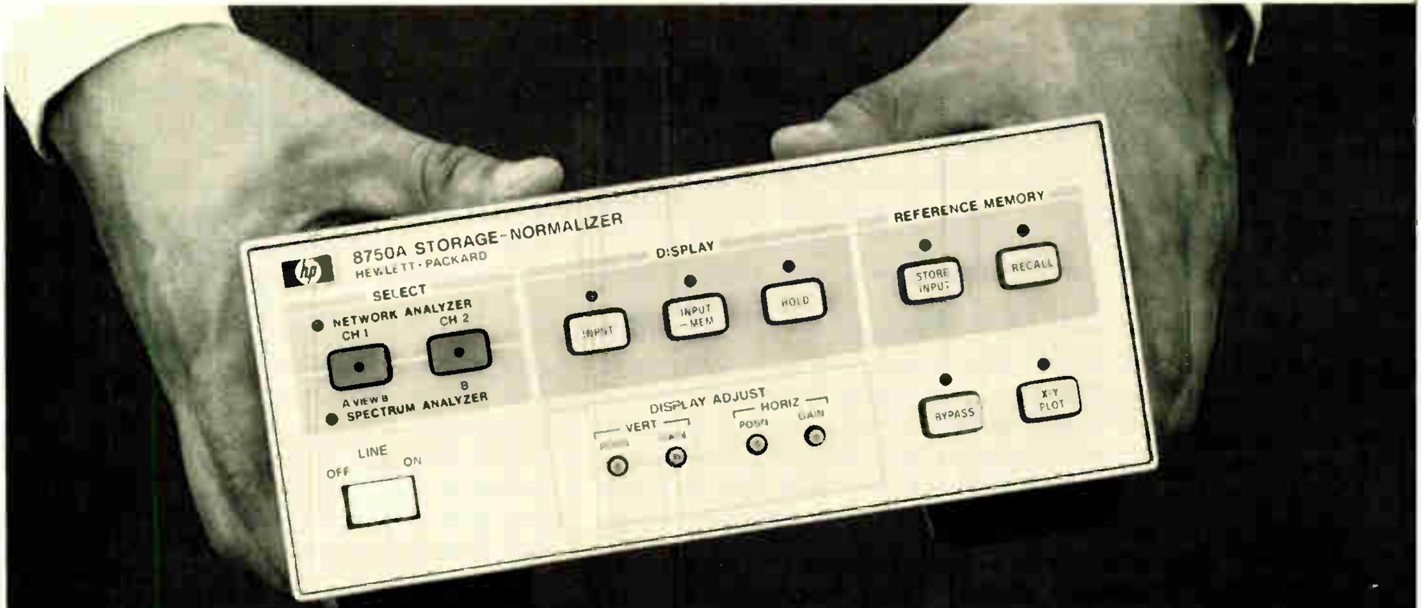
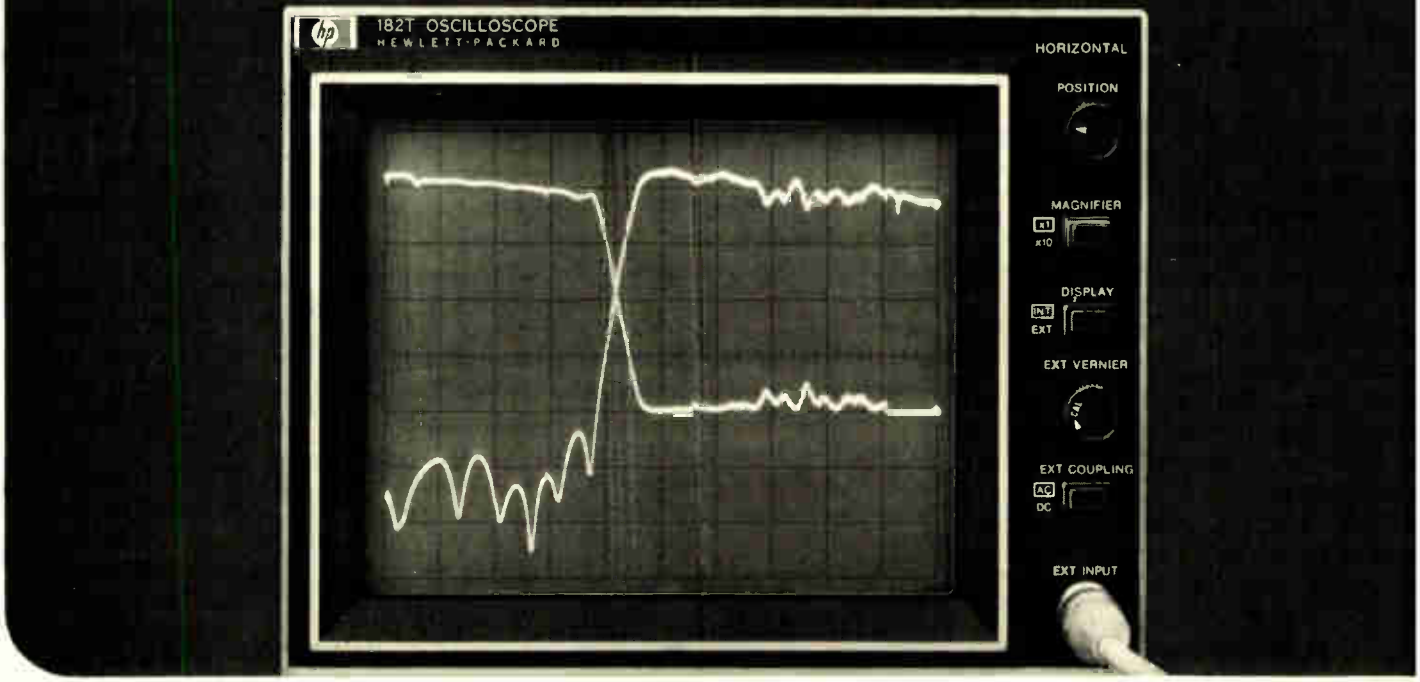


Add this to your HP Network or Spectrum Analyzers and immediately enhance their capability.

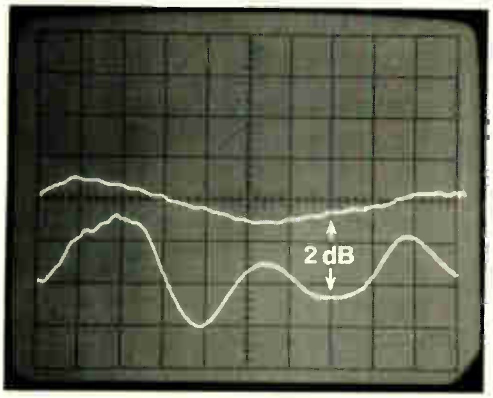


The HP8750A Storage-Normalizer: It brings additional accuracy and simplicity to swept frequency measurements.

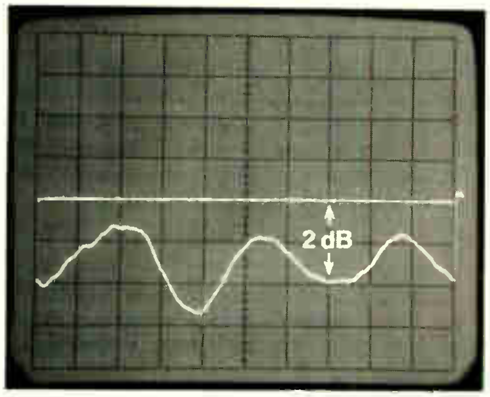
Here's an extremely useful and versatile accessory for most HP Network and Spectrum Analyzers. The 8750A Storage-Normalizer employs memory techniques to "normalize"— that is, remove system response from measured data. And its digital storage, constantly updated, provides a continuous flicker-free display regardless of sweep speed.

Here are some examples of the improvements it can bring to your swept frequency measurements:

High Accuracy Measurements.



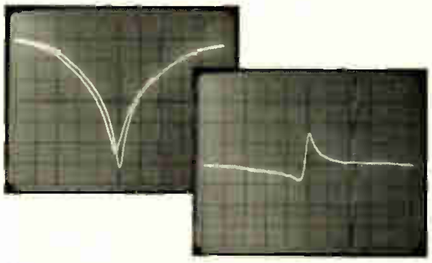
Before Normalization



Normalized

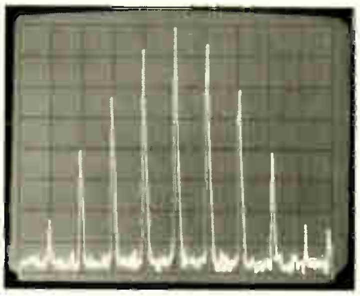
Frequency response or tracking errors in transmission or reflection measurements are eliminated with normalization. You can calibrate the test system's response and store it, then subtract it from the measured data. The resultant difference represents the corrected measurement that's displayed directly in dB.

Comparison Measurements.



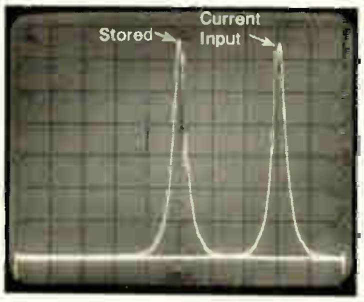
No longer is it necessary to visually scale deviations between two traces. With the HP 8750A, you can now display the *difference* between the two. Deviation between test devices is displayed directly in dB with a single trace.

Slow Sweep Measurements.



Use it for high resolution measurements when slow scan times are needed and get a bright, flicker-free display. Measurement data are displayed from memory with continuous refresh, independent of scan time and scope adjustments.

Spectral Comparisons.



Using the 8750A in spectrum analysis applications, a signal spectrum can be frozen on the CRT and then compared directly with the current input signal.

Because the HP 8750A can "freeze" the display, photography is simplified and hard copies such as X-Y recordings can automatically be plotted, even while new measurements are being made.

Domestic U.S. price of the Storage-Normalizer is $1450.

Call your HP field engineer for more information on how the 8750A enhances measurements made with HP 8755, 8410, 8407 and 8505 Network Analyzers, HP 8557, 8558 and 8565 Spectrum Analyzers, plus other instruments. Or write.

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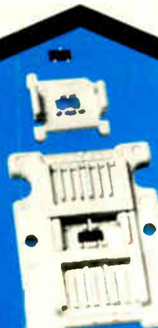

People

Corell's concern is for people, as well as for engineering

The new vice president of engineering at Centronics Data Computer Corp. appears to be as genuinely interested in the career objectives of his engineers as he is in their design and development skills. In fact, Edward B. Corell is convinced that concern for those objectives will help his engineering department meet its responsibility for research and advanced development and product and manufacturing engineering.

Centronics, a $75-million-a-year company based in Hudson, N. H., manufactures printers for a broad range of computer systems and data networks. Corell brought concern for his employees' goals from Digital Equipment Corp., where, as a group engineering manager, he helped lead the minicomputer giant into the terminal business.

Since arriving at Centronics last month, the 37-year-old Corell has held weekly breakfast meetings with members of his department. "We want people to realize that management wants to hear their thoughts and ideas," Corell says. "Some people are concerned about the pace of technology, others about their careers. I think the meetings have been beneficial to me in getting to understand them and, I hope, in helping them to understand me."

Corell wants to enlist his people's ideas "and make them feel that this is their own company. We really want them to participate in decisions. If people feel a plan is theirs, they'll make it a success."

Organizational structures can stifle ideas, Corell believes, and he wants to make sure he has an open path through which ideas may reach him. "Ideas are fragile," he says, "and they may not surface again if they're knocked down because the whole discussion revolves about meeting production schedules."

If it all sounds like a bit too much motherhood, Corell, who has a doctoral degree in mechanical engineering, points out that concern for people's goals can work well. He wants to blend a strong entrepreneurial business drive with strong design and manufacturing capabilities "for a fantastically powerful combination." Does that mean that Centronics might branch out from printers into other peripherals? All Corell will say is that "we'll have the right products when they're required, whether they are printers or not."

Team-up. Edward Corell wants to mix entrepreneurial drive with engineering ability.

Sauvé looks to boost Canada's space work

Canada wants more space systems work for itself and less dependence on facilities in the United States. That's why Canada's minister of communications, Jeanne Sauvé, is behind the $20 million expansion of the government's David Florida Laboratory at the Communications Research Center in Ottawa.

The expanded lab will provide Canadian industry with a fully equipped facility for final assembly and testing of communications satellites, the minister says. It will be used for Canada's own space projects, as well as for those of other nations. In addition, the center will create some 1,500 new jobs, important for a country where unemployment is high. "And the government is exploring other methods of industrial stimulation and technology transfer from government research to industry," Sauvé says.

The communications minister for

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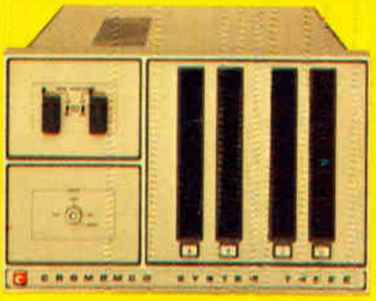

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People

Booster. Minister Sauvé wants more for Canada's 40-plus aerospace companies.

the past three years, Sauvé looks back on an extensive career as a broadcaster and journalist, as well as a Liberal member of Parliament elected in October 1972. Shortly after, she joined Prime Minister Trudeau's cabinet as minister of state in charge of science and technology, and later she was named minister of the environment, serving until her appointment to her present post in December 1975.

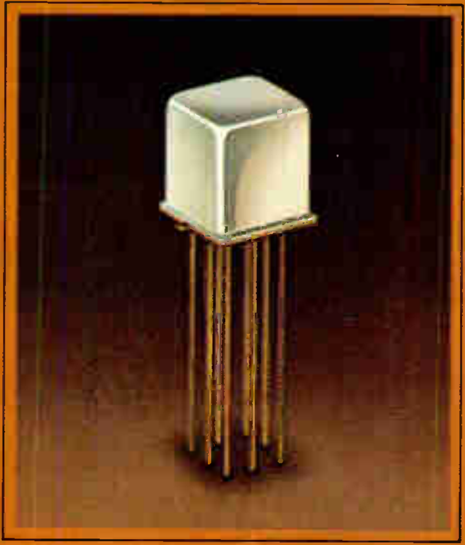
Continuing strong. It is her hope that Canada will continue as a strong contributor to space programs. "Canada was the third country in the world, after the Soviet Union and the United States, to design and build its own satellite and the first country in the world to have a geostationary domestic satellite communications system," she says. "And we had the first time-division multiple-access system anywhere."

Sauvé wants the more than 40 Canadian companies engaged in space systems work to have a goodly share of the space market, amounting to billions of dollars, over the next two decades. "Canada will compete aggressively," she promises.

She says her ministry will cooperate wherever possible with the Canadian Advanced Technology Association, a new group devoted to promoting the interest of Canadian high-technology companies [*Electronics*, June 22, p. 52]. She also is concerned about the controversy between Bell Canada and Canadian regulatory agencies in their disagreement over how revenues from foreign contracts should be apportioned in setting domestic tariffs. ☐

TO-5 RELAY UPDATE

Centigrid II: Never before a relay this sensitive at this size



We told you that our Centigrid® was the ultimate subminiature relay – and it is. Centigrid II is not a replacement, but a companion developed for applications that demand ultra-small size *plus* ultra-high sensitivity. Centigrid II dissipates 65% less power than the .150 grid relay, and 75% less than the ½ crystal can. And it still features .100″ grid spaced pinout for optimum pc board layouts and occupies only .14 sq. in. of board space.

Like the TO-5, the Centigrid II makes an ideal subminiature RF switch, providing high isolation and low insertion loss up through UHF frequencies. And the low coil power requirement means extended battery life for hand-held transceivers.

Centigrid II meets all requirements of MIL-R-39016, and is available with internal diode suppression. Call or write us today for complete specification data.

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Measure Frequency to 512 MHz or 1,250 MHz.
New 6040 Series of Thin Line Frequency Counters make automatic measurements to 512 MHz (Model 6042A) and 1,250 MHz (Model 6043A). The IEEE-488 bus feature is standard, and so are:
- input attenuation • full 8-digit LED readout
- overload protection • and down to earth prices.

S-D:
The bus compatible people. And a lot more.

all IEEE-488 systems.

Measure DC Voltage, AC (true RMS) Voltage and Resistance. The new 4½-digit Model 7344A Digital Multimeter does it all with the IEEE-488 bus feature. It is the companion twin to the two Thin Line Counters. In only 1¾ inches of total panel height you can now make IEEE-488 bus controllable multimeter measurements with 0.02% DC accuracy. Combine the 7344A with a 6040 Series counter and you have the most advanced measurement system for your test bench or system console.

To find out more about these quality products, contact Scientific Devices, our nation-wide, factory-trained manufacturer's representatives. (See phone numbers below.) Or contact us at 10 Systron Drive, Concord, CA 94518. Phone (415) 676-5000.

Other S-D IEEE-488 system instruments

Model 1626 Frequency Synthesizer (Left)
This new 26 GHz Frequency Synthesizer is a state-of-the-art frequency source for the most demanding applications requiring high stability and accuracy.

Model 3530 Instrumentation Controller (Center)
The Model 3530 controls any IEEE-488 compatible instrument. Language: BASIC. Includes microcomputer with up to 64K byte memory. Also available: programmable 16 x 64 matrix switching system with expansion capability.

Model 1702 Signal Generator (Right)
A fully programmable synthesized signal generator covering 100 Hz to 1,000 MHz in one range. Order with or without GPIB option. Resolution 100 Hz

Not shown:
Model 6054B 26 GHz Automatic Counter
Model 154-4 Automatic Pulse Generator
Model 7115 DVM with microprocessor control
Model DPSD-50 Dual 50 W Power Supply

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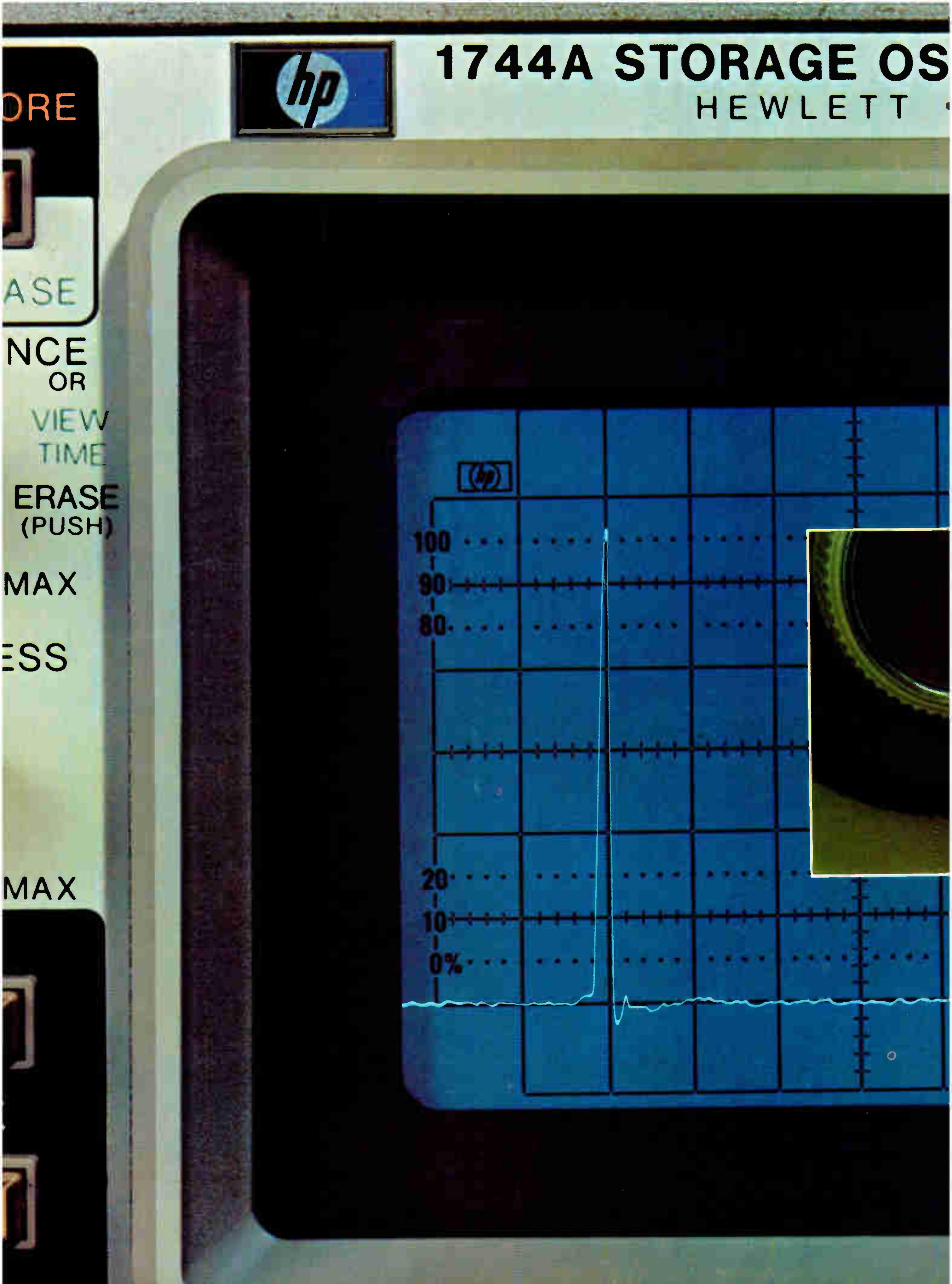
World Radio History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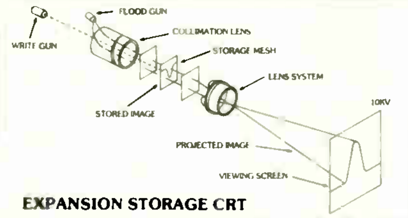
For a 100 MHz storage scope that can capture its bandwidth and display glitches this sharply...

HP's new 1744A is the Answer.

The key to this storage scope's superior performance is HP's advanced CRT design. It's called Expansion Storage. And this faster-writing technique lets you capture single-shot and low-rep-rate events over a larger display area with greater clarity.



EXPANSION STORAGE CRT

Take a good, hard look. Any input signal within bandwidth specification will be displayed cleanly by the 1744A. With the sharpness you need for detailed evaluation of hard-to-catch waveforms. Our Auto Erase/Auto Store modes simplify your pursuit of these elusive signals. Auto Erase provides hands-off operation while Auto Store prepares the scope to snare the troublemaker the instant it occurs. Both are powerful tools for capturing the spurious spikes that disrupt your logic circuitry.

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Editorial

IEEE's routine election

Like the national off-year elections earlier this month, balloting for officers of the Institute of Electrical and Electronics Engineers produced little change.

Once again, fewer than 50,000 voting members selected the president and executive vice president to represent some 180,000 members. Once again, Irwin Feerst lost. Once again, a constitutional amendment put on the ballot by one of the local sections and opposed by the board of directors fell short of adoption. (It would have required direct election of those board members chosen by the IEEE annual assembly.)

Apparently, the majority of members do not care about electing officers and have no interest in the running of the institute. If anything, the drop in ballots cast suggests interest is declining. The total number of votes fell from just over 49,000 last year to not quite 43,500 this year.

However, we have always contended that multi-candidate elections and constitutional amendments proposed by the grass roots keep the IEEE leadership on its toes. In this respect, Irwin Feerst is to be commended for his tenacity in challenging the establishment during his many presidential campaigns. But it is time for other faces and thinking from the reform wing of the institute.

Therefore, rather than discount these elections, it would be good to base a plan on its message. If IEEE leaders are to be decided by a minority, now is the time for that minority to start looking for some fresh new members to run for office—both from the establishment and from among the grass-roots reformers.

Just as the voters in a national election are turned off by seeing the same old names on the ballot and turned on by bright newcomers, IEEE members should respond to a completely new lineup of candidates.

The changing semiconductor game

If you haven't started your broad-based semiconductor company yet, forget it. The technological and economic barriers stacked against the kind of enterprise that, legend has it, started in a garage and spawned the industry are enough to turn back even the most starry-eyed entrepreneurs.

Look at the prices of semiconductor manufacturing equipment: in some cases, the cost of a piece of equipment has risen to $500,000 from the $100,000 of just a few years ago. With very large-scale integration coming, the curve will head only upward.

But all is not lost. The high price of such equipment might encourage small, specialized semiconductor makers to chip off small pieces of the market that are of no interest to the giants. As the big get bigger, moreover, they will be contracting out more of the routine design and production jobs that they once completed in house, offering more opportunities for alert businesses.

So if you've always wanted to be a semiconductor manufacturer, just redirect your sights a bit below the vertically integrated giants. You might see a gap worth filling.

Heavy duty programmer duplicates PROMs like greased lightning.

Simple, pass/fail production-line programming.

Use our benchtop M910 production programmer for general production line programming, for blank-checking or verification, or for quality assurance testing. The M910 is so simple and provides such readily understood pass/fail information that you can teach your manufacturing personnel to use it in minutes. In the M910's automatic mode, the operator loads the PROM, pushes one button and the programmer automatically blank checks, duplicates and verifies. A pass/fail light and an accompanying audio tone give dual indications of PROM status. The M910 also has individual pushbutton selection of blank check, duplicate or verify functions.

No matter what your PROM, the M910 can program it with maximum yield using one of our vendor-approved plug-in personality modules.

The M910 accepts our full range of PROM personality modules including dedicated modules for single PROMs, gang modules which let you program up to 8 PROMs simultaneously, and generic modules which program entire PROM families.

The M910 gives you a direct PROM to PROM copy with no intermediary buffering. We use separate sockets for the master PROM and the copy PROM. No programming voltages go to the master socket, so your master can't be accidentally altered or destroyed by operator error.

Like all our control units and PROM personality modules, the M910 comes U.L. listed, designed and built to U.L. electrical safety standards.

It's a fully portable benchtop unit that weighs less than 18 pounds with personality module installed.

Top yield and throughput per dollar.

An M910 control unit costs only $1,400. Single PROM personality modules cost from $350 to $600. Generic modules start at $530. Gang modules are $950 to $1,050.

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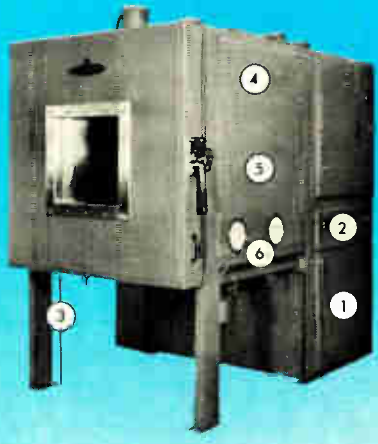

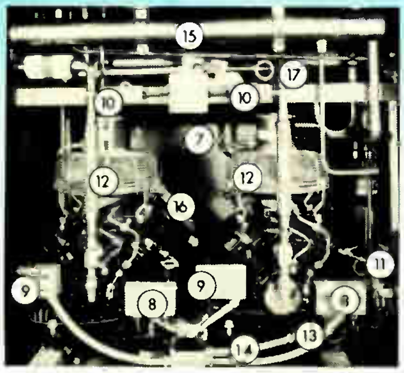

Meetings

Annual Convention of the Association of Computing Machinery (Mountvale, N. J.), Sheraton Park Hotel, Washington, D. C., Dec. 4–6.

Small Computing Systems Conference and Exhibition, American Institute of Industrial Engineers (Santa Monica, Calif.), Sheraton Palace Hotel, San Francisco, Dec. 4–6.

International Electron Devices Meeting, IEEE, Washington Hilton Hotel, Washington, D. C., Dec. 4–6.

National Telecommunications Conference, IEEE, Hyatt Hotel, Birmingham, Ala., Dec. 4–6.

Winter Simulation Conference, IEEE, Deauville Hotel, Miami Beach, Fla., Dec. 4–6.

Midcon 78 Show and Convention, Electronic Conventions Inc. (El Segundo, Calif.), Dallas Convention Center, Dallas, Dec. 12–14.

Computer Networking Symposium, IEEE, the National Bureau of Standards, Gaithersburg, Md., Dec. 13.

Third Biennial University/Industry/Government Microelectronics Symposium, IEEE, Texas Tech University, Lubbock, Texas, Jan. 3–4.

Modern Data Communications Seminar, George Washington University, Washington, D. C., Jan. 3–5

Winter Consumer Electronics Show, Electronic Industries Association, Las Vegas Convention Center, Las Vegas, Nev., Jan. 6–9.

17th Conference on Decision and Control, IEEE, Islandia Hyatt House, San Diego, Calif., Jan. 10–12.

Radar Signal Processing Seminar, George Washington University, Washington, D. C., Jan. 15–19.

Fourth Automated Testing for Electronics Manufacturing Seminar and Exhibit, Benwill Publishing Corp. (Boston), Marriott Hotel, Los Angeles, Jan. 23–25.

Only Mostek has all the numbers.

Mostek Telecommunications Family

Tone Dialers	Pulse Dialers	Tone Receiver	Codecs	Repertory Dialers
MK 5087	MK 5098	MK 5102	MK 5116	MK 5170
MK 5089	MK 5099	MK 5103	MK 5150	
MK 5091	MK 50981		MK 5155	

Coming soon, MK 5200 Codec filter.

Mostek has a full line of telecommunication circuits that offer cost effective solutions for big systems or small. Tone dialers, pulse dialers, repertory dialers, tone receivers and codecs are available in volume now, with 2-4 wire converters and monolithic filters coming soon.

We made a commitment to telecommunication products in 1974 when we built our first tone dialer. During the past year, we've shipped over two million circuits and earned our reputation as industry's most dependable source for reliable products.

Mostek's leading role in technology has brought outstanding products to the telecommunications industry. Our MK5102 Tone Receiver operates from a single 5-volt power supply in a space-saving 16-pin package. And our new one-chip codec, the MK5116, offers industry's smallest package (16-pin) and lowest power (30mW), making it ideal for applications where space and power are critical.

The point is, for total telecommunications capability, there's only one name in the book. Mostek. The company with all the numbers.

Call or write for details: Mostek, 1215 West Crosby Road, Carrollton, Texas 75006; Telephone 214/242-0444. In Europe, contact Mostek Brussels; Telephone (32) 02/660.25.68.

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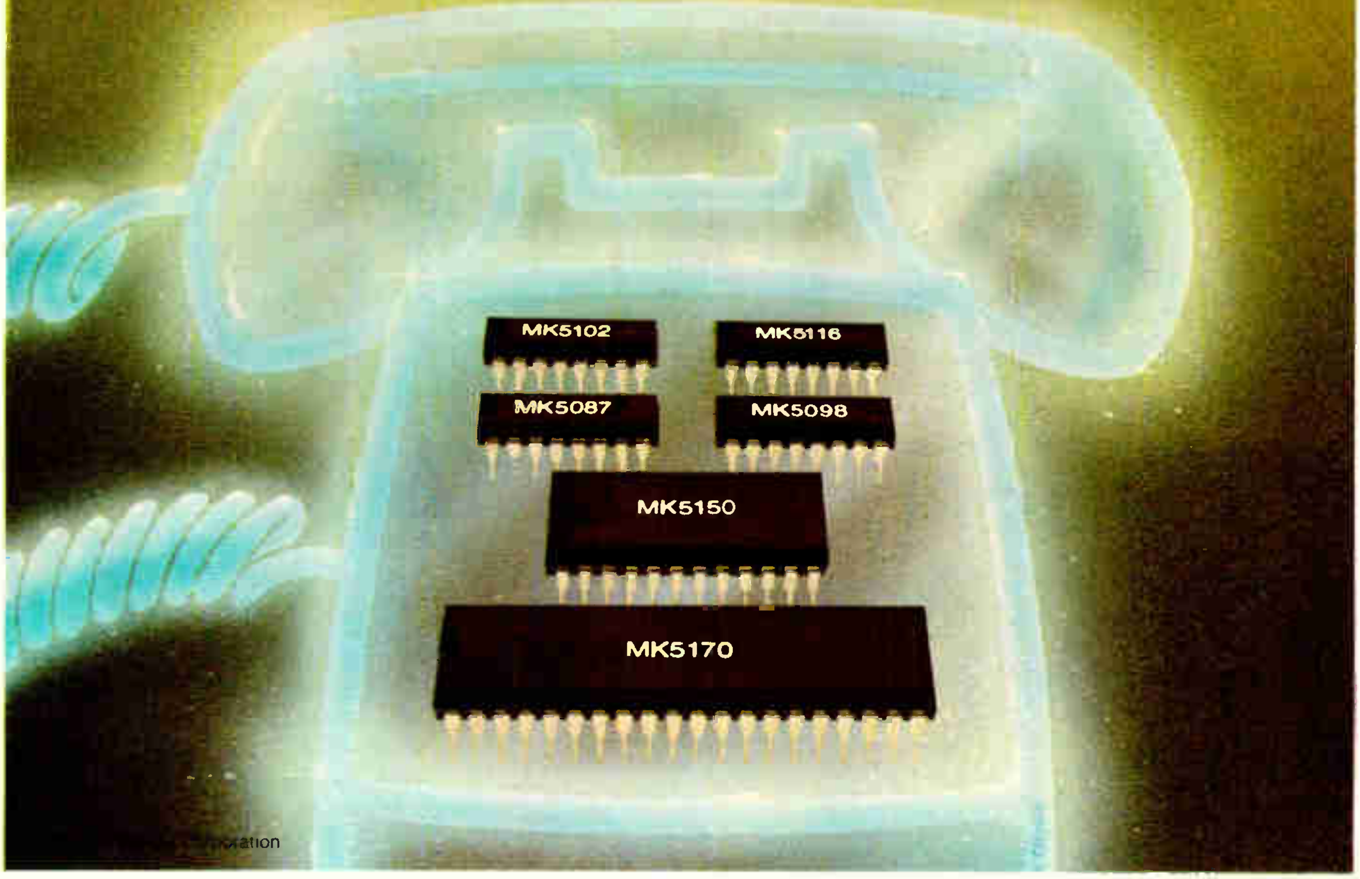

Circle 27 on reader service card

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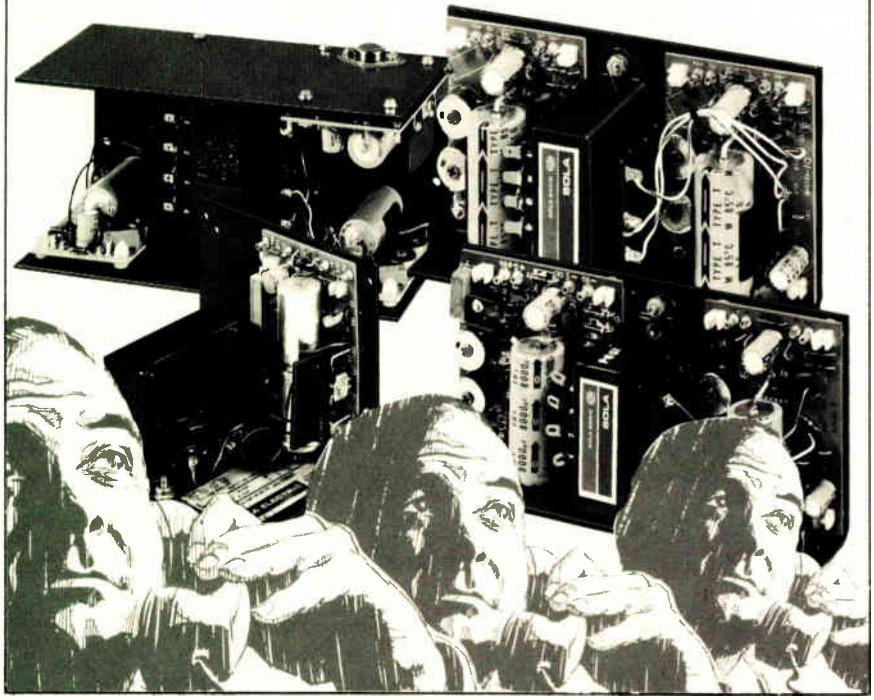

Circle 28 on reader service card

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Meetings

Conference on Reliability and Maintainability, IEEE, Shoreham Americana Hotel, Washington, D. C., Jan. 23–25.

Communication Networks Conference & Exposition, The Conference Co. (Newton, Mass.), Sheraton Park Hotel, Washington, D. C., Jan. 30–Feb. 1.

Wincon—Aerospace & Electronic Systems Winter Conference, IEEE, Sheraton Universal Hotel, Los Angeles, Feb. 6–8.

Phase Locked Loops Seminar, George Washington University, Washington, D. C., Feb. 12–13

International Solid-State Circuits Conference, IEEE, Sheraton Hotel, Philadelphia, Feb. 15–17.

Intelcom 79—Second International Telecommunications Exposition, Horizon House International (Dedham, Mass.), Dallas Convention Center, Dallas, Feb. 26–March 2.

Nepcon West 79, Industrial and Scientific Conference Management Inc. (Chicago), Anaheim Convention Center, Anaheim, Calif., Feb. 27–March 1.

Digital Encoding and Processing of Voice and Video Seminar, George Washington University, Washington, D. C., Feb. 27–March 1.

ICE 79—International Computer Expo, Marcom International Inc. (Tokyo) and Golden Gate Enterprises Inc. (Sunnyvale, Calif.), Tokyo Harumi Fairgrounds, Tokyo, Feb. 28–March 2.

Optical Fiber Communication Meeting, IEEE and Optical Society of America, Shoreham Americana Hotel, Washington, D. C., March 6–8.

Fifth Annual Conference and Exhibit on Industrial and Control Applications of Microprocessors, Information Gatekeepers Inc. (Brookline, Mass.), Sheraton Hotel, Philadelphia, March 19–21.

Move over 2114s.
Mostek's 8K static RAM is moving in!

Double your system density by replacing two 2114s with Mostek's new MK 4118 8K static RAM. In addition, you gain significant improvements in speed, power, and design flexibility over older generation 2102 and 2114 static RAMs.

MK4118 Family

	Access Time	Cycle Time
MK 4118-1	120 ns	120 ns
MK 4118-2	150 ns	150 ns
MK 4118-3	200 ns	200 ns
MK 4118-4	250 ns	250 ns

Organized as 1K X 8 bits, the MK 4118 is designed to interface directly with all present and future generation microprocessors. A Chip Select control is provided for easy memory expansion and decoding, and internal latches are available to latch the Address and Chip Select inputs, further simplifying system design. If the Latch function is not needed, it can be bypassed by connecting the Latch control input to +5V (the only power supply needed for the MK 4118). A fast Output Enable function (50% of address access) allows easy control of the data bus in all bus configurations.

All inputs and outputs are TTL compatible, and the MK 4118 is pin compatible with standard 24-pin ROMs, PROMs, and EPROMs, such as the MK 2716.

Advanced circuit design and Mostek's Poly R™ process technology are combined to pack 8K bits of static RAM on a chip comparable in size to 4K static RAMs. Performance, reliability, flexibility, compatibility. The 4118 is the obvious choice. For information contact Mostek, 1215 West Crosby Road, Carrollton, TX. 75006. Telephone 214/242-0444. In Europe, contact Mostek, Brussels; Telephone (32) 02/660.25.68.66013.

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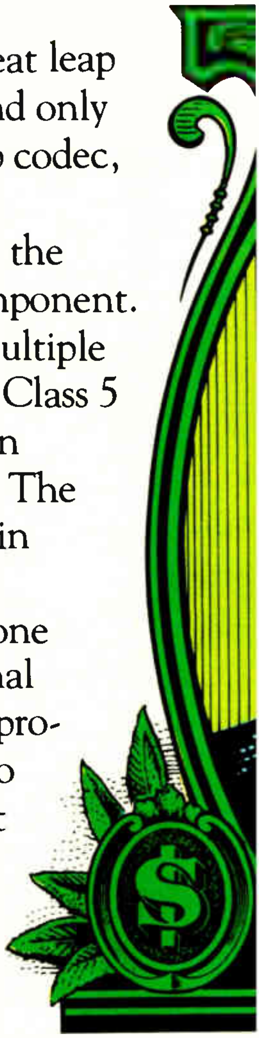
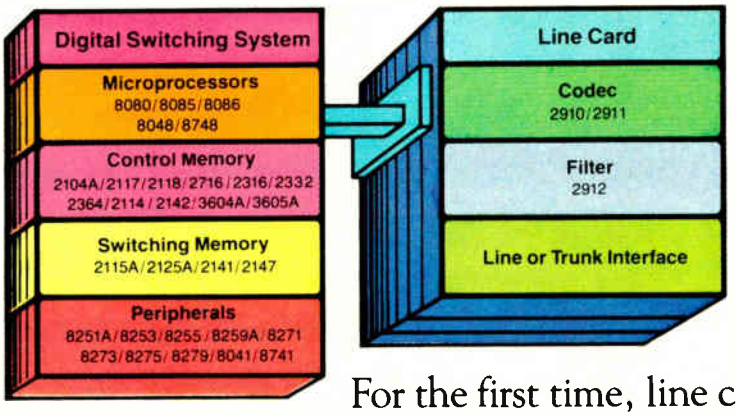
How Intel's codec cut PCM



The switchover to an all digital telephone network just took a great leap forward. Introducing Intel's 2912 transmit/receive filter. It's the first and only one-chip LSI filter. And it's the only filter with a companion one-chip codec, our 2910 (μ Law) and 2911 (A Law).

Since we introduced the 2910/2911, line card designers have had the capability to code and decode digital signals with a single, reliable component. Now our 2912 goes a step further. Like our codec, the 2912 replaces multiple devices with a monolithic solution. And it meets the stringent digital Class 5 Central Office requirements for both D3/D4 and CCITT Transmission Standards, with necessary voiceband flatness and stop band rejection. The 2912 also has a 50-60 Hz notch to filter AC line noise, and permits gain adjustments of voice signals.

We designed our codec and filter to work together. And neither one requires precision external components. The 2912 provides a direct interface to line or trunk circuits that use either transformers or electronic hybrids.



Meeting in the middle of the digital highway

For the first time, line card design can dramatically reduce PCM switching costs in most TDM systems. That's because our codec has a built-in microcomputer interface that allows switching directly on the PCM highway, eliminating or greatly reducing the size of the time-slot interchange memory and allowing greater flexibility in the level of blocking selected for the system.

So when line card designers select Intel's filter and codec, the systems savings and design simplicity extend beyond the entrance to the digital highway. System

new filter and system costs.

engineers benefit, too, with important economies in hardware and common control overhead.

How Intel gives you a head start in digital technology

We've long been a supplier to the telecommunications industry, at the forefront of each new step in the evolving digital network. Today we supply microprocessors, memory components and peripheral support circuits, as well as our codec and filter.

All our telecommunications products use the same NMOS process we use to manufacture tens of millions of semiconductor components each year. And every Intel telecommunications product undergoes extensive testing before it's shipped.

Best of all, the 2912 filter, as well as our codec, is in volume production and available for delivery now. To order, or to obtain additional information, contact: Intel Corporation, 3065 Bowers Avenue, Santa Clara, CA 95051, or telephone (408) 987-6475.

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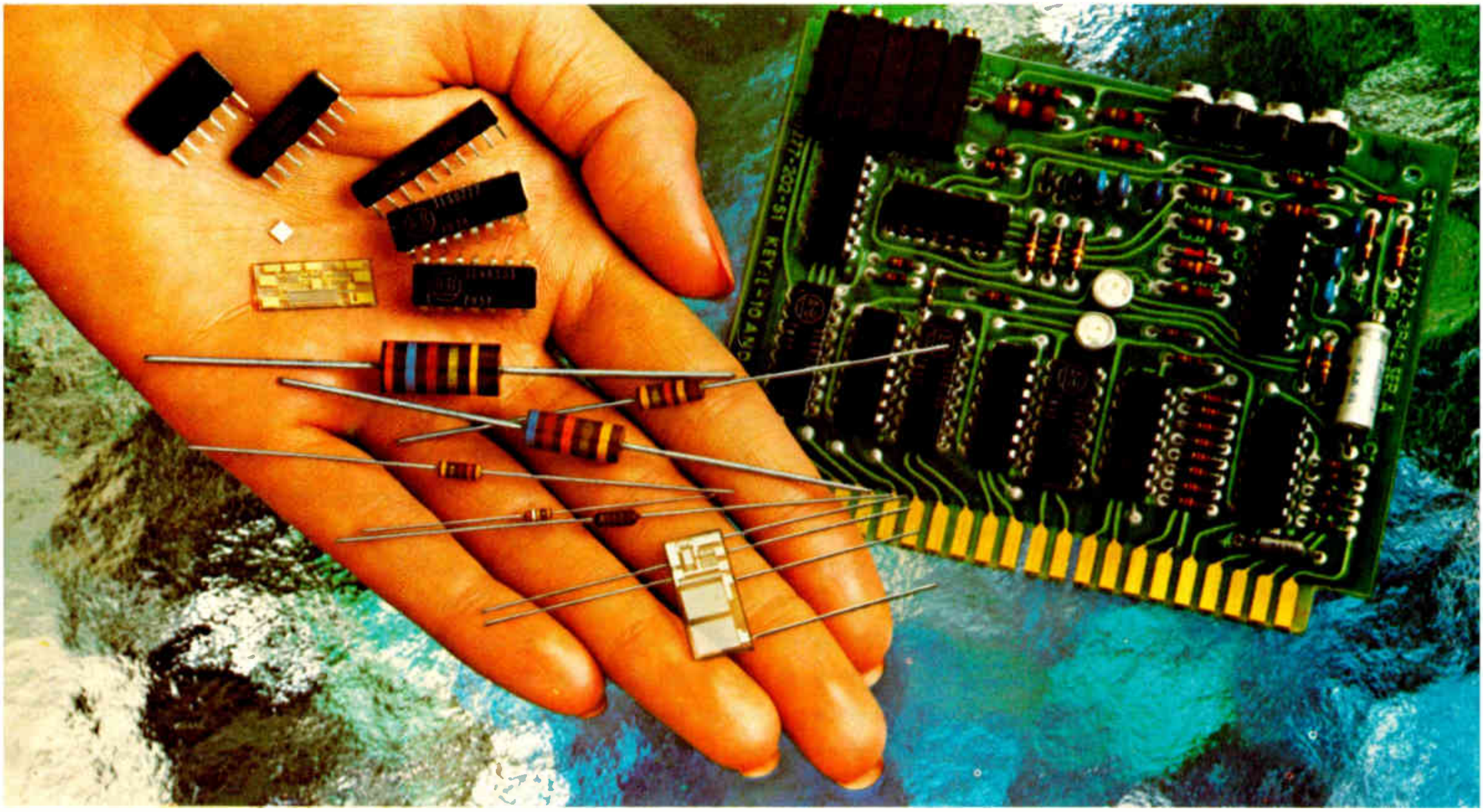
RESISTOR TYPE	RESISTANCE RANGE	POWER RATING	TOLERANCE	TCR
Carbon Comp	1 ohm to 100 megs (custom to 1 million megs)	⅛W to 4W @ +70°C	±5% to ±20%	Typically less than 250 PPM/°C from +15°C to +75°C
Cermet Film	10 ohms to 22 1 megs	0 125W @ +125°C 0 5W @ +70°C	±0 5% and ±1%	±50 and ±100 PPM/°C
I-DIPs	22 ohms to 1 meg (customs for other values)	100 to 500 mW per resistor @ +70°C	±1%, ±2%	±100 and ±200 PPM/°C
I-SIPs	22 ohms to 1 meg (customs for other values)	125 to 500 mW per resistor at +70°C	±2% or ±1 ohm whichever is greater	±100 PPM/°C
Chips	50 ohms to 10 megs	10 to 250 mW per resistor at +125°C	as low as ± 015%	±25 PPM/°C



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Electronics newsletter

SIA unveils 4-point program for freer Japanese trade . . .

Charging that the Japanese market is effectively closed to U. S. semiconductor manufacturers, the Semiconductor Industry Association has detailed a four-point program that it says would show that Japan is opening its home market. A Japanese industry delegation immediately rejected it.

The plan, unveiled at this month's U. S.-Japan semiconductor seminar attended by key executives from semiconductor companies of both nations, calls for: an active market in IC technology between the two countries, **including free access to licenses in all very large-scale integration research;** a single-tier pricing system under which the Japanese would equalize their domestic and export prices; Nippon Telegraph and Telephone Public Corp. to open procurement for foreign suppliers; and a significant increase in IC imports to Japan.

However, executives from Fujitsu Ltd., Hitachi Ltd., and Nippon Electric Co. denied these problems exist, stated that NTT is an independent entity and cannot be told what to do, and claimed that U. S. chip makers do not understand the Japanese culture and thus cannot sell into it.

. . . but says it doesn't expect any improvement

After the meeting in Palo Alto, Calif., Robert Noyce, Intel Corp. chairman, and Charles Sporck, National Semiconductor Corp. president, said privately that they did not expect any improvement. Stating that they do not want protectionist trade barriers, they indicated that **they might push for faster and tougher enforcement of dumping laws** and plain outcompete the Japanese. During their speeches at the meeting, the two executives warned Japan to change course or the U. S. might turn protectionist, a shift that would hurt the Japanese severely in the long run. But at a meeting, called by the visitors to find common ground, the two sides could not even agree on a common set of trade and government research figures to discuss the issue.

Motorola plans microwave transistor push

Though well-known as a volume supplier in the high-power transistor marketplace, Motorola Inc.'s Semiconductor Products division has not been a force in the microwave transistor field. That is going to change over the next months as the company introduces its new line of npn silicon devices suitable for Class B and C amplifiers. **"We intend to produce volume parts at volume prices,"** says Danny Schnell, product marketing manager for rf products in Phoenix. The first four devices for up to 2-GHz operation (designated MRF-2001, 2003, 2005, and 2010) are available now in sample quantities. Nine more, for the 960-to-1,190-MHz Tacan band—with 250-W peak power capability—will follow shortly. Others coming in 1979 will handle the 1.7-to-2.3-GHz point-to-point communications band. According to Schnell, the parts will be "substantially less expensive" than competitors' versions.

Home computer may be coming from Atari

Is the nation's largest manufacturer of commercial video games preparing to market a personal computer? Industry observers believe that Atari Corp. of Sunnyvale, Calif., is going to do just that **and, moreover, is pressing to have one ready for the January Consumer Electronics Show.** The machine apparently will use MOS Technology Inc.'s 6502 processor, Basic programming language, and an rf modulator to interface with a color television monitor. And the price could be relatively low.

Electronics newsletter

Rockwell adds analog inputs to 4-bit family

Joining other semiconductor firms expanding their one-chip microcontrollers, Rockwell International Corp.'s Electronic Devices division, Anaheim, Calif., is adding analog-to-digital converters to its PPS-4 family of 4-bit microcomputer chips. **The MM78A/D will have zero-crossing detection, direct touch-plate inputs, high-current drive outputs, and a pair of analog inputs with full 8-bit resolution.**

Fairchild CCD packs 180,000 elements on chip

Fairchild Camera and Instrument Corp., Mountain View, Calif., is supplying a complex charge-coupled-device imaging chip to the Air Force for a head-up cockpit display. The 470-by-430-mil chip contains 185,440 visual elements in a 488-by-380 array—enough to give commercial-quality TV resolution. In addition, there are 90,000 register elements on chip. **Despite this complexity and the use of triple polysilicon multilayer construction, yields are good,** according to Thomas A. Longo, Fairchild's vice president and chief technical officer.

Chip makers report double ordering is creeping in

Silicon Valley semiconductor manufacturers report a new concern: double ordering. It is happening to products across the board, observes Charles Sporck, president of National Semiconductor Corp. in Santa Clara, Calif., **but he says that inventories remain tight with little buildup.** "It's nothing like 1974," Sporck says. Generally agreeing, Wilfred J. Corrigan, chairman of Fairchild Camera and Instrument Corp., in nearby Mountain View says, "We haven't seen panic set in." He points out that there's a lot of capacity coming on stream that should ease things and that inventories, are better controlled now than in 1974. But over at Advanced Micro Devices Inc. in Sunnyvale, marketing vice president Terry Jones says that lack of capacity is causing double ordering of low-power Schottky devices, big programmable read-only memories, and MOS erasable programmable ROMS. Last month, Wyle Distributors Group said that it had detected double ordering.

Intel decides against entering CCD market

Although Intel Corp. had announced that it was going to make charge-coupled-device memories, it probably will never enter that market, says Andrew S. Grove, executive vice president and chief operating officer. The reason: **cranking up to meet the projected demand would divert too much productive capacity** from profitable, high-volume lines, he says.

Zilog slates Z8000 products

Right after its Z8000 16-bit microprocessor, Zilog Inc. of Cupertino, Calif., plans to launch boards based on the part. Due the first quarter of 1979 is an evaluation board with a nominal amount of software that also will have other computing applications. Following will be a Z8000 development system expected out midyear, **and at the end of the year a full-blown computing system.**

Translating computer fits in hand

A small Miami, Fla., company, Lexicon Corp., has developed a $225 hand-held device that translates from one language to another. Words and phrases punched into an alphanumeric keyboard are translated and their foreign-language equivalents are read out on a digital display. **Plug-in modules contain about 1,500 words each.**

Static 4K RAM's run rampant.

The 18 pin industry standard 4K x 1 static RAM's you'd give nearly anything to get right now can be yours right now. For no more than you'd normally expect to pay.

National has MM 5257's by the roomful. Our 4″ wafer-fab facility in Salt Lake City utilizes National's well known mass production technology. So you get the same high volume delivery we're famous for in other product lines.

Our MM 5257's are available now in speed selections from 200 to 450 ns, with standard and low power options. They are alternative source parts for T.I. TMS 4044's.

If you'd like to pick up on National's run of 4K static RAM's, get in touch with your nearest National distributor or representative. He'll make sure you get what you want when you want it.

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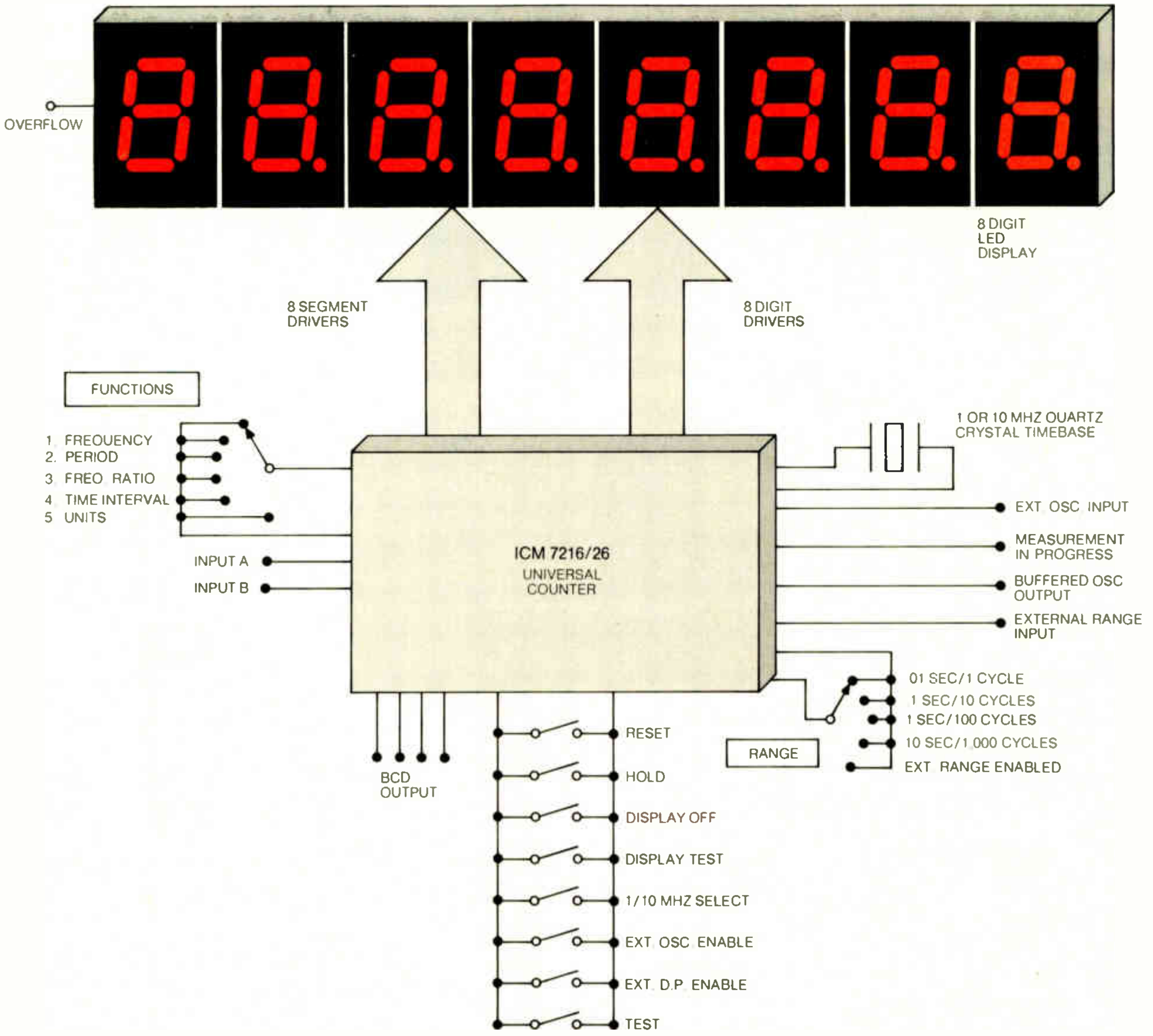

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	Functions	Pkg	100 Pc Price
ICM7226A	Universal counter		20.00
ICM7226B	Pre-scale controls, BCD outputs	40 pin DIP	16.65
ICM7216A	Universal counter	28 pin DIP	20.00
ICM7216B		28 pin DIP	16.65
ICM7216C	Frequency counter only	28 pin DIP	16.65
ICM7216D		28 pin DIP	13.35

*1000 pc. price (7216BIPI)

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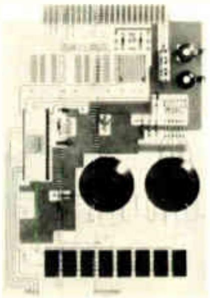

Call or write your nearest Intersil Franchised Distributor for a complete evaluation kit. Including: the ICM7226AIDL; a 10MHz quartz crystal; eight 7 segment .3" LED's; PC board; resistors; capacitors; diodes; DIP switches and IC socket. Slip it together. Plug it in. And start counting.

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Mark Twain was right. "Thunder is good, thunder is impressive; but it is lightning that does the work." At Intersil, our newest lightning is MAXCMOS.™ CMOS at the leading edge of the technology. It means lower cost, greater function and higher reliability in a universal counter... on a single chip. Find out for yourself. Compare the cost/performance of the ICM7216/26 family of universal counters to the multi-component system you're probably using now. Order the evaluation kit from your Intersil Franchised Distributor, or, return the coupon below for complete information.

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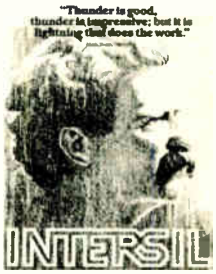

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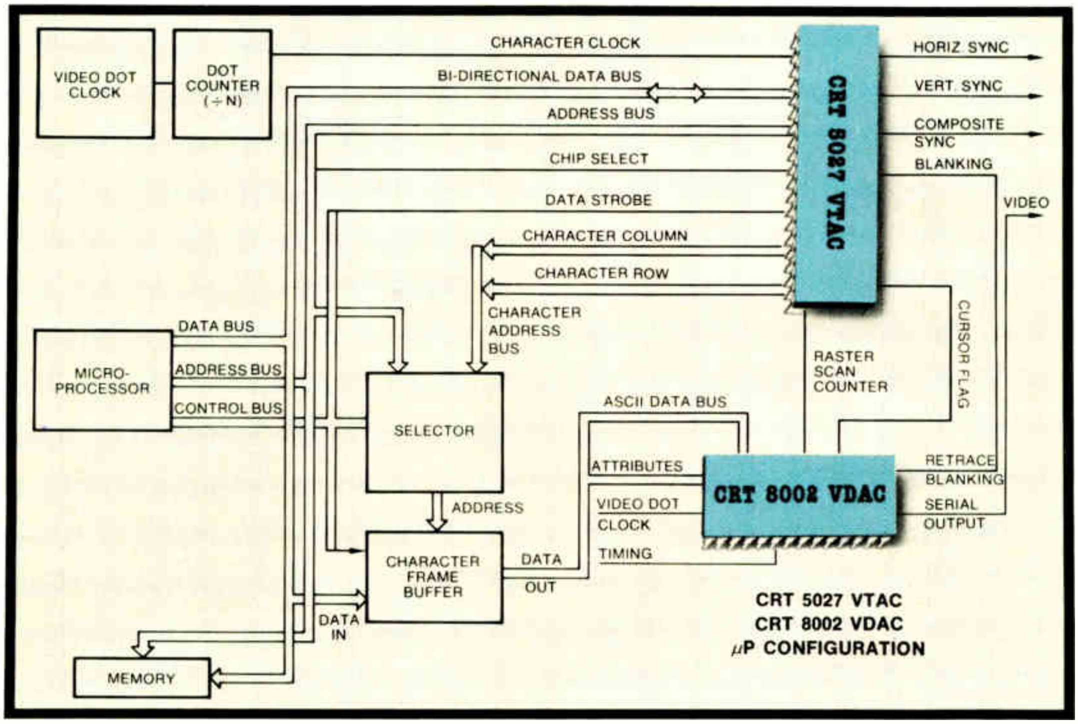
ALL THE DISPLAY CIRCUITRY FOR A CRT TERMINAL IS NOW ON TWO MOS/LSI CHIPS.



In 1977, we announced the CRT 5027 VTAC® the Video Timing and Controller, an MOS/LSI chip with logic functions capable of generating all timing signals for presentation and formatting all video data in a CRT system.

NOW, we are adding another dimension for display circuitry with our new CRT 8002 VDAC™ Video Display Controller-Video Generator. This device provides all the logic needed for character generation, video attribute and graphics.

The SMC CRT 8002 Video Display-Controller (VDAC)™ is an N-channel COPLAMOS® MOS/LSI device which utilizes CLASP™ technology. It contains a 7x11x128 character generator ROM, a wide and thin graphics mode, external input mode, character address/data latch, field and/or character attribute logic, attribute latch, four cursor modes, two programmable blink rates, and a high speed video shift register. The CRT 8002 VDAC™ is a companion chip to SMC's CRT 5027 VTAC® Together these two chips comprise the circuitry required for the display portion of a CRT video terminal.

Four cursor modes are available on the CRT 8002. They are: underline, blinking underline, reverse video block, and blinking reverse video block. Any one of these can be mask programmed as the cursor function. There is a separate cursor blink rate which can be mask programmed to provide a 15Hz to 1Hz blink rate.

The CRT 8002 attributes include: reverse video, character blank, blink, underline, and strike-thru. The character blink rate is mask programmable from 7.5Hz to 0.5Hz and has a duty cycle of 75/25. The underline and strike-thru are similar but independently controlled functions and can be mask programmed to any number of raster lines at any position in the character block. These attributes are available in all modes.

In the wide graphics mode, the CRT 8002 produces a graphic entity the size of the character block. The graphic entity contains 8 parts, each of which is associated with one bit of graphic byte, thereby providing for 256 unique graphic symbols. Thus, the CRT 8002 can produce either an alphanumeric symbol or a graphic entity depending on the mode selected. The mode can be changed on a per character basis.

The thin graphics mode enables the user to create single line drawings and forms.

The external mode enables the user to extend the on-chip ROM character set and/or the on-chip graphics capabilities by inserting external symbols. These external symbols can come from either RAM, ROM or PROM.

The CRT 8002 video output may be connected directly to a CRT monitor video input. The CRT 5027 blanking output can be connected directly to the CRT 8002 retrace blank input to provide both horizontal and vertical retrace blanking of the video output.

Combined, the CRT 8002 VDAC™ and the CRT 5027 VTAC® generate all the logic functions necessary for a CRT terminal. In fact, functions never before offered on a CRT system now become standard with the utilization of the VTAC®-VDAC™ pair.

For details on the CRT 8002 and CRT 5027, or our custom circuit capabilities, call Standard Microsystems Corporation.

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The largest manufacturer of MOS/LSI data communication circuits

Bell Labs develops telephone powered by lightwaves alone

Phone systems will no longer be limited in bandwidth by twisted pair or coax cable; future applications enormous

Bell Laboratories has developed a telephone powered by light carried to it by a fiber-optic cable. Such a development brings the totally fiber-optic phone system closer to reality, but it is more than a major technological advance.

Fiber-optic cable can handle all the bandwidth that communications could need for the foreseeable future. Thus the new phone could establish American Telephone & Telegraph Co. and other phone companies as the No. 1 provider of such wideband services to home and industry as color television, data and computer services, electronic mail, and color holograms.

Though these applications are far in the future, the questions of what to provide and when are as much socioeconomic and political as technical. Answering them can only increase the controversy concerning the service role of the telephone companies as regulated monopolies. For example, such a major undertaking as Bell's recently announced Advanced Communication System could be affected—its data-handling capabilities are enormously enhanced by fiber-linked phones.

Source. This latest fuel to an already hot fire comes out of the Light Wave Sources department in Murray Hill, N. J. It was put together "just to demonstrate technical feasibility," says department head Barney De Loach Jr. "Our initial data proved out the concept, although the work is still in its early stages and a lot more effort will be required before the phone could go into customer service."

"Such work must include demonstrations of reliability and total compatibility with the existing phone system, as well as meshing with basic telephone system economics," he continues. "There is no way to build or run two separate telephone systems. Ideally, if we do something, the first installation should be in a controlled building with a PBX [private branch exchange], for example." For now, De Loach and his co-workers at Bell will spend part of the next six months improving the audio qualities of the phone.

A ringer. The major problem was making the phone run off the power available from the fiber cable. The biggest headache here, according to De Loach, was the conventional telephone ringing mechanism.

This electromechanical device needs an 80-volt ramp, and there was no way to power it from the 4 to 5 milliwatts available from the laser-diode-driven 1-kilometer fiber-optic cable used in the simulated central-office setup. So a new ringer was designed that worked perfectly well at a couple of volts.

It uses an electroacoustic tone generator with a thin piezoelectric active element. "This device has some exceptional specs," says De Loach. "For example, its overall efficiency from the optical input to the acoustic output is more than 33%."

With the ringer problem solved, the power requirements of the rest of the phone were readily satisfied. This power, as well as the ringer drive, comes from a Bell-developed photodetector, which converts light to electrical pulses. The same device can act as a photodiode, too.

The photodetector's narrow-bandwidth conversion efficiency at 0.81 micrometer is 56%—the highest ever reported. It is a double-heterostructure device with layers of gallium aluminum arsenide sandwiching one of gallium arsenide and grown on a single crystal substrate. A hole etched in the substrate exposes some of either GaAlAs layer, and the glass fiber butted at that point couples

On the phone. Barney De Loach Jr. and associates test light-powered phone. Box contains photodetector and electronics. Standard phone has new ringer driven over fiber-optic cable at left.

light to and from the photodetector.

But the phone handset must send as well as receive, so Bell has designed the photodetector to generate light as well, at a wavelength different from the incoming light. With time-sharing and automatic switching, the phone sends signals back to the central office at a 0.9-μm wavelength. It operates in a duplex mode, taking further advantage of fiber's bandwidth capability.

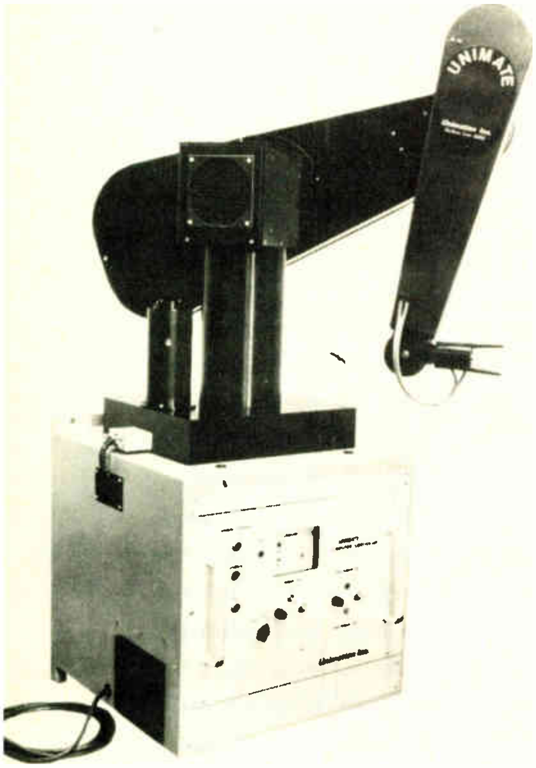
The laser light coming from the central office is on for about 95% of the time. It is pulse-width-modulated by the voice or data. Since the modulation bandwidth is small compared with the carrier wavelength, the change in pulse width is easily controllable. □

Packaging & production

Conference sees new robot geared for electronics assembly

Robots are coming out of the foundries and paint shops and into the cleaner rooms of the electronics industry. This month Unimation Inc., Danbury, Conn., unveiled Puma, the first commercially available microprocessor-controlled robot designed especially for assembling the small items of hardware found in computers, instruments, and motors.

Puma was shown at the third Industrial Robot Conference and Exposition in Chicago at which a horde of electronics industry representatives from such companies as Texas Instruments, International Business Machines, and Zenith Radio crowded out the traditional attendees from metal-bending companies. Until now, robots devoted to chores like painting and welding and to manipulating equipment weighing hundreds of pounds or more held center stage at the conference.



"The electronics industry had been left out in the cold with the larger machines," says Joseph F. Engelberger, president of Unimation, one of the old-line manufacturers of the heavy-duty robots. Electronics companies are using, or will soon use, assembly robots (actually programmable arms or manipulators) to lay out wiring harnesses, dip and stuff printed-circuit boards, and insert parts in instrument panels and chassis, say Unimation officials.

Impressed. Among those electronics manufacturers that already use robots (see following story), Westinghouse Electric Corp. and General Electric Co. were impressed by Puma. Richard G. Abraham, Westinghouse's programmable-automation manager, says he will probably use it as part of a completely automated batch-assembly line he has designed. Vernon E. Estes, GE's robot applications chief, says, "We're taking a real interest in the Puma. It offers real-time and off-line programming." And, notes an industry observer, even at preproduction prices, the Puma can pay for itself very quickly as an alternative to manual labor on many assembly lines.

Puma. Programmable Universal Manipulator for Assembly stands about 26 in. at its "shoulder," measured above the control box, and can reach 34 in. to its "wrist."

Light bulbs. At the robot conference, the servo-controlled Puma was picking up small light bulbs from a pallet and installing them in automotive dashboard assemblies. The result of 18 months of development by Unimation and General Motors, the Puma is puny by traditional robot standards: with controller, it weighs 175 pounds, a figure equal to the lift capacity alone of its brawnier brothers.

The heart of the 20 preproduction Puma models now being shipped to companies like GM, IBM, and Siemens is an LSI-11 microcomputer system from Digital Equipment Corp., with a floppy-disk storage and 10 kilobytes of programmable read-only memory and 4 kilobytes of random-access memory. The DEC system acts as a controller, instructing five microprocessors with 1 kiloword of RAM from MOS Technology Inc. and 2-K-by-8-bit PROMs from Intel Corp. A microprocessor is dedicated to each of the five axes in the robot arm: waist, shoulder, elbow, wrist, and the flange, which is the mounting point for a gripper or other tool, explains Brian R. Carlisle, Unimation's Puma project manager.

Puma's special talent is in lifting a light load—less than 7.7 pounds—and quickly moving it to a subassembly with a repeatability of ±0.004 inch. Tip velocity is a maximum of 3.3 feet per second.

The key to Puma's capability is its own programming language, called VAL. Rather than physically moving the arm through each required task, the X-Y coordinate locations of its required movement can be programmed into the controller, and it will design and instruct the microprocessor to move the arm in the most efficient path. Also, the Puma can perform one task while being programmed to do another.

Production models of Puma will

be available next year and will include a sixth axis and software ready to incorporate visual and tactile sensors, says Unimation's Engelberger. Pre-production units sell for $35,000 each, he says. GM has committed itself to buying the first 100 production models for $22,000 each, Engelberger adds. ☐

Robots surface at TI, GE, Westinghouse

Although reluctant to talk specifics, managers at three large electronics companies—Texas Instruments Inc., General Electric Co., and Westinghouse Electric Corp.—earlier this month at the robot conference in Chicago began to talk in general terms about their interest in robots on the assembly line. TI, for example, uses a robot designed in house to assemble calculators and other electronic products. The machines can identify and grasp parts through pattern recognition, says Ward McClure, manager of the vision-aided manufacturing program.

Each robot on the assembly line is controlled by a TMS 9900 microprocessor linked to a TMS 980 computer, and has a camera with a much bigger field of vision than the solid-state camera sold by General Electric, McClure says. That camera has a 184-by-244 picture-element sensor and is used on the first commercially available manipulator with vision, from Auto-Place Inc. [*Electronics*, Nov. 24, 1977, p. 46].

General Electric is buying existing hardware and adapting it to its needs. This year it bought 43 robots, for a total of 53, that are now loading and assembling on GE production lines or in its development laboratories, says Vernon E. Estes, manager of machining systems technologies at the company's Schenectady, N.Y., Corporate Services group. Assembly applications include manipulation of electrical components and small parts. The robots have dedicated microprocessors and use air pressure to trigger operations.

After surveying 45 GE plants, Estes's group identified an average of five robot applications per plant. "Robots are a mature technology, ripe and ready for picking," he says, and he predicts that other manufacturers will soon sell small robots for precision assembly.

Still not right. Westinghouse Electric, however, says the right hardware is not available for a completely automated batch-assembly line. With the help of a $225,000 National Science Foundation grant, Westinghouse recently completed preliminary designs for an automated small-motor assembly plant using seven robots. If the company gets a second NSF grant, says Richard G. Abraham, programmable-automation manager at Westinghouse, a pilot automated assembly line could be in operation in three years.

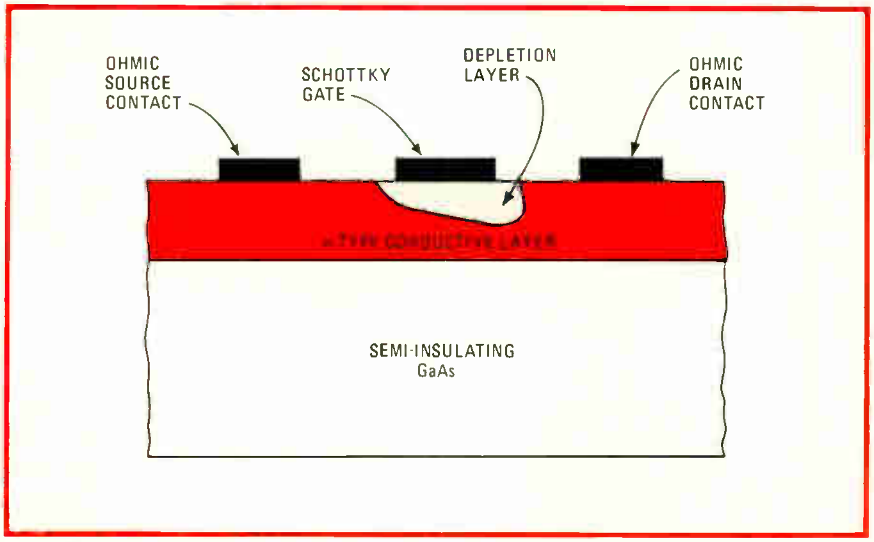
Working with SRI International, the Charles Stark Draper Laboratory and the University of Massachusetts, Abraham's team designed an assembly line capable of handling 450 different motor styles with an average batch size of 600 units. A distributed computer system, including a minicomputer controller with a 64-K memory and 14 microprocessors—2 per robot arm—can automatically reprogram the assembly units for each product changeover.

Abraham predicts the first commercial installations of completely automated batch assembly lines will appear by 1983. Another prediction: 50% of direct labor in small component assembly will be replaced by programmable automation by 1988, concludes a study completed earlier this year by the University of Michigan and the Society of Manufacturing Engineers. ☐

Solid state

IBM, Rockwell say GaAs looks good for high-speed VLSI circuits

Gallium arsenide has been used for many years to build microwave transistors because it is a faster semiconductor than silicon—its electrons can move at nearly 10 times the speed of those in silicon. But what that translates into in terms of large- and very large-scale integrated circuits has only recently been projected by Rockwell International Corp. and International Business Machines Corp. in independent investigations. Their findings? They reached the same conclusion: GaAs



Speedy GaAs. Simple oxideless structure of enhancement-mode MESFET will yield VLSI circuits in gallium arsenide that are six times faster than those in silicon.

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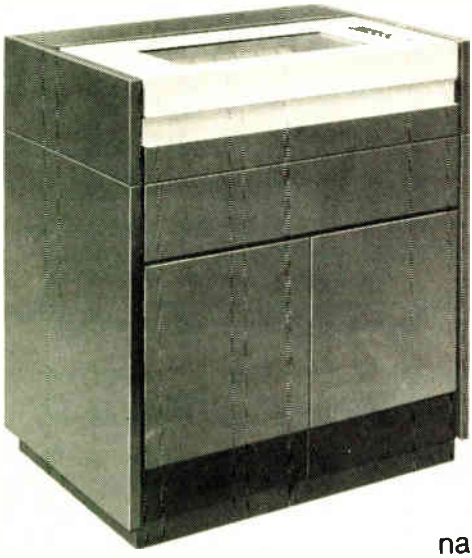

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will provide a sixfold speed advantage over silicon in LSI and VLSI circuits.

Their findings will be presented in papers devoted to the feasibility of GaAs logic at the International Electron Devices Meeting in Washington, D. C., next month. The projections were arrived at by two different techniques: Paul M. Solomon at IBM's Thomas J. Watson Research Center in Yorktown Heights, N. Y., used computer simulations, whereas Richard C. Eden at Rockwell International's Science Center in Thousand Oaks, Calif., made measurements on actual devices.

The device under consideration is the n-channel metal-semiconductor field-effect transistor, or MESFET. As shown in the figure, MESFETs, unlike metal-oxide-semiconductor FETs, have no gate-insulating oxide. Both Rockwell and IBM compared identical structures in GaAs and silicon, although, according to Rockwell, silicon MESFETS exhibit about the same characteristics as MOSFETS, which are the most common FETs in silicon ICs.

Short channels. The place for GaAs in future technology is in FETS with channel lengths of 1 micrometer or less. Discrete microwave transistors with such dimensions have been around for some time but are depletion-mode FETS. These normally on devices have extremely fast switching speeds—delay times of less than 100 picoseconds—but are power-hungry, dissipating 20 to 40 milliwatts each. That would allow no more than a few hundred of them to be put on a chip.

It's the enhancement-mode, or normally off, FET that is the key to VLSI GaAs circuits, IBM and Rockwell agree. Though not quite as fast as depletion-mode devices, enhancement-mode FETS dissipate much less power, occupy less space, and can be run off a single power supply. Moreover, enhancement-mode devices plus resistor loads are basic to the relatively simply direct-coupled FET logic designs used on silicon, which will simplify the design job on GaAs.

At Rockwell, 1-μm-gate enhancement-mode FETs have shown 60-ps gate delays and impressive power-delay products of less than 40 femtojoules. (A comparable silicon MESFET would have a 400-ps gate delay for the same power-delay product.) Rockwell concludes that for a given power-delay product, the GaAs MESFET would be over six times faster than a silicon MESFET. Alternatively, for a given speed, the GaAs circuits would have enormously lower power-delay products than silicon—and that is the name of the game for VLSI applications.

IBM, on the other hand, likes the speed advantages of GaAs. Its simulations were of 0.5-μm-gate-length devices, the level at which it feels "GaAs would be most competitive in the high-speed arena." Whereas Rockwell emphasizes denser chips and 1-μm line widths, which it says state-of-the-art optical projection lithography can handle, IBM intends to exploit the speed advantages of GaAs by using "the shortest possible channel lengths, for both on-chip and off-chip driving capability."

Rockwell's GaAs program at the Space Center has a goal of no less than 1,000-gate LSI parts in about two years. But it does not expect the developments to stop there. ☐

VHSI plans will go to military next month as concerns arise

Initial plans for the Department of Defense's very high-speed integration project to advance the state of U. S. military semiconductor technology will go to the three military services by mid-December, says VHSI project leader Larry W. Sumney. Even as he prepares his draft plan, reaction in the semiconductor industry is beginning to be heard—and it's not all favorable.

The proposed six-year program would cost about $200 million for research, development, and pilot production, in addition to separate outlays by the three services for brassboard demonstrations in six weapons systems [*Electronics*, Oct. 12, p. 58]. The services have set up three VHSI committees, each with different areas of responsibilities.

The Air Force Avionics Laboratory's John Decaire heads the DAST committee (for design, architecture, software, and testing). These areas would receive about a quarter of the VHSI money.

Leading the committee on lithography to advance the state of integrated-circuit mask making to submicrometer dimensions is Charles R. Caposell of the Naval Air Systems Command. Lithography also is expected to get about 25% of the proposed VHSI funds.

Head of the VHSI fabrication committee, which will get the remaining 50% for developing initial, heavily automated pilot production lines is the Army's Karl A. Zaininger. He runs the Microelectronics division of the Electronics Technology and Devices Laboratory at the Adelphi, Md., headquarters of the Electronics Research and Development Command.

Although most chip makers have indicated interest in the program some concerns have surfaced. Rights to technology, especially automated production hardware, is perhaps the biggest stumbling block for big firms looking at the VHSI plan. Manufacturers are pushing to retain control over patent and license rights to new production equipment that they may develop under the program, a position contrary to existing Government regulations. Though some DOD officials are looking for ways to compromise on the issue, says a source outside the Pentagon, "Congress and the Justice Department are sure to oppose it."

Intel says no. One major semiconductor company, Intel Corp., is not interested in taking part in the VHSI program. There is only a small pool of top design talent in the country, says Andrew S. Grove, executive vice president and chief operating officer of the Santa Clara, Calif., company. "DOD doesn't need to spend more money chasing after the same limited supply of talent," he says. "Pouring another $125 million won't speed up the technology." All that happens is that "the cost of goods goes up."

As for not participating, "we don't want to give up the freedom to develop our technology as we see it," Grove maintains. And his commercially oriented firm could change direction when it chooses. What's more, the Government puts too many obstacles in front of high-technology companies trying to sell to it, he says.

Although he welcomes Government help to develop VHSI circuits, Thomas D. Hinkelman, executive director of the Semiconductor Industry Association, Cupertino, Calif., thinks emphasis should be shifted. He would prefer the Government to establish advanced research centers at major universities. These would train more students and get them up to speed when they enter the industry.

Also, like Intel's Grove, he is concerned that the VHSI program will dilute the limited pool of available design resources, as well as divert the development of advanced circuits from what he calls the main stream. ☐

IEEE

Jerome Suran elected IEEE president as voter turnout falls below 30%

New chief. Suran comes to the IEEE presidency from heading up General Electric's Electronics Laboratory in Syracuse, N. Y.

Although the television networks did not broadcast up-to-the-minute bulletins, the Institute of Electrical and Electronics Engineers' election was gearing down at about the same time as the national political battles. Final tabulations on Nov. 7 showed that Jerome J. Suran was elected IEEE president with 25,851 votes, with four-time candidate Irwin Feerst, a consulting engineer from Massapequa, N. Y., receiving 17,637. Running uncontested for executive vice president was Leo Young, staff consultant of the Electronics Technology division, Naval Research Laboratory, Washington, D. C. Suran takes over Jan. 1 for a one-year term. He succeeds Ivan A. Getting of The Aerospace Corp.

"I'm delighted that the wait is over," says Suran, 52, manager of General Electric Co.'s Electronics Laboratory in Syracuse, N. Y., and currently the IEEE's vice president of educational activities. "But it was a bit disappointing to see the decrease in voters." Feerst, agreeing with Suran for perhaps the first time in the campaign, adds, "My major disappointment wasn't at losing, but at the appalling voter turnout."

Only about 43,000 of a possible 150,000 voters filled out ballots. Feerst feels this apathy could be due to "the IEEE's having taken a decided turn against the wishes of the practicing engineer." Suran contends that a complex ballot may have confused marginal voters.

No amendment. Neither, however, regrets that the one constitutional amendment on the ballot did not get the two-thirds majority needed to pass. Proposed by Robert Bruce of the Long Island Professional Activities Committee, it would have allowed members to elect all officers and governing board members. Nine of 29 are now appointed.

"The board's resistance to my amendment and the news blackout in the IEEE press obviously results from a desire to keep power from the voters," says Bruce. But Suran insists that the reason for having appointed positions is to get people "with the correct background and experience. An election might result

Herz takes over as IEEE general manager

Not content with simply having a new president, the IEEE has also ended its almost two-year search for a new general manager. Replacing Richard M. Emberson, who retires next year, will be Eric Herz, a senior project engineer at General Dynamics Corp.'s Convair division, San Diego, Calif. Herz, who will oversee the institute's day-to-day functions, has spent the past 21 years at General Dynamics. His duties there included supervising telemetry data-processing stations, participating in space shuttle studies and, this year, managing support equipment for the air-launched Cruise missile competition.

Active in IEEE activities, Herz has served on the board of directors, been a San Diego section chairman and a president of the institute's Aerospace and Electronic Systems Society, and is currently vice president for technical activities. "I've spent my years as a volunteer, served on committees, and chaired conferences," says Herz. "It all comes together in this job."

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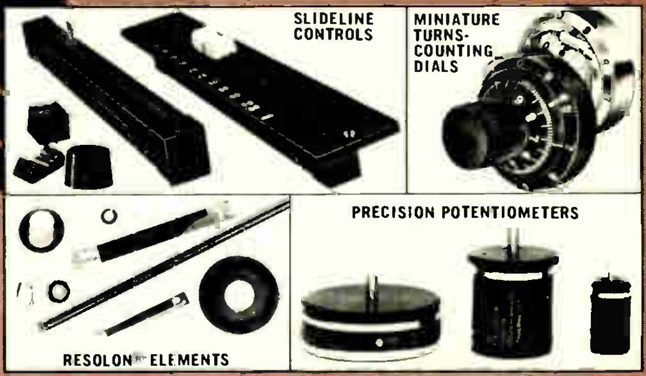

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in a politically astute winner who knows nothing about the internal operations of the IEEE."

However, Suran is not averse to amending the constitution to permit members to elect the chairman of the U. S. Activities Board. This board is the professional activities arm of the institute and is "of direct concern to the members," he says.

Balance. Suran's other plans include achieving a good balance between the technical and professional aspects of the institute. He says it was manifestly unfair of Congress to turn down the Limited Employee Retirement Account Act, a bill that would permit professionals not vested in employer-sponsored plans to create independent retirement accounts. "I'd like the IEEE to start a major lobbying effort on this issue. And we also have to work to highlight the role of technology in solving societal problems." ☐

Microprocessors

Mostek to make Intel's 8086

With 1979 expected to be a formative year for the emerging 16-bit microprocessor market, the battle lines are becoming clearer as second-source arrangements develop. This month Mostek Corp. disclosed its plans to second-source Intel Corp.'s 8086, a 16-bit device that became available earlier this year.

Announcement of the pact followed closely the surprise signing of an alliance between Zilog Inc. and Advanced Micro Devices Inc. by which AMD will second-source Zilog's forthcoming 16-bit Z8000 [*Electronics*, Sept. 14, p. 52].

New allies. The latest move completes a flip-flop in allies for the next-generation microprocessor wars. Mostek is the second source for Zilog's 8-bit Z80, whereas AMD serves as an alternate for Intel's earlier-generation 8080, 8048, and 8085. Furthermore, Mostek and Intel promise that a second part of the deal will be announced later but refuse to say what it involves.

Mostek plans to use its Scaled Poly 5 process to produce samples of its version of the 8086 by the third quarter of next year. The Carrollton, Texas, firm will not get masks from Intel; instead it will design its own part based on circuit information garnered from a series of engineering meetings. No software or peripherals beyond the basic six-chip 8086 set are included in the current agreement. Mostek will initially write a cross-assembler to accommodate the 8086 on its existing Z80-based development system and will design software and peripheral chips later as needed, officials say.

In Austin, Texas, where Motorola Inc.'s MOS integrated-circuit operation remains without a signed second source for its planned 16-bit MC68000, reaction to the Mostek-Intel deal was low key. "We are in the process of negotiating a second source," says Robert Nobis, strategic marketing manager for high-end microprocessors. "I don't think [the deal] will make the negotiating more difficult, though it might make us negotiate a little faster," he concedes. Samples of the 68000 are planned for early next year and will compete against the 8086 and Z8000.

At his company's Sunnyvale, Calif., headquarters, AMD president Jerry Sanders characterizes the Intel-Mostek deal as "Intel's reaction to the power of the AMD-Zilog arrangement." To be sure, that deal did affect Mostek's thinking, concedes marketing vice president Berry Cash, but he prefers to look at the agreement with Intel as a logical move based on a similarity between Mostek's and Intel's process approaches, the fact that the 8086 is the only one of the three 16-bit parts available in silicon, and a desire to give the part credibility during the critical design-in period to come.

Upgrading. Because the 8086 represents an upgrading of Intel's earlier 8-bit 8080 microprocessor family, some say the part may not fare well against the Z8000 and 68000, both of which will use advanced 16-bit architectures to pro-

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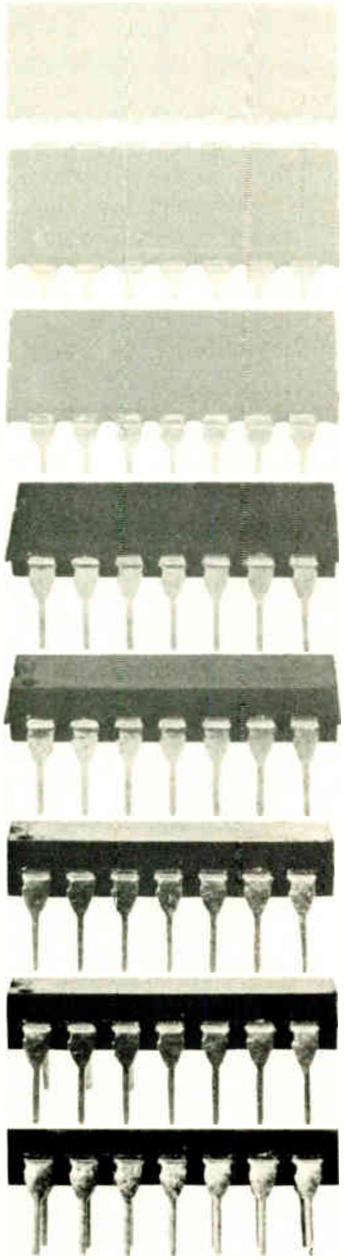

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vide higher performance. But Cash pooh-poohs the critics. "The 8086 is available now and that's one of the things that make it very attractive."

The Intel part does have performance limitations compared with the Z8000 and the 68000. Zilog's part has been said to offer 30% higher throughputs at a lower clock rate than the 8086, for example, and throughput performance for the 68000, with its more powerful and flexible instruction set is also expected to be better. But, not surprisingly, Cash predicts the 8086 will find its niche in the marketplace. It is already being designed into a number of applications where, he believes, it will never be replaced by more powerful chips, even when they do become available. ☐

Conventions

Midcon show faces a test in Dallas

Organizers of Midcon 78 have their fingers crossed over their prospects for success next month when the IEEE's electronics show for the Midwest opens its doors at the Dallas Convention Center. Booth space for the Dec. 12–14 affair is sold out, indicating it will be a financial success. But a good turnout is needed to make exhibitors want to return, especially as Midcon's debut in Chicago last year fell more than 4,000 short of its projected 15,000 attendance.

"This is a critical year for Midcon," says William C. Weber Jr., general manager for Electronic Conventions Inc. "It's got to make it in Dallas, or it isn't going to fly."

Electronic Conventions is the nonprofit organization that runs Midcon and the established West and East Coast events—Wescon and Electro. All three conventions are cosponsored by units of the Institute of Electrical and Electronics Engineers and the Electronic Representatives Association of America.

Attendance is again projected to hit the 15,000 mark by the backers of the show, which is supposed to alternate each year between Chicago and Dallas. Some 300 exhibitors will display their wares in 544 booths, well up from the 400 booths originally budgeted.

Tough market. The Midwest, with its widely dispersed and divergent industrial base, has traditionally been a tough market for electronics conventions. Still, where other across-the-board electronics shows have been wiped out entirely in Chicago, Midcon did reach the financial break-even point last year with some 400 exhibit booths, says Weber. He is optimistic that the upbeat electronics economy in general, coupled with expansion in the Southwest in particular, will make for a successful Dallas event.

Also helping to nudge attendance along is a 36-session professional program tailored to interest engineers working in the Southwest. This means sessions on oil-well logging instrumentation and other energy-related topics, as well as the usual heavy dose of sessions on microprocessor hardware and software, bubble and charge-coupled-device memories, telecommunications, personal computers, and applications of large-scale integrated circuits.

Also planned as "a means of dragging in some extra attendance" from surrounding Air Force bases and military and aerospace contractors are classified technical sessions in the nearby Dallas Federal Building, points out the convention's director, Robert L. Carrel. Topics here include electronic warfare and Cruise missile technology. ☐

Instruments

100-MHz test station keeps pace with LSI

When equipment makers, device producers, and users of large-scale integrated circuits gathered at the annual Cherry Hill (N. J.) Test Conference this month, they grappled with the problems of keeping test systems up to the speeds of

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Phoenix, Arizona 85036.

*ALABAMA, Huntsville	Hall-Mark Electronics	(205) 837-8700
ALABAMA, Huntsville	Pioneer Electronics	(205) 837-9300
ARIZONA, Phoenix	Hamilton Avnet Electronics	(602) 275-7851
*ARIZONA, Phoenix	Liberty Electronics	(602) 349-2232
ARIZONA, Phoenix	Sterling Electronics	(602) 258-4531
CALIFORNIA, Costa Mesa	Avnet	(714) 754-6111 (213) 558-2345
CALIFORNIA, Culver City	Hamilton Electro Sales L.A.	(213) 558-2000
*CALIFORNIA, El Segundo	Liberty Electronics Corp.	(213) 322-8100
CALIFORNIA, Irvine	Cramer Los Angeles	(213) 771-8300
CALIFORNIA, Irvine	Schweber Electronics	(213) 537-4321 (714) 556-3800
*CALIFORNIA, Mountain View	Elmar Electronics, Inc.	(415) 961-3611
CALIFORNIA, Mountain View	Hamilton Avnet Electronics	(415) 961-8600
CALIFORNIA, Palo Alto	Kierulff Electronics, Inc.	(415) 968-6292
CALIFORNIA, San Diego	Hamilton Avnet Electronics	(714) 273-2421
*CALIFORNIA, San Diego	Liberty Electronics	(714) 565-9171
#CALIFORNIA, Sunnyvale	Western Microtechnology Sales	(408) 737-1660
*COLORADO, Commerce City	Elmar Electronics, Inc	(303) 287-9611
COLORADO, Denver	Hamilton Avnet Electronics	(303) 534-1212
CONNECTICUT, Danbury	Schweber Electronics	(203) 792-3500
CONNECTICUT, Georgetown	Hamilton Avnet Electronics	(203) 762-0361
CONNECTICUT, North Haven	Cramer Connecticut	(203) 239-5641
FLORIDA, Clearwater	Hamilton Avnet Electronics	(813) 576-3930
FLORIDA, Ft Lauderdale	Hall-Mark Electronics	(305) 971-9280
FLORIDA, Ft Lauderdale	Hamilton Avnet Electronics	(305) 971-2900
FLORIDA, Hollywood	Schweber Electronics	(305) 927-0511
FLORIDA, Orlando	Cramer Orlando	(305) 894-1511
*FLORIDA, Orlando	Hall-Mark Electronics	(305) 855-4020
GEORGIA, Atlanta	Schweber Electronics	(404) 449-9170
GEORGIA, Norcross	Hamilton Avnet Electronics	(404) 448-0806
*ILLINOIS, Chicago	Newark Electronics Corp	(312) 638 4411
ILLINOIS, Elmhurst Industrial Park	Semiconductor Specialists, Inc./Chicago	(312) 279-1000
ILLINOIS, Elk Grove Village	Pioneer Chicago	(312) 437-9680
ILLINOIS, Elk Grove Village	Schweber Electronics	(312) 593-2740
ILLINOIS, Mt Prospect	Cramer/Chicago	(312) 593-8230
ILLINOIS, Schiller Park	Hamilton Avnet Electronics	(312) 678 6310
INDIANA, Indianapolis	Graham Electronics Supply, Inc	(317) 634-8202
*INDIANA, Indianapolis	Pioneer Indianapolis	(317) 849-7300
KANSAS, Overland Park	Hamilton Avnet Electronics	(913) 888-8900
KANSAS, Shawnee Mission	Hall-Mark Electronics	(913) 888-4747
LOUISIANA, Metairie	Sterling Electronics	(504) 887-7610
MARYLAND, Gaithersburg	Cramer Washington	(301) 948-0110
*MARYLAND, Gaithersburg	Pioneer Washington Electronics	(301) 948-0710
MARYLAND, Hanover	Hamilton Avnet Electronics	(301) 796-5684
MARYLAND, Rockville	Schweber Electronics	(301) 881-3300
MARYLAND, Savage	Pyttronic Industries Inc	(301) [illegible]
**MASSACHUSETTS, Burlington	Zeus Components	(617) 273-0750
MASSACHUSETTS, Lexington	Harvey Electronics	(617) 861-9200
*MASSACHUSETTS, Newton	Cramer Electronics, Inc	(617) 969-7700
MASSACHUSETTS, Newton	Impact Sales Co Inc	(617) 964-7740
MASSACHUSETTS, Waltham	Schweber Electronics	(617) 890-8484
MASSACHUSETTS, Woburn	Hamilton Avnet Electronics	(617) 933-8000
MICHIGAN, Livonia	Hamilton Avnet Electronics	(313) 522-4700
*MICHIGAN, Livonia	Pioneer Standard Electronics	(313) 525-1800
MICHIGAN, Livonia	R S Electronics	(313) 525-1155
MINNESOTA, Bloomington	Hall-Mark Electronics	(612) 884-9056
MINNESOTA, Eden Prairie	Schweber Electronics	(612) 941-5280
*MINNESOTA, Edina	Cramer-Minnesota	(612) 835-7811
MINNESOTA, Edina	Hamilton Avnet Electronics	(612) 941-3801
MISSOURI, Earth City	Hall-Mark Electronics	(314) 291-5350
MISSOURI, Hazelwood	Hamilton Avnet Electronics	(314) 731-1144
†MISSOURI, Kansas City	LCOMP Kansas City Inc	(816) 221 2400
*MISSOURI, Maryland Heights	LCOMP St Louis Inc	(314) 291-6200
NEW JERSEY, Cedar Grove	Hamilton Avnet Electronics	(201) 239-0800
NEW JERSEY, Mt Laurel	Hamilton Avnet Electronics	(609) 234-2133
NEW JERSEY, Pennsauken	RESCO Electronics	(609) 662-4000 (215) 925-6900
NEW JERSEY, Somerset	Schweber Electronics	(201) 469-6008
NEW MEXICO, Albuquerque	Hamilton/Avnet Electronics	(505) 765-1500
***NEW YORK, Elmsford	Zeus Components	(914) 592-4121
NEW YORK, Farmingdale	Harrison Radio Corporation	(516) 293 7070
NEW YORK, Hauppauge, L I	Cramer/Long Island	(516) 231-5600
*NEW YORK, Rochester	Cramer/Rochester	(716) 275-0300
NEW YORK, Rochester	Hamilton Avnet Electronics	(716) 442-7820
NEW YORK, Rochester	Schweber Electronics	(716) 461-4000
*NEW YORK, Syracuse	Cramer Syracuse	(315) 437-6671
NEW YORK, East Syracuse	Hamilton Avnet Electronics	(315) 437 2642
†NEW YORK, Westbury L I	Schweber Electronics	(516) 334-7474
NEW YORK, Woodbury, L I.	Harvey Electronics	(516) 921-8700
NORTH CAROLINA, Greensboro	Pioneer Washington	(919) 273-4441
NORTH CAROLINA, Raleigh	Hall Mark Electronics	(919) 832 4465
NORTH CAROLINA, Raleigh	Hamilton Avnet Electronics	(919) 829 8030
NORTH CAROLINA, Winston-Salem	Cramer Winston-Salem	(919) 725 8711
OHIO, Beachwood	Schweber Electronics	(216) 464-2970
OHIO, Cincinnati	Hughes-Peters	(513) 351-2000
OHIO, Cleveland	Hamilton Avnet Electronics	(216) 461-1400
*OHIO, Cleveland	Pioneer-Standard Electronics, Inc.	(216) 587-3600
OHIO, Columbus	Hughes-Peters	(614) 294-5351
OHIO, Dayton	Hamilton/Avnet Electronics	(513) 433-0610
*OHIO, Dayton	Pioneer Dayton	(513) 236-9900
OHIO, Solon	Cramer Cleveland	(216) 248-8400
OKLAHOMA, Tulsa	Hall-Mark Electronics	(918) 835-8458
PENNSYLVANIA, Horsham	Pioneer Washington	(215) 674-4000
PENNSYLVANIA, Montgomeryville	Pyttronic Industries	(215) 643-2850
**PENNSYLVANIA, Philadelphia	Philadelphia Electronics Inc	(215) 568-7400
*PENNSYLVANIA, Pittsburgh	Pioneer-Standard Electronics	(412) 782-2300
SOUTH CAROLINA, Columbia	Dixie Electronics	(803) 779-5332
TEXAS, Austin	Hall Mark Electronics	(512) 837-2814
TEXAS, Austin	Sterling Electronics	(512) 836-1341
*TEXAS, Dallas	Hall Mark Electronics	(214) 234-7400
TEXAS, Dallas	Hamilton Avnet Electronics	(214) 661-8661
TEXAS, Dallas	Schweber Electronics	(214) 661-5010
TEXAS, Dallas	Sterling Electronics	(214) 357-9131
TEXAS, El Paso	Midland Speciality Co	(915) 533-9555
**TEXAS, Dallas	Trevino Electronics Inc	(214) 358-2418
TEXAS, Houston	Hall Mark Electronics	(713) 781-6100
TEXAS, Houston	Hamilton Avnet Electronics	(713) 780-1771
*TEXAS, Houston	Sterling Electronics, Inc	(713) 627-9800
UTAH, Salt Lake City	Hamilton Avnet Electronics	(801) 972-2800
WASHINGTON, Bellevue	Hamilton/Avnet Electronics	(206) 746-8750
WASHINGTON, Bellevue	Liberty Electronics Corp.	(206) 453-8300
*WASHINGTON, Seattle	Almac Stroum Electronics	(206) 763-2300
*WISCONSIN, Milwaukee	Marsh Electronics	(414) 475 6000
WISCONSIN, New Berlin	Hamilton Avnet Electronics	(414) 784 4510

CANADA

CALGARY, Alberta	L A Varah Ltd	(403) 276-8818
DOWNSVIEW, Ontario	Zentronics, Ltd	(416) 635 2822
EDMONTON, Alberta	Bowtek Electric Co., Ltd	(403) 426-1072
HAMILTON, Ontario	L A Varah Ltd	(416) 561-9311
LONDON, Ontario	C M Peterson Co Ltd	(519) 434-3204
MISSISSAUGA, Ontario	Hamilton Avnet Int'l Canada Ltd	(416) 677-7432
MONTREAL, Quebec	Cesco Electronics Ltd.	(514) 735-5511
OTTAWA, Ontario	Zentronics, Ltd.	(613) 232-3591
OTTAWA, Ontario	Hamilton Avnet Int'l Canada Ltd	(613) 626-1700
QUEBEC CITY, Quebec	Cesco Electronics Ltd	(418) 524-4641
ST. LAURENT, Quebec	Hamilton Avnet Int'l Canada Ltd	(514) 331-6443
TOWN OF MOUNT ROYAL, Quebec	Zentronics, Ltd.	(514) 735-5361
VANCOUVER, B C	Intek Electronics, Ltd.	(604) 324-6831
VANCOUVER, B C	L A Varah, Ltd.	(604) 873-3211
†WILLOWDALE, Ontario	Electro Sonic, Inc.	(416) 494-1555
WINNIPEG, Manitoba	L A Varah Ltd	(204) 633-6190

*Power Products
**Military Products
#LS TTL, M2900 Series, TTL RAMs
†Subsystem Products Also
††Subsystem Products

MOTOROLA CASE 152 UNIWATT

For lead or chassis mounted application or use with heat sink power dissipation of 1 watt (FREE AIR T_A = 25°C) to 10 watts at 25°C case

I_C Cont Amps Max	V_{CEO} (sus) Volts Min	Device Type		h_{FE} Min/Max	@ I_C Amp	Resistive Switching			f_T MHz Min	P_D (Case) Watts @ 25°C
		NPN	PNP			t_s µs Max	t_f µs Max	@ I_C Amp		
0.5	65	MPS-U31		10 min	0.1					10
	300	MPS-U10	MPS-U60	30 min	0.030				60	10
0.8	40	MPS-U02	MPS-U52	30 min	0.5				150	10
1	120	MPS-U03		40 min	0.010				100	10
	180	MPS-U04		40 min	0.010				100	10
2	30	MPS-U01	MPS-U51	50 min	1				50	10
	40	MPS-U01A	MPS-U51A	50 min	1				50	10
		MPS-U45●	MPS-U95●	4k min	1				100	10
	60	MPS-U05	MPS-U55	60 min	0.25				50	10
	80	MPS-U06	MPS-U56	60 min	0.25				50	10
	100	MPS-U07	MPS-U57	30 min	0.25				50	10

● Darlingtons

MOTOROLA TO-202 DUOWATT

For lead or chassis mounted applications or use with heat sink, power dissapation of 2 watts (FREE AIR T_A = 25°C) to 10 watts at 25°C case

I_C Cont Amps Max	V_{CEO} (sus) Volts Min	Device Type		h_{FE} Min/Max	@ I_C Amp	Resistive Switching			f_T MHz Min	P_D (Case) Watts @ 25°C
		NPN	PNP			t_s µs Max	t_f µs Max	@ I_C Amp		
0.1	250	D40N1		30/90	0.02				50	6.25
		D40N2		60/180	0.02				50	6.25
	300	D40N3		30/90	0.02				50	6.25
		D40N4		60/180	0.02				50	6.25
0.5	30	D40C1●		10k/60k	0.2	0.35 typ	0.8 typ	1	100	6.25
		D40C2●		40k min	0.2	0.35 typ	0.8 typ	1	100	6.25
	40	D40C4●		10k/60k	0.2	0.35 typ	0.8 typ	1	100	6.25
		D40C5●		40k min	0.2	0.35 typ	0.8 typ	1	100	6.25
	120	D40P1		40 min	0.08	2.5		0.08	50	6.25
	150	2N6591		40/200	0.1				35	10
	180	D40P3		40 min	0.08	2.5		0.08	50	6.25
	200	2N6592		30/200	0.1				35	10
	225	D40P5		40 min	0.08	2.5		0.08	50	6.25
	250	2N6557		40/180	0.03				45	10
		MDS20		40/250	0.03				60	10
		2N6593		30/200	0.1				35	10
	300	2N6558		40/180	0.03				45	10
			MDS60	30 min	0.03				45	10
		MDS21		40/250	0.03				60	10
	350	2N6559		40/180	0.03				45	10
1	30	D40D1	D41D1	10 min	1	0.2 typ	0.05 typ	1	200 typ	10
		D40D2	D41D2	20 min	1	0.2 typ	0.05 typ	1	200 typ	10
	45	D40D4	D41D4	10 min	1	0.2 typ	0.05 typ	1	200 typ	10
		D40D5	D41D5	10 min	1	0.2 typ	0.05 typ	1	200 typ	10
	60	2N6551	2N6554	25 min	0.5				75	10
		D40D7	D41D7	10 min	1	0.2 typ	0.05 typ	1	200 typ	10
		D40D8	D41D8	10 min	1	0.2 typ	0.05 typ	1	200 typ	10
	75	D40D10	D41D10	10 min	1	0.2 typ	0.05 typ	1	200 typ	10
		D40D11	D41D11	10 min	1	0.2 typ	0.05 typ	1	200 typ	10
		D40D13	D41D13	50/150	0.1	0.2 typ	0.05 typ	1	200 typ	10
		D40D14	D41D14	50/150	0.1	0.2 typ	0.05 typ	1	200 typ	10
	80	2N6552	2N6555	25 min	0.5				75	10
	100	2N6553	2N6556	25 min	0.5				75	10
2	30	D40E1	D41E1	10 min	1	0.4 typ	0.17 typ	1	230 typ	8
		D40K1●	D41K1●	1k min	1.5				100	10
		D40K3●	D41K3●	1k min	1.0				100	10
	40	2N6548●		5k min	1				100	10
		2N6549●		3k min	1				100	10
	50	D40K2●	D41K2●	1k min	1.5				100	10
		D40K4●	D41K4●	1k min	1.0				100	10
	60	D40E5	D41E5	10 min	1	0.4 typ	0.17 typ	1	230 typ	8
	80	D40E7	D41E7	10 min	1	0.4 typ	0.17 typ	1	220 typ	8
3	40	MDS26†	MDS76†	30 min	1.0				50	10
	60	MDS23	MDS73	50/250	0.1				50	10
		MDS27†	MDS77†	30 min	1.0				50	10
	65*	MDS1678		10 min	1.5				100	10
	80	MDS24	MDS74	50/250	0.1				50	10
	100	MDS25	MDS75	50/250	0.1				50	10

● Darlingtons * V_{CBO} † Pin out is: Pin 1-Base, Pin 2-Collector, Pin 3-Emitter

MOTOROLA TO-126 THERMOPAD

For lead mounted applications or use with heat sinks power dissipation of 12.5 to 40 watts at 25°C case

I_C Cont Amps Max	V_{CEO} (sus) Volts Min	Device Type		h_{FE} Min/Max	@ I_C Amp	Resistive Switching			f_T MHz Min	P_D (Case) Watts @ 25°C
		NPN	PNP			t_s µs Max	t_f µs Max	@ I_C Amp		
0.3	250	MJE3440		40/160	0.02				15	15
	350	MJE3439		40/160	0.02				15	15
0.5	150	MJE341		25/200	0.05				15	20.8
	200	MJE344		30/300	0.05				15	20.8
	250	2N5655		30/250	0.1	3.5 typ	0.24 typ	0.1	10	20
	300	MJE340	MJE350	30/240	0.05					20.8
		2N5656		30/250	0.1	3.5 typ	0.24 typ	0.1	10	20
	350	2N5657		30/250	0.1	3.5 typ	0.24 typ	0.1	10	20
1	40	2N4921	2N4918	20/100	0.5	0.6 typ	0.3 typ	0.5	3	30
	60	2N4922	2N4919	20/100	0.5	0.6 typ	0.3 typ	0.5	3	30
	80	2N4923	2N4920	20/100	0.5	0.6 typ	0.3 typ	0.5	3	30
1.5	300	MJE13002†‡		5/25	1	4	0.7	1	5	40
	400	MJE13003†‡		5/25	1	4	0.7	1	5	40
3	30	MJE520	MJE370	25 min	1					25
	40	MJE180	MJE170	50/25	0.1	0.6 typ	0.12 typ	0.1	50	12.5
	60	MJE181	MJE171	50/250	0.1	0.6 typ	0.12 typ	0.1	50	12.5
	80	MJE182	MJE172	50/250	0.1	0.6 typ	0.12 typ	0.1	50	12.5
4	40	MJE3300†●	MJE3310†●	1k min	1				20	15
		2N5190	2N5193	25/100	1.5	0.4 typ	0.4 typ	1.5	2	40
		MJE521	MJE371	40 min	1					40
		2N6037●	2N6034●	750/18k	2	1.7 typ	1.2 typ	2	25	40
	60	MJE3301†●	MJE3311†●	1k min	1				20#	15
		2N5191	2N5194	25/100	1.5	0.4 typ	0.4 typ	1.5	2	40
		MJE800●	MJE700●	750 min	1.5				1#	40
		2N6038●	2N6035●	750/18K	2	1.7 typ	1.2 typ	2	25	40
	80	MJE3302†●	MJE3312†●	1k min	1				20#	15
		2N5192	2N5195	25/100	1.5	0.4 typ	0.4 typ	1.5	2	40
		2N6039●	2N6036●	750/18k	2	1.7 typ	1.2 typ	2	25	40
	100	MJE243	MJE253	40/120	0.2	0.7 typ	0.08 typ	0.2	40	15
5	25	MJE200	MJE210	45/180	2	0.13 typ	0.035 typ	2	65	15

● Darlingtons † Case 77R (Style 3) Pin out is: Pin 1-Base, Pin 2-Collector, Pin 3-Emitter
‡ Switchmode # h_{fe} @ 1 MHz

MOTOROLA TO-127 THERMOPAD

For lead mounted applications or use with heat sinks power dissipation of 65 to 100 watts at 25°C case

I_C Cont Amps Max	V_{CEO} (sus) Volts Min	Device Type		h_{FE} Min/Max	@ I_C Amp	Resistive Switching			f_T MHz Min	P_D (Case) Watts @ 25°C
		NPN	PNP			t_s µs Max	t_f µs Max	@ I_C Amp		
5	40	2N5977	2N5974	20/120	2.5	0.45 typ	0.18 typ	2.5	2	75
	50	MJE205	MJE105	25/100	2					65
	60	2N5978	2N5975	25/100	2.5	0.45 typ	0.18 typ	2.5	2	75
	80	2N5979	2N5976	20/120	2.5	0.45 typ	0.18 typ	2.5	2	75
8	60	MJE6043●	MJE6040●	1k/20k	4	1.5 typ	1.5 typ	4	4#	75
	80	MJE6044●	MJE6041●	1k/20k	4	1.5 typ	1.5 typ	4	4#	75
	100	MJE6045●	MJE6042●	1k/20k	4	1.5 typ	1.5 typ	4	4#	75
10	60	MJE3055	MJE2955	20/70	4				2	90
12	40	2N5989	2N5986	20/120	6	0.5 typ	0.25 typ	6	2	100
	60	2N5990	2N5987	20/120	6	0.5 typ	0.25 typ	6	2	100
	80	2N5991	2N5988	20/120	6	0.5 typ	0.25 typ	6	2	100
15	40	MJE1660	MJE1290	20/100	5				3	90
	60	MJE1661	MJE1291	20/100	5				3	90

● Darlingtons

MOTOROLA TO-220 THERMOWATT

For lead mounted applications or use with heat sinks power disippation of 30 to 100 watts at 25°C case

I_C Cont Amps Max	V_{CEO} (sus) Volts Min	Device Type		h_{FE} Min/Max	@ I_C Amp	Resistive Switching			f_T MHz Min	P_D (Case) Watts @ 25°C
		NPN	PNP			t_s µs Max	t_f µs Max	@ I_C Amp		
0.5	350	MJE2360T		15 min	0.1				10 typ	30
		MJE2361T		40 min	0.1				10 typ	30
1	40	TIP29	TIP30	15/75	1	0.6 typ	0.3 typ	1	3	30
	60	TIP29A	TIP30A	15/75	1	0.6 typ	0.3 typ	1	3	30
	80	TIP29B	TIP30B	15/75	1	0.6 typ	0.3 typ	1	3	30
	100	TIP29C	TIP30C	15/75	1	0.6 typ	0.3 typ	1	3	30
	250	TIP47		30/150	0.3	2 typ	0.18 typ	0.3	10	40
	300	TIP48		30/150	0.3	2 typ	0.18 typ	0.3	10	40
	350	TIP49		30/150	0.3	2 typ	0.18 typ	0.3	10	40
	400	TIP50		30/150	0.3	2 typ	0.18 typ	0.3	10	40
2	60	TIP110●	TIP115●	500 min	2	1.7 typ	1.3 typ	2	25#	50
	80	TIP111●	TIP116●	500 min	2	1.7 typ	1.3 typ	2	25#	50
	100	TIP112●	TIP117●	500 min	2	1.7 typ	1.3 typ	2	25#	50
3	40	TIP31	TIP32	25 min	1	0.6 typ	0.3 typ	1	3	40
	60	TIP31A	TIP32A	25 min	1	0.6 typ	0.3 typ	1	3	40
	80	TIP31B	TIP32B	25 min	1	0.6 typ	0.3 typ	1	3	40
	100	TIP31C	TIP32C	25 min	1	0.6 typ	0.3 typ	1	3	40
4	45	2N6121	2N6124	25/100	1.5	0.4 typ	0.3 typ	1.5	2.5	40
	60	2N6122	2N6125	25/100	1.5	0.4 typ	0.3 typ	1.5	2.5	40
	80	2N6123	2N6126	20/80	1.5	0.4 typ	0.3 typ	1.5	2.5	40
	300	MJE13004‡		6/30	3	3	0.7	3	4	60
	400	MJE13005‡		6/30	3	3	0.7	3	4	60
5	60	TIP120●	TIP125●	1k min	3	1.5 typ	1.5 typ	3	4#	65
	80	TIP121●	TIP126●	1k min	3	1.5 typ	1.5 typ	3	4#	65
	100	TIP122●	TIP127●	1k min	3	1.5 typ	1.5 typ	4	4#	75
	250	MJE51T		5 min	5	2 typ*		2.5	2.5	80
		2N6497‡		10/75	2.5	1.8	0.8	2.5	5	80
	300	MJE52T		5 min	5	2 typ*		2.5	2.5	80
		2N6498‡		10/75	2.5	1.8	0.8	2.5	5	80
	350	MJE53T		5 min	5	2 typ*		2.5	2.5	80
		2N6499‡		10/75	2.5	1.8	0.8	2.5	5	80
6	40	TIP41	TIP42	15/75	3	0.4 typ	0.15 typ	3	3	65
	60	TIP41A	TIP42A	15/75	3	0.4 typ	0.15 typ	3	3	65
	80	TIP41B	TIP42B	15/75	3	0.4 typ	0.15 typ	3	3	65
	100	TIP41C	TIP42C	15/75	3	0.4 typ	0.15 typ	3	3	65
7	30	2N6288	2N6111	30/150	3	0.4 typ	0.15 typ	3	4	40
	50	2N6290	2N6109	30/150	2.5	0.4 typ	0.15 typ	3	4	40
	70	2N6292	2N1607	30/150	3	0.4 typ	0.15 typ	3	4	40
8	40	2N6386●		1k/20k	3				20#	65
	60	2N6043●	2N6040●	1k/20k	4	1.5 typ	1.5 typ	3	4#	75
		TIP100●	TIP105●	1k/20k	3	1.5 typ	1.5 typ	3	4#	80
	80	2N6044●	2N6041●	1k/10k	4	1.5 typ	1.5 typ	3	4#	75
		TIP101●	TIP106●	1k/20k	3	1.5 typ	1.5 typ	3	4#	80
	100	2N6045●	2N6042●	1k/10k	3	1.5 typ	1.5 typ	3	4#	75
		TIP102●	TIP107●	1k/20k	3	1.5 typ	1.5 typ	3	4#	80
	120	MJE15028	MJE15029	40 min	3				30	50
	150	MJE15030	MJE15031	40 min	3				30	50
	300	MJE13006‡		6/30	5	3	0.7	5	4	80
	400	MJE13007‡		6/30	5	3	0.7	5	4	80
10	60	MJE2801T	MJE2901T	25/100	3					75
		MJE3055T	MJE2955T	20/70	4					75
		2N6387●		1k/20k	5				20#	65
	80	2N6388●		1k/20k	5				20#	65
		D44H10	D45H10	20 min	4				50 typ	50
		D44H11	D45H11	40 min	4				50 typ	50
12	300	MJE13008‡		6/30	8	3	0.7	8	4	100
	400	MJE13009‡		6/30	8	3	0.7	8	4	10
15	40	2N6486	2N6489	20/150	5	0.6 typ	0.3 typ	5	5	75
	60	2N6487	2N6490	20/150	5	0.6 typ	0.3 typ	5	5	75
	80	2N6488	2N6491	20/150	5	0.6 typ	0.3 typ	5	5	75

● Darlingtons ‡ Switchmode * t_{off} # h_{fe} @ 1MHz

TEAR ALONG PERFORATION FOR SELECTOR GUIDE . . . USE IT AS POCKET GUIDE, TACK IT UP, OR FILE IT.

today's advanced circuits. So it was that a Japanese newcomer scored a technical hit when it unveiled a 100-megahertz, 64-pin test station designed for LSI.

Takeda Riken Industry Co.'s 100-MHz station dazzled equipment users limited to 20-MHz and 25-MHz testers with specifications like 0.7-nanosecond transition times for driver output and comparator input waveforms, minimum driver pulse widths of 2 ns, and ± 100-picosecond timing skew between pins.

At a time when most testers are barely able to keep up with the faster devices, manufacturers are attempting to test LSI chips functionally at their actual operating speeds. As a result, Takeda's announcement raises confidence that it will be possible to keep up with the still faster LSI devices of the future.

Moreover, Tohru Kazamaki, Takeda's manager of research and development, promises that a complete 100-MHz test system, including high-speed controller and memory, will be ready for sale in December 1979, a few months after its debut in Japan.

The present test station has 64-pin cards encircling its test-head, one for each test point. Each card contains a driver circuit for applying test waveforms and a comparator circuit for monitoring output data waveforms of the device under test. The test head permits the testing of a 64-pin device on one side or an unpackaged wafer on the other, simply by flipping the head over.

Hybrid ICs do it. How does the company get the speed and reliability necessary for the station? A large part of the solution is in the custom hybrid integrated circuits developed for the driver and comparator circuits. These hybrids have transistor chips mounted on thin-film pads of tantalum sputtered on an alumina substrate. With their 4-gigahertz transition frequency, the transistors are fast enough to allow a transition time of 0.4 ns for a driver output of 1 volt. However, the driver output is set at 0.8 V, increasing the transition time to 0.7 ns to match that of the 50-ohm microstrip transmission lines used throughout. This driver output setting insures waveform quality, which gets harder to maintain as frequency increases.

The reliability of the hybrid ICs, which is temperature-dependent, was as important as high-speed operation. An 85°C target was set for the chip transistor's maximum junction temperature and is achieved in the driver hybrid with an unusual packaging technique.

The substrate side of the package, usually mounted directly on the printed-circuit board, has been flipped over and fitted with a heat sink fin that dissipates heat generated by the driver (1.5 watt maximum). This package actually keeps the junction at 80°C when air flows across it at 1.5 meters per second. ☐

Medical

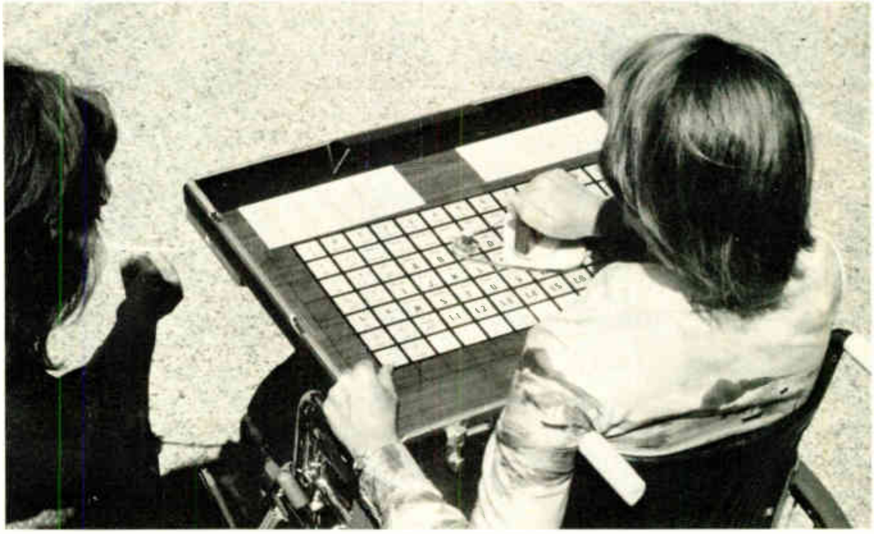
Telesensory readies aids for handicapped

Electronics continues to make life easier for disabled persons, though the relatively small market keeps the cost of the aids high. Two of the latest—one composes messages for those who cannot speak, the other allows blind persons to take notes in braille on a tape cassette—are being prepared for market by Telesensory Systems Inc. This is the Palo Alto, Calif., company that has been a pioneer in developing such aids, particularly for the blind.

Ouija board. Telesensory's message composer, which will sell for $4,000, is designed for victims of diseases like cerebral palsy who neither can speak nor have the motor coordination to use a keyboard. The device, called Autocom, resembles a ouija board: the user chooses words, phrases, or symbols printed on a lap-sized board, shown in the photograph, by pushing a magnetic pointer into place. Words and symbols in the board's spaces are also stored within the unit's electronic memory.

Magnetic sensors beneath the board determine where the pointer is placed, and a microcomputer retrieves the material from memory and displays it on a 32-character light-emitting-diode display. At the same time, the material is formatted for printout on an accessory unit like an electric typewriter. The unit's vocabulary can be changed by substituting memory chips. And its pointer can be designed for a range of motor abilities.

The flat, lap-tray design of the battery-powered Autocom contrasts with the Universal Communicator, or Unicom, developed at the Massachusetts Institute of Technology to perform the same task [*Electronics*, May 11, p. 42]. Unicom has three



Composer. Messages, composed on Autocom by pushing magnetized pointer over letters, words, and phrases, are read on LED display housed in black rectangle at board's far edge.

separate elements: the input device, electronic "box," and a TV display.

Telesensory obtained the rights to Autocom, which stands for auto-monitoring communication board, from its developer, the University of Wisconsin's Trace Research and Development Center for the Severely Communicatively Handicapped in Madison.

Versabraille. Telesensory's aid for the blind is Versabraille, a $2,600 cassette recorder that stores information keyed in the six-cell braille code. The braille can be not only recorded, played back, and erased, but also indexed and edited. The 10-pound machine, which resembles a thick, portable cassette recorder, records audio signals as well.

Information goes into the recorder via a six-button braille key and is placed within a 1,000-character random-access buffer memory that forms a page. Up to 200 pages can be recorded on one side of a 60-minute-long audio tape cassette, with the first page holding an index. Line-by-line or character-by-character reading, writing, and editing anywhere within the page are controlled by an 8-bit, single-chip microcomputer. Words are read out on a 20-cell tactile braille display with each cell consisting of the six-dot braille matrix.

Seven-year-old Telesensory, which sold $5 million worth of instruments in its last fiscal year, is also developing an automatic page reader to convert print into synthetic speech. Plans call for a family of products available by late 1979. ☐

Displays

Substrate holds 32 LC characters

Pushing forward the state of the LCD art is the liquid-crystal display containing 32 multiplexed characters on a single substrate announced last month by Crystaloid Electronics Co. The characters, arranged in a single straight line, number at least twice as many as had ever been placed on a single such substrate before; multicharacter displays are usually obtained by butting individual LCDs together, a costly method.

Moreover, Crystaloid, a Hudson, Ohio, maker of LCDs for watches, clocks, and instruments, has developed a multiplexed driving and control scheme for the display. It is offering the package of the three-chip driver plus display for $395.

"We're initially going after the market for the single-line displays used on many of the typewriters in word-processing systems," says Ken Richardson, vice president of engineering of the 70-employee subsidiary of Eaton Corp. This display, generally implemented with 32 individual five-by-seven-dot–matrix light-emitting diodes, shows what is being typed into the system before it is stored in memory.

"At our price, we think we could provide a considerably cheaper system in the long run and one that would use a lot less power," Richardson continues. "The market is a substantial one: 80,000 units a year, at least, and growing at a 22% annual rate."

In the wings. Meanwhile Crystaloid has a still larger display waiting in the wings. This model has 64 characters in a single row—about the number of characters printed across the page of a standard 8½-by-11-inch piece of typing paper. Only 0.14 in. high, the characters are half the size of those in the 32-character display.

But Crystaloid has a competitor here. Static Systems Inc., New York, for which Crystaloid developed the 64-character display, says that it, as well as Crystaloid, will market the display, in addition to putting it to use.

That use is in a "solid-state" typewriter that Static Systems has been promoting heavily for more than a year in advertisements in the trade press. The company has yet to put together its first unit, however, although president Robert W. Lester says that will happen early next year.

Rather than use mechanical keys to strike an inked ribbon, the new typewriter will rely on the 64-character LCD to expose characters on paper, which will then be processed in an office copier. The paper would be exposed a line at a time, after the words had been key-punched and edited in the unit. "The size of the LCD characters is very close to the standard character type you find today," Lester adds.

Proprietary process and design techniques, which Crystaloid will not discuss, enabled it to come up with a system on a board that includes a programmable controller, a multiplexed liquid-crystal display, and drive circuits. The controller generates the ASCII characters and has a 32-bit-by-8-word random-access memory for character position and display refreshing. The RAM can be programmed to rotate the display, shift it left or right, clear it, and increment the cursor. Display and logic operate off +5 volts and interface with complementary-metal-oxide-semiconductor circuitry. The display alone sells for $75. ☐

Communications

Grumman designs new fire helmet

No one would expect an astronaut walking in the hostile environment of the moon to use one of his two hands to hold a radio communication set. Yet, fire fighters in the middle of a raging fire must do just that. But help is now on the way as equipment concepts used as long ago as the Korean War are being applied to the problems of today's firemen.

"We developed a fire helmet with a built-in communications system based on a bone-conduction microphone," says Hy Kaplan, civil technology manager at Grumman Aerospace Corp. in Bethpage, N. Y. "Until now, because they were expensive, heavy, and clumsy, only officers carried the portable radios needed for communications with local fire control. But it's certainly obvious that for maximum safety, each fireman should be able to communicate

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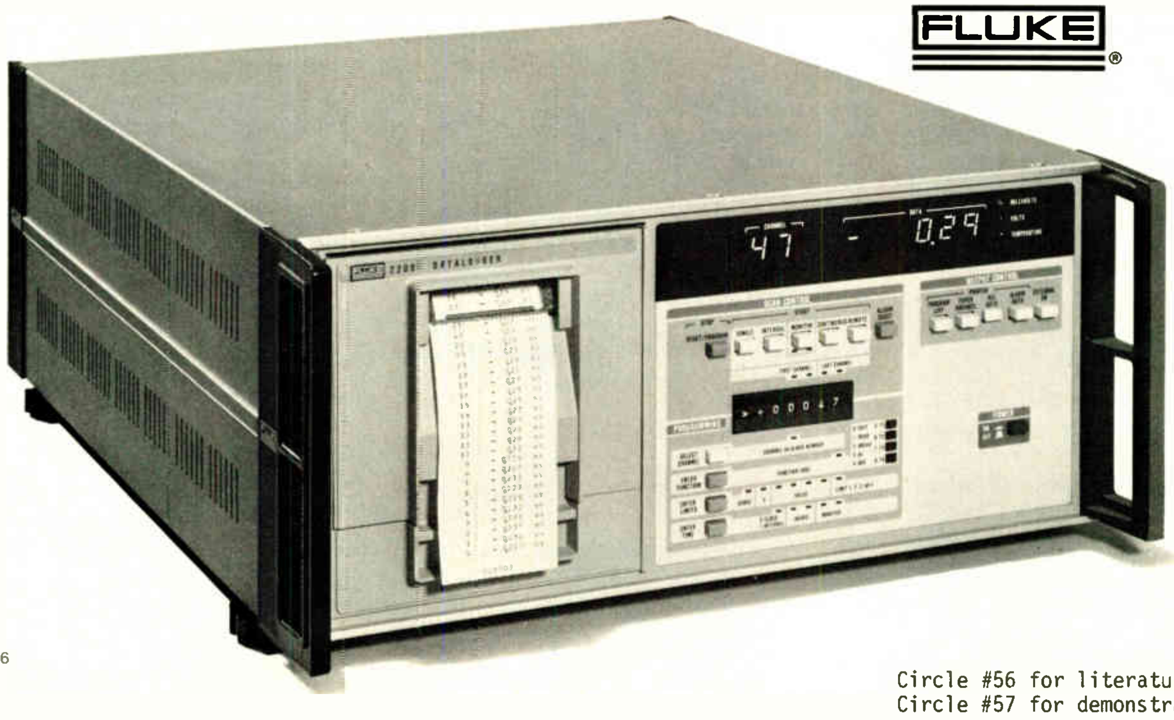

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Circle 58 on reader service card

New look. Grumman fire fighter's helmet builds in a bone-conduction microphone that allows hands-free communications.

quickly with the control center."

Grumman's work was performed under a $480,000 contract with the National Fire Prevention and Control Administration and the National Aeronautics and Space Administration. Its goal was to apply the latest in technology to redesign the fire fighter's clothing and communications gear to afford the greatest possible utility and protection. The result so far is an outfit that is more akin to an astronaut's than to the conventional fireman's.

Lots of interest. Various fire-fighting organizations around the country gave Grumman technical advice in the project. Though they may like what they now see, their decision to apply the new equipment awaits further tests and study and the availability of commercial products. Such products may be available soon: Motorola Inc. is discussing with Grumman the possibility of producing the radio-helmets.

For the microphone, Grumman is using the model D578 bone-conduction unit developed for military applications by Dynamagnetics Inc., Westbury, N. Y. When a transducer is pressed tightly against a speaker's head, it will pick up the speech

World Radio History

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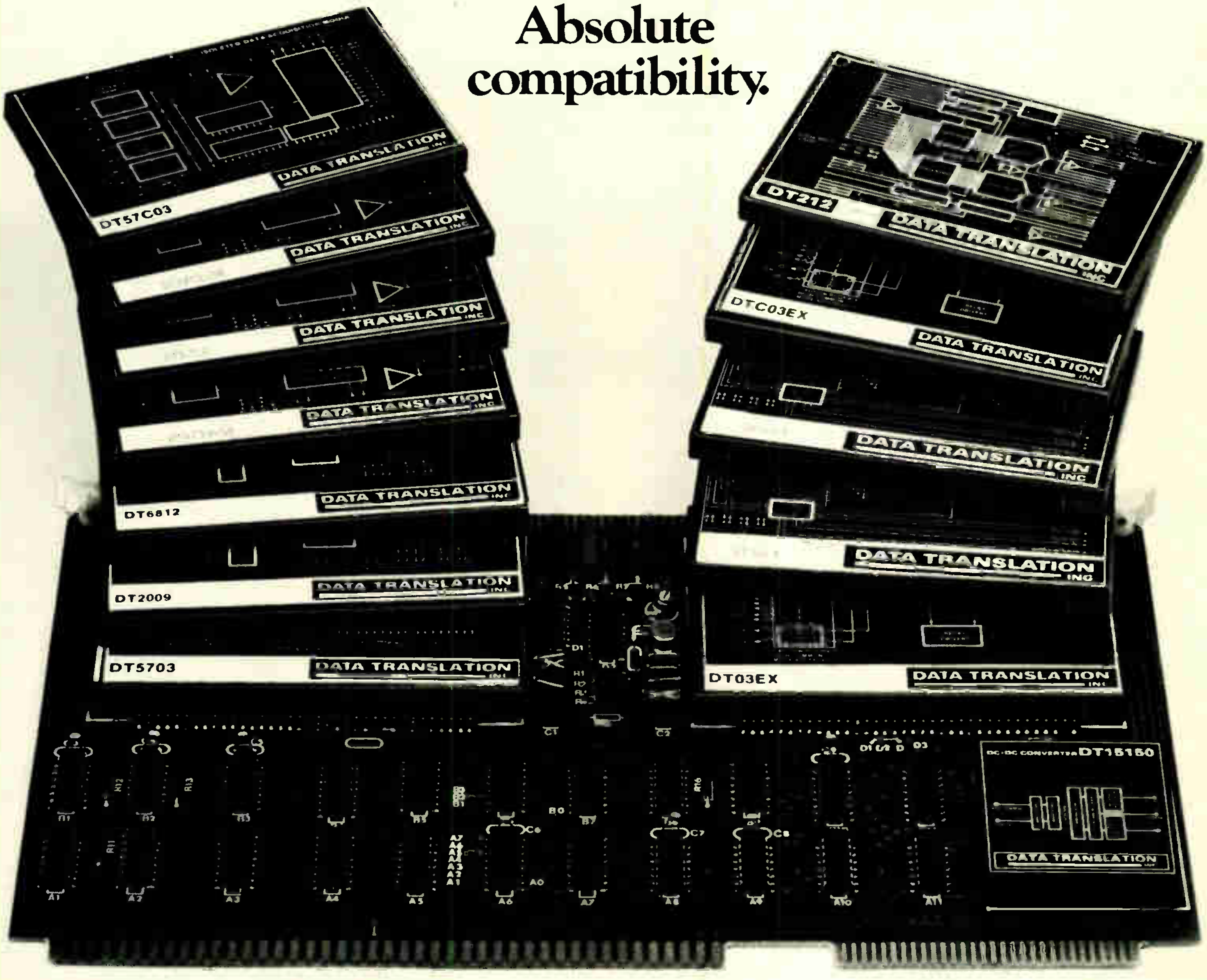

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vibrations of the bone structure.

Accordingly, the microphone is suspended in the helmet lining and presses against the forehead. This provides noise-free transmission in a 100-decibel noise environment (about that of a noisy subway), which is typical of fire scenes. Better still, the helmet has a public address system. Also, it can generate an emergency location signal so that if the fireman becomes injured or trapped he can transmit an alarm to aid others in locating him. (Dynamagnetics has gone into bankruptcy, but Grumman expects another company to pick up its product line.)

The complete system, including batteries, weighs less than 1½ pounds and operates with a 5-mile line-of-sight range, as well as within a 10-story steel and concrete building. "The radio's specs were set up with practicality in the field being all-important," Kaplan notes. "For example, the up-to-six-channel receiver [how many depends on the needs of the individual fire department] has a 95% probability of intelligible transmission of a 5-second message in a 250°C ambient temperature. It can also be used to talk to a fireman as close as 2 feet away."

"You can't consider any of the communications gear to use radically new technology," Kaplan says. "We merely took a good look at the fireman's problems for the first time. The result is to bring his communications into the space age." ☐

News briefs

Anderson to become Rockwell's chairman

Robert Anderson will be elected to the top spot at Rockwell International Corp. next February, when Williard F. Rockwell Jr. intends to step down as chairman of the board, a year earlier than originally planned. Rockwell will be 65 next April. Anderson, whose new title will be chairman and chief executive officer, joined the Pittsburgh-based firm in 1968 and was elected president and chief executive officer in 1970. Donald R. Beall, currently executive vice president, aerospace and electronics, will be named president and chief operating officer, filling the post vacated by Anderson.

Charles Tandy, director of Radio Shack expansion, dead at 60

Charles D. Tandy, board chairman and president of Tandy Corp., the parent company of the Radio Shack chain, died in his sleep of a heart attack early this month. The Fort Worth millionaire, 60, whose annual salary had reached $847,050, guided Radio Shack from a faltering group of nine Boston-area ham radio stores in 1963 to a chain of more than 6,500 consumer electronics stores with sales this year of more than $1 billion. The company recently launched a chain of Radio Shack computer centers based on sales of its own $600 TRS-80 personal computer. Phil R. North, a Tandy director since 1966, was elected chairman and president following Tandy's death.

Controller maker develops double-action hardware

Xebec Systems Inc., a Santa Clara, Calif., manufacturer of controllers for cartridge disk drives compatible with Digital Equipment Corp. computers, has achieved what it is calling a breakthrough in discrete integrated-circuit microprocessor design. Its new X-2 bipolar microprogrammed unit does the work of two separate microprocessors but uses little more than the hardware for one, according to Alton B. Otis, director of research and development. Controlling two asynchronous subsystems—a disk drive and the host computer's data bus—the X-2, an integral part of Xebec's Quad cartridge disk controller, can process instructions in 125 nanoseconds.

CB licenses climb 22% in year, total a record 14 million

The U. S. now has a record 14 million-plus citizens' band radio licensees following the issuance of 2.5 million new licenses in the 12 months ended Oct. 30—a 22% annual growth rate. The Federal Communications Commission says Texas leads with more than 1 million licensees, followed by California and Ohio with over 800,000 each.

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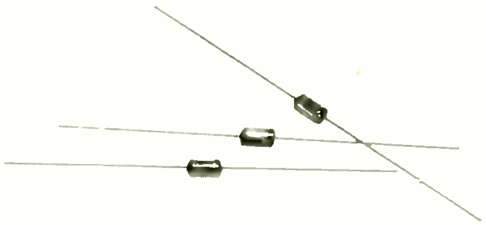

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Circle 62 on reader service card

Washington newsletter

Congress will push DOD to accelerate procurement cycle . . .

The House Armed Services Committee will push next year to shorten the Pentagon's prolonged weapons system acquisition cycle and put more state-of-the-art hardware into the military's hands. Research and development subcommittee chairman Richard Ichord (D., Mo.) says the procurement cycle, already "ridiculously long," could become even longer under the Office of Management and Budget's A-109 procurement policy circular. The committee's skepticism of A-109 "is universally shared," Ichord says. Earlier this year, he detailed subcommittee findings [*Electronics*, Sept. 14, p. 58]. Ichord attributes most program problems to **unnecessary paperwork during R&D that often attempts to set rigid performance specifications too early in a program** and to prolonged testing and inadequate funding during the transition to production.

. . . U. S. trails Soviets in EW, IFF areas, Ichord says

Overlong procurement cycles have already put the U. S. "decisively behind" the Soviet Union in electronic warfare, target detection, and identification-of-friend-or-foe hardware, Rep. Ichord declares, noting that **a five-year technology lead is of no value if it is still in development and not deployable.** To rectify the imbalance, he outlined five House committee goals before the Government Microcircuit Applications Conference earlier this month at Monterey, Calif. The House committee will focus on limiting A-109's fly-before-buy and prototyping requirements to high-risk, sophisticated systems; tailoring acquisition strategies to individual program times and costs; guaranteeing future availability of adequate production funds at the time of full-scale development; ensuring system flexibility by limiting specifications early in the cycle; and requiring the Defense Department to consider upgrading existing systems as an alternative before initiating the development of new ones.

TV price hikes despite sales slip worry White House

Wary of a 1979 recession, White House monitors of consumer economics say they are concerned that U. S. color TV makers are increasing prices despite October's 2.4% dip in sales to dealers—the first monthly decline this year. Also, monochrome set sales dropped 6.7% in the month from the 1977 level. Although color and monochrome unit sales are still ahead of last year by 14% and 8%, respectively, the White House economists call it **bad planning to push prices up when sales start slipping, even though the increases may be small.** The color price increases will be small—an average 3% to 5% at retail—but they will be the second in a year, the economists point out.

New rfi inquiry set by FCC; comments due May 1

A new inquiry into radio-frequency interference is being readied by the Federal Communications Commission in response to increasing business and consumer complaints. The notice of inquiry under Docket No. 78-369 is expected to be ready in December, with comments due by May 1, 1979. **Nearly three quarters of the rfi complaints come from home-entertainment electronics users,** the FCC says, and usually involve citizens' band, amateur, broadcast, and land-mobile transmitters. Other malfunctions produced by rfi involve air navigational aids, pacemakers, truck braking, and automotive electronic fuel-injection systems, as well as explosive systems used at construction sites.

Washington commentary

Competition: the Bell System's challenge for Charlie Brown

Seventy percent of America's consumers, running scared before inflation, favor more telephone industry competition, according to pollster Louis Harris. Close to half of the Harris sample believes that more competition would produce better service, and nearly a quarter of it thinks that competition will lead to lower charges for local service.

"You must seize the initiative," Harris told his telephone company clients, but cautioned, "It is critical that you do not communicate the fact that you are accepting competition because you had no choice in the end."

Instead, Harris said, "It would be far better if you said to your customers—the American public—something like this: 'We've had it with monopoly status and we think you have, too. . . . We think the state of technology now makes competition both possible and desirable, and we welcome it. . . .'"

The Justice Department has had it with American Telephone & Telegraph Co.'s monopoly status for some time, of course. It has been four years since the department initiated its most recent antitrust effort against the company. The fact that AT&T's assets of nearly $94 billion make it the largest corporation in world history troubles Federal prosecutors less than their conviction that AT&T has abused its enormous leverage in the marketplace to stifle applications of new telecommunications technology developed outside its own system (see p. 98).

AT&T disputes the Government's allegations, of course, and the Justice Department has a lot of work to do before it can prove its charges in court. AT&T, meanwhile, is not standing still.

Beating Justice to the punch

A total restructuring of the Bell System is just beginning and will continue under the guidance of AT&T's president and chairman-elect Charles L. Brown. That reorganization will take a couple of years at least, involving as it does 65 corporate entities including the Long Lines division, 23 operating companies, and the respective manufacturing and research operations of Western Electric and Bell Laboratories. Nevertheless, it is a reorganization that should be completed and operating before any final court ruling on whether AT&T should be broken up.

That seems to be just what the company wants to achieve, even though AT&T's successor to chairman John D. deButts vigorously denies it. "Some have speculated that the decision to reorganize has a pressing 'hidden agenda' of legal and regulatory apprehensions," Brown recently told Bell System workers. "There are no grounds for this speculation. None. Our agenda is not hidden—but it is pressing."

What, then, is AT&T's rationale for its far-reaching reorganization? It is, Brown says, "a response to equally far-reaching changes in the society we serve. And we can expect the pace of change—organizational and social—to accelerate." Clearly, Charlie Brown has read his Harris poll, as well as his Justice Department briefs. Unlike his predecessor, he is reported to like the idea of competition—particularly when his company can compete from a position of strength. "We are in a time of corporate strength," he points out. "There is no better time for change."

A new outlook on competition

The selection of Brown for the chairmanship of an organization whose annual revenues account for nearly 2% of the Gross National Product could prove to be a stroke of genius. If so, much of the credit should go to John deButts, who seems to have recognized that his reputation as a tough, uncompromising leader is no longer appropriate for the times.

Having changed AT&T's image at the top and by encouraging competition, Brown may be able to cut the ground out from under the Government's antitrust suit and its insistence that the company divest itself of Western Electric and Bell Laboratories. Brown surely knows that not everyone in Government shares the Justice Department's view that Western Electric itself should be broken up into several pieces in order to prevent its dominance of the equipment marketplace.

That prospect scares some senior officials at the Commerce and State Departments, for example. They see the issue in terms of growing world telecommunications markets in which AT&T and Western Electric are significant forces, making important contributions to increasing the American market share.

Such support from within the Government is important to AT&T, of course, although it is probably less critical than gaining widespread customer support—including that of the U. S. telecommunications equipment industry. If AT&T promotes innovation and widespread competition while sheltering smaller domestic manufacturers under its own market umbrella, who will be left to complain? It seems highly unlikely that any manufacturer would be willing to stand up in court and denounce the practices of its best customer.

Ray Connolly

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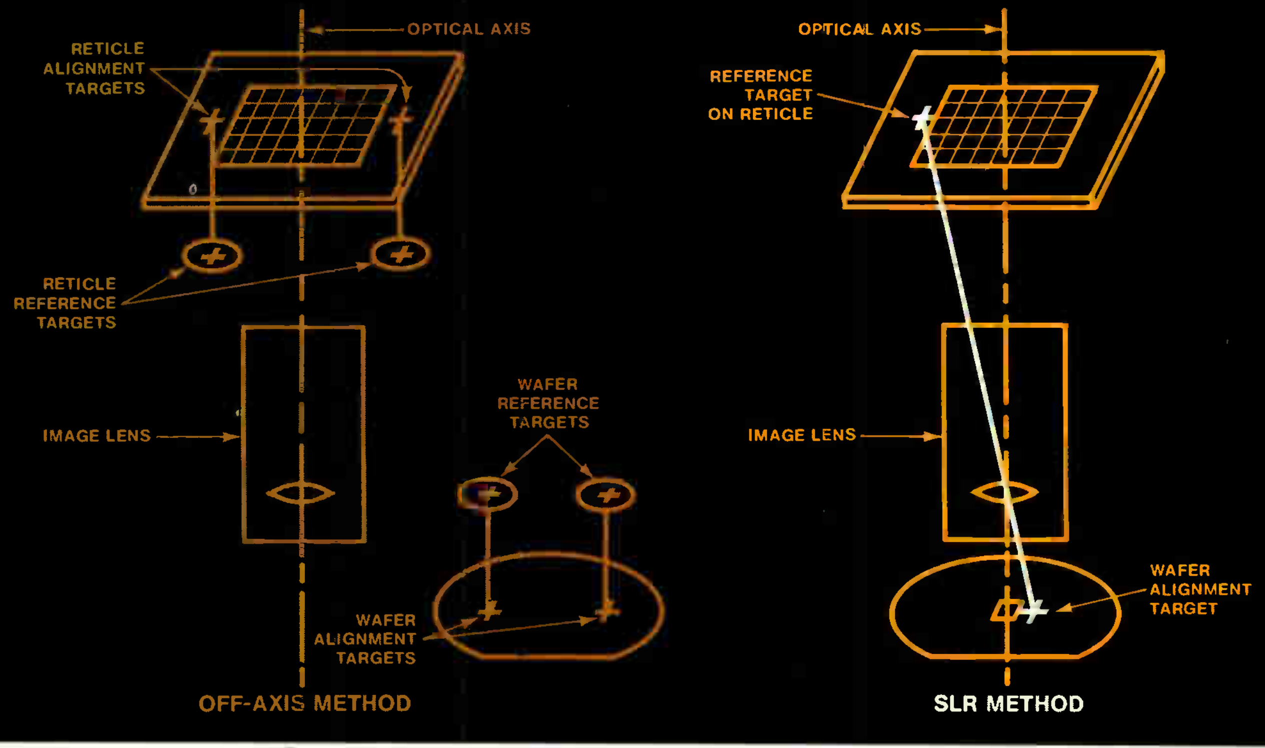

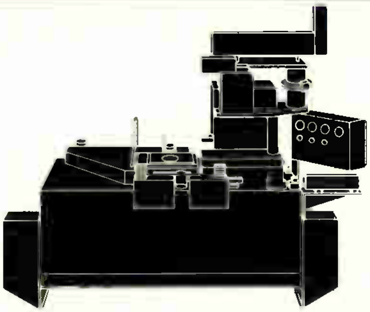

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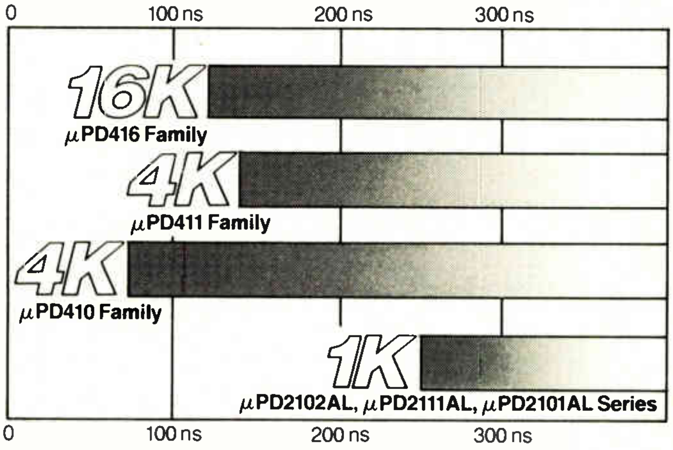

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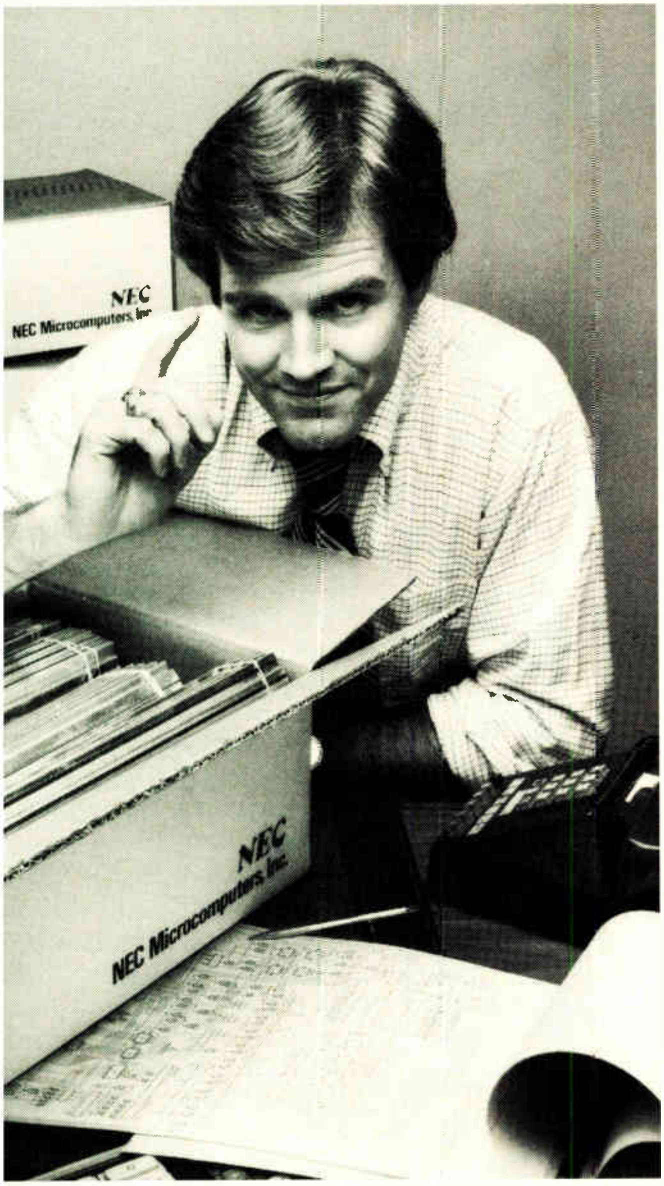

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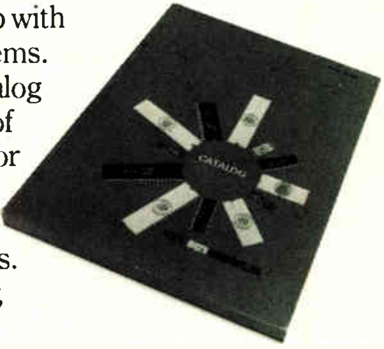

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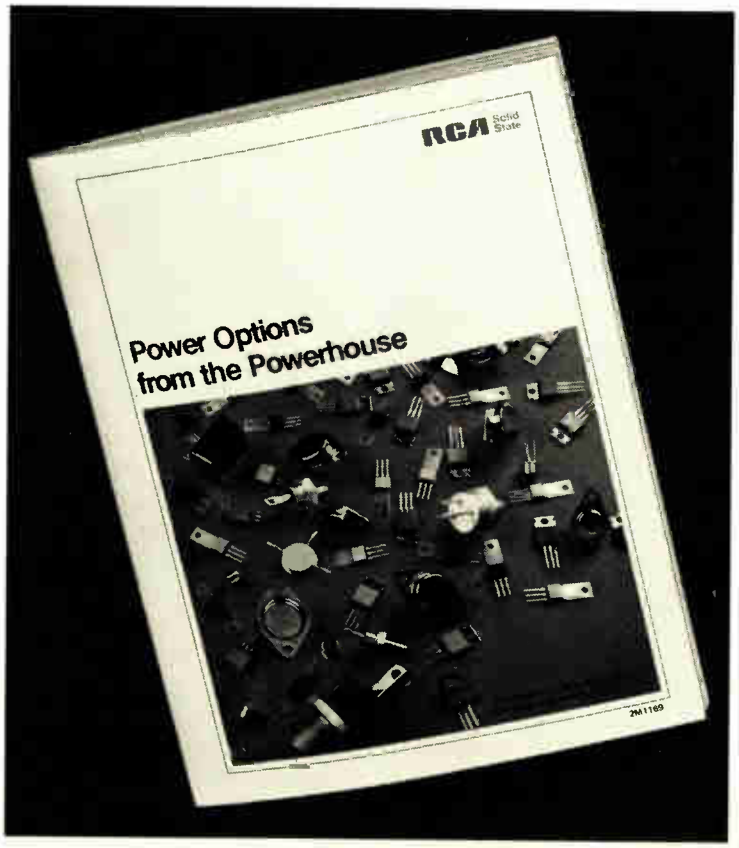

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Circle 68 on reader service card

International newsletter

Multichannel codec from Plessey challenges per-channel units

Taking a different track from other codec manufacturers, Plessey Semiconductors in Swindon, UK, is launching its 30-channel, two-chip, 2-megabit coder-decoder. **Plessey claims it is cheaper than single-channel codecs for multichannel pulse-code-modulated applications.** The chip set includes a multiplexer and a codec on a chip made with Plessey's emitter-coupled-logic process and an n-MOS digital control chip. It meets European requirements for a 30-channel A-law–coded system.

40 characters a line in new LCD from Hitachi

Cramming more and more characters into liquid-crystal displays seems to be the game these days. Surpassing the 32 alphanumerics of Crystaloid Electronics Corp.'s display (p. 56), Japan's **Hitachi Ltd. is in the final stages of development of one- or two-line 40-character-per-line displays.** The H2515 and 2516 modules will incorporate Hitachi-designed complementary-MOS driver ICs operating off +5-V and −7-V supplies. The five-by-seven-dot characters measure 3.1 by 4.4 mm, in itself a feat of miniaturization. The displays, to cost $300 to $400, are slated for worldwide introduction in May 1979.

TV image joins head-up display in military prototype

Seeking to improve military aircrafts' all-weather capabilities, West Germany's Teldix GmbH has developed a prototype system combining on the windshield a head-up display of flight information and a TV display of the outside world. Within the field of view of the HUD system, **the TV image coincides with the pilot's view of the outside world for a smooth transition from direct to TV viewing in twilight or poor visibility.** The combination greatly enhances flight safety, the company says, because with both displays in the same viewing plane, the pilot need not constantly shift his vision from the instrument panel to the windshield. Teldix, a Heidelberg-based firm jointly owned by AEG-Telefunken and the Robert Bosch group, is also working on a wide-angle HUD system giving a 35° field of view instead of the more common 25°.

Siemens rejoins computer joustings in France

Siemens AG is reentering the French computer market. The prime reason is to be present on a market that after West Germany's "ranks as the European continent's biggest and is growing at above-average rates," the German company says. **Equipment lineup for France encompasses small business systems, peripherals, and word processors,** as well as computers of the new 7700 and 7800 families [*Electronics*, Nov. 9, p. 63]. The company's decision to reactivate its sales operations in France comes about three years after the demise of the Unidata computer combine that linked Siemens, Holland's Philips, and France's CII.

Line up now for Canon fine-line projectors

Canon Inc. is now taking orders for its new line of aligners for fine-pattern photolithography on silicon wafers. Available now for about $170,000 is the PLA-520A proximity-mask aligner, which uses a 200-to-260-nanometer ultraviolet source **to give a minimum line width of 0.5 μm for contact printing or 2 μm when the mask-wafer separation is 20 μm.** Alignment precision is ±0.5 μm. The other two models are similar step-and-repeat aligners [*Electronics*, Oct. 12, p. 63]. Developed with guidance from Japan's Cooperative Laboratory for the very large-scale integration project, they will cost about $186,000, with delivery to begin next fall. The

FPA-211FA can reach a minimum line width of 2 μm with alignment of ±0.3 μm and can process more than 46 4-in. wafers in an hour. The FPA-112FA can reach a minimum line width of 1.5 μm, but it takes 14 steps to expose a 4-in. wafer, rather than the seven of the 211FA, because it covers little more than half the area in one exposure.

VW, Nixdorf are negotiating a partnership

In an effort to diversify its interests, Volkswagenwerk AG, West Germany's biggest car producer, is seeking to buy itself into Nixdorf Computer AG, West Germany's leading office-computer maker. However, it is unlikely that VW will become majority shareholder of the privately owned computer maker, whose sales could reach $500 million this year. **Significantly, Nixdorf is Germany's most successful computer company in the hotly contested U. S. market.** If negotiations bear fruit, Nixdorf would have the strong financial backing it needs to keep expanding on the world's computer markets. For VW, a partnership with Nixdorf would represent its first engagement in a nonautomotive activity.

Magnetic-stripe watermark process proposed for passports

Among proposals to an International Civil Aviation Organization panel on high-security passport cards is one from the UK backing a system using the magnetic-stripe watermark process from EMI Data in Hayes, Middlesex. The ICAO is seeking a passport card with personal data printed in machine-readable format together with the holder's photograph. It is intended to speed customs transit and to detect counterfeit passports. **As an additional security check, the card number is carried on a backing magnetic stripe,** and for this EMI is proposing its watermark system. The EMI microprocessor-controlled demonstration reader has a read head composed of a charge-coupled-device array.

Germany mediates French-British viewdata squabble

The German Bundepost is proposing a compromise on an international character set for viewdata information services linking the domestic television by phone to a computerized data bank. Essentially the Germans propose that each country keep its own character set, but add a mechanism for automatic switching to others. **This tack would reconcile the incompatible French Antiope and UK Prestel services.** Great Britain says its CCITT-based character set provides high security against mutilation of data for complementary-broadcast information services. For its part, France claims its character set, which uses back spacing and overstrike to impose accents, is compatible with mechanical printers.

Motorola, Thomson-CSF, French atomic agency set technology transfer

That long-awaited pact on technology transfer among Motorola, Thomson-CSF, and the French Commissariat a l'Energie Atomique (CEA) has finally been signed. Under the deal, Thomson's Sescosem semiconductor division **gains access to some of Motorola's bipolar processing techniques, accompanied by a reciprocal second-source agreement.** Similarly, EFCIS (Société pour l'Etude et la Fabrication de Circuits Integrés Speciaux), the Thomson-CEA joint venture, will get Motorola's n-MOS production techniques, also accompanied by a reciprocal second-source agreement.

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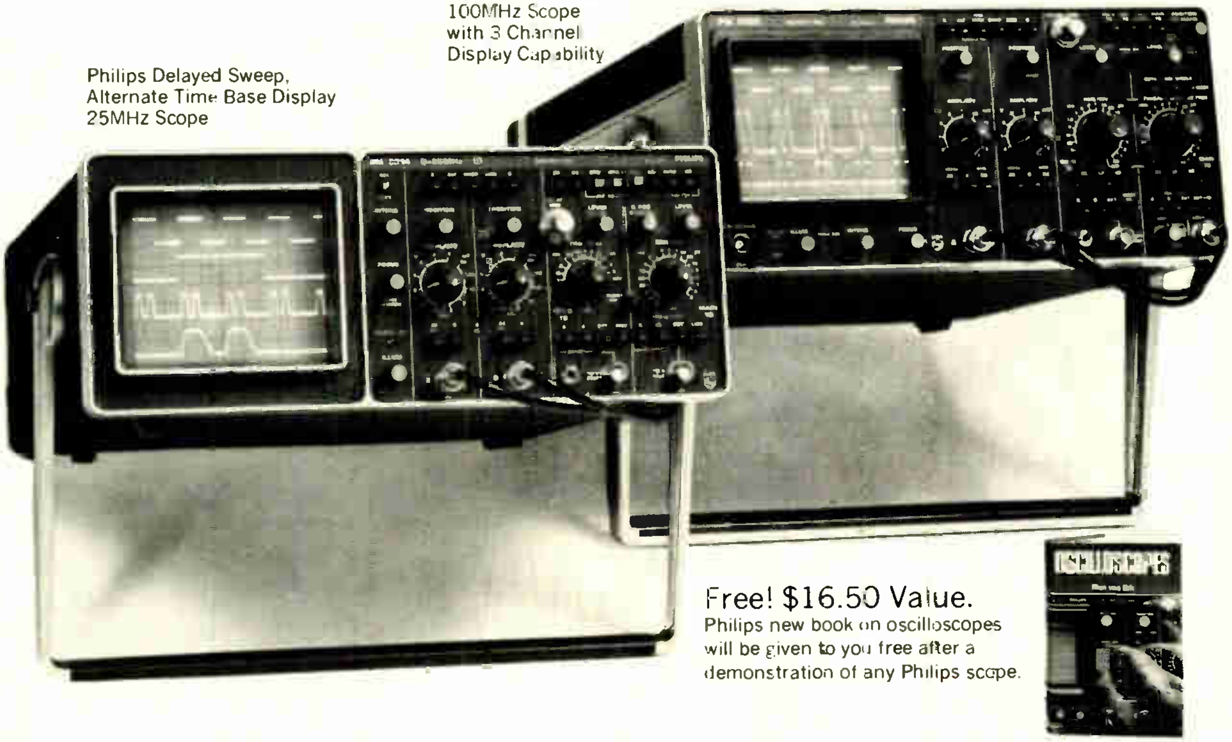

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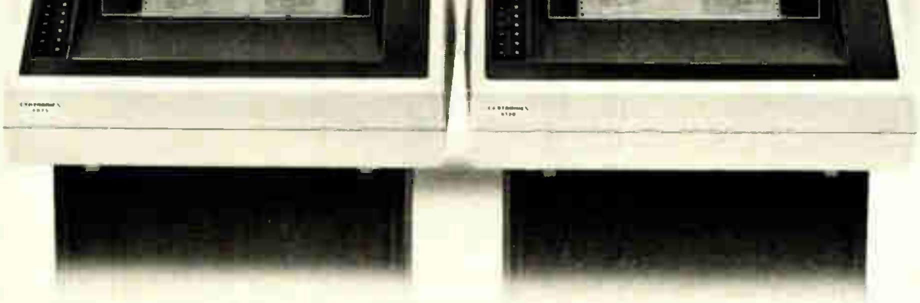

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E-beam projector takes giant steps towards practicality

Solved are problems hobbling electron-beam projection in the race for fine-line VLSI chip production

Well on its way in the long trek from concept to feasibility is an electron-beam image projector that promises to achieve the 1-micrometer line widths, 0.1-μm wafer alignments, and 0.2-μm mask alignments necessary for very large-scale integration. What's more, the still experimental technique will yield these line widths in production, says Peter Daniel, head of the development group at Philips' British Research Laboratory, Redhill, Surrey.

The Philips researchers have overcome several of the stumbling blocks that have prevented electron-beam projection from becoming as strong a candidate to replace optical lithography as are electron-beam pattern generation and X-ray lithography.

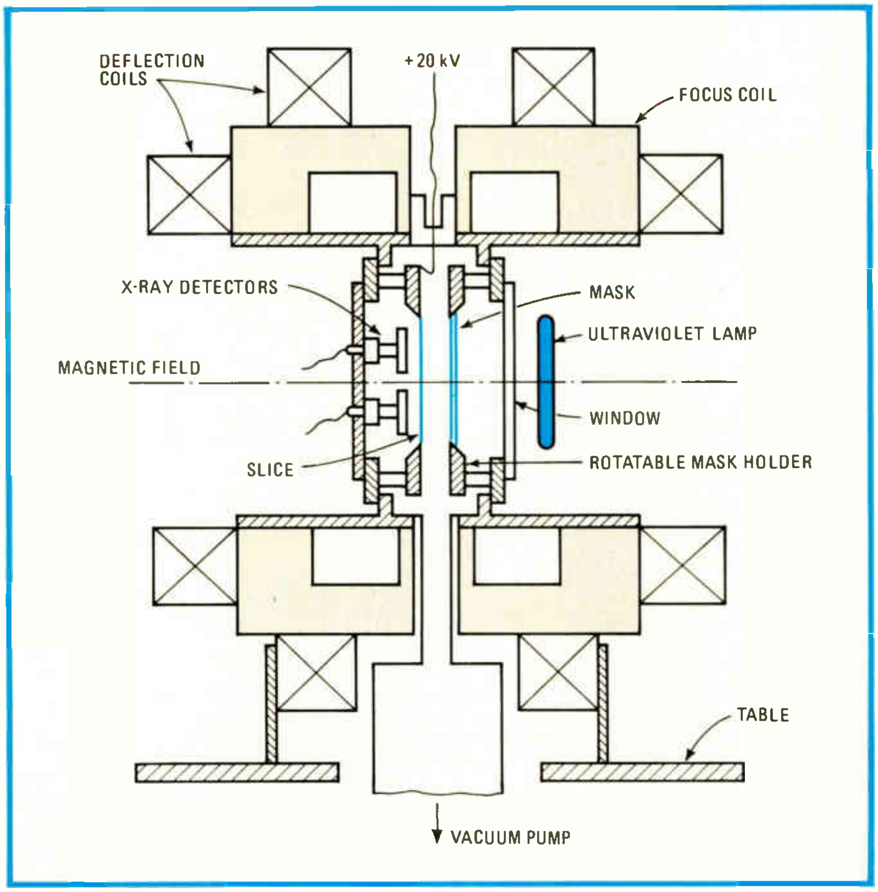
Achievements. What the development group has done is to perfect an X-ray method of aligning mask and wafer and to refine the magnetic focusing system to reduce image distortion radically. Also, a high-speed photocathode allows operation in a less-than-perfect vacuum.

Also at work on the technique is Electron Beam Microfabrication Corp., San Diego, Calif. President William Livesay says the company, which owns the rights to the initial electron-beam projector work of Westinghouse Electric Corp., has a U. S. Navy contract for a machine that will produce 0.5-μm line widths with 0.2-μm alignment accuracy at an output of 60 wafers per hour. Delivery may come in late 1979.

Philips has reached the point of turning out working circuits: simple shift registers with 1-to-2-μm gate windows and bubble-memory circuits [*Electronics*, Nov. 9, p. 63].

In operation, a chrome-on-quartz mask 4 inches in diameter is coated with photoemissive caesium iodide and loaded into the imager vacuum chamber (see diagram). Illumination from an intense ultraviolet lamp causes electron emission from the unmetalized mask areas. The electrons are accelerated onto the slice by a 20-kilovolt electrical field and focused by a parallel magnetic field. Complete exposure can take as little as 30 seconds.

For alignment, current in the deflection coils is adjusted to shift the image, thus aligning mask and wafer grid markers. An ac signal, imposed on the deflection coil's current, causes the image to oscillate



Finer lines. Electron-beam image projector is moving into the race for VLSI lithography equipment, now that Philips has solved such key problems as alignment and focusing.

across the wafer. Because the wafer's grid marker is made of tantalum, this oscillation yields a modulated X-ray output signal proportional to the misalignment. Phase-sensitive photodetectors with the same grid patterns as mask and wafer pick up the signal and apply it to an analog servocorrection system.

Philips developed a focusing air-core magnet with a field that is uniform to within a few parts in 10^5 over the entire wafer surface. Such an accuracy keeps image distortion to less than 0.1 μm.

Also significant is the switch to caesium iodide, which is relatively insensitive to vacuum and deposition conditions, says Daniel. Thus it is possible to shorten the pump-down time since full vacuum is not necessary. Also, the high emitted electron energy gives higher resolutions.

Flatter wafers. Philips is attacking another important problem: wafer bowing, which can distort the image seriously in VLSI patterns. It has come up with an electrostatic chuck, which flattens the wafers.

Problems remaining to be solved include reduction of image contrast because of back-scattered electrons returning to the wafer surface and correction for proximity effects. However, the firm hopes for routine use in production within five years.☐

West Germany

Bloodless blood test under development; infrared spectroscopy is the secret

A fallout from research on the controlled fusion of atomic nuclei may soon radically simplify blood analysis. Nils Kaiser of the Max Planck Institute for Plasma Physics, Garching, West Germany, has developed an infrared spectroscopy technique that determines the concentration of various substances in the blood faster and more accurately than the methods that require taking samples from the patient.

Kaiser is putting together laboratory equipment to implement his blood test method. The patient simply presses his lips against a small, flat plate (as Kaiser is doing in the photograph). By using infrared spectroscopy principles, the equipment determines the content of substances in the blood like ethanol, glucose, cholesterin, or uric acid.

The basic idea for the new test came to Kaiser a number of years ago when he was a research assistant at the Max Planck Institute for Physics and Astrophysics. There he encountered work on measuring the instabilities and the density of ions in a plasma with microwaves—work that was related to the controlled fusion of atoms.

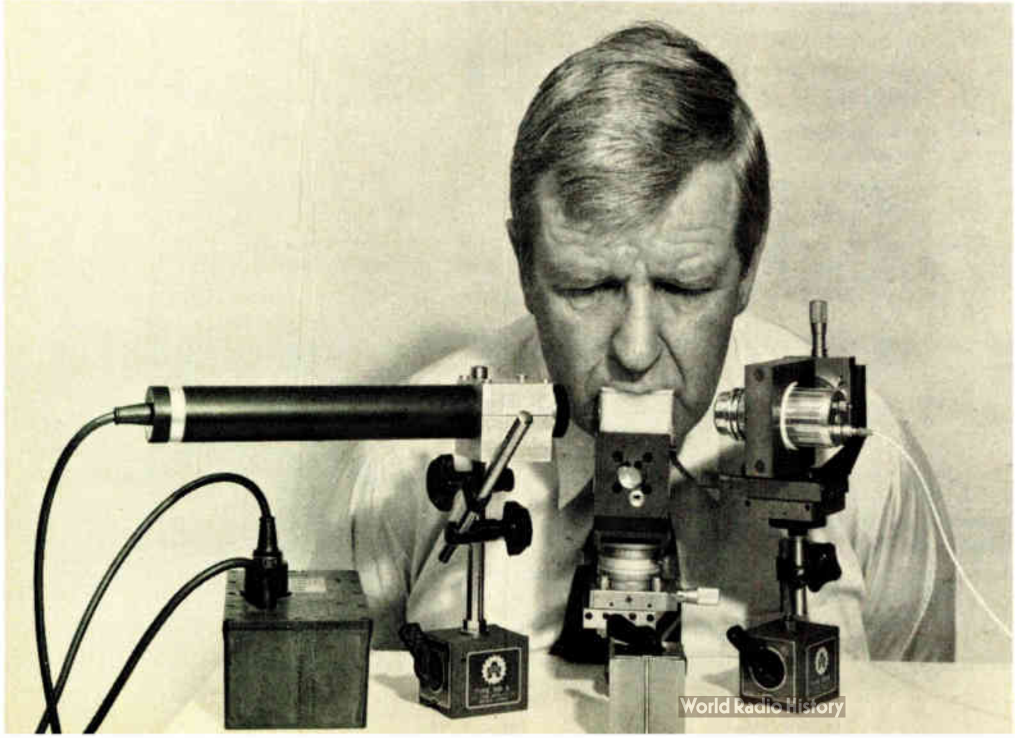
A variation of these microwave-measuring principles underlies the new blood test method. It uses a 2-watt carbon-dioxide laser emitting IR light at a 10.6-micrometer wavelength. The light hits an ATR (attenuated total reflection) plate and is evenly distributed over the object to be examined, in this case the lips.

Absorption. The radiation penetrates the lips' blood cell walls to a depth of about three wavelengths, or roughly 30 μm, and induces vibrations of the blood molecules. Specific molecules absorb specific laser light components; the higher the molecule's concentration, the greater the absorption. "In principle, the method is based on ordinary infrared spectroscopy," Kaiser says (see "How infrared spectroscopy works").

For detection of the absorption rate, one substance is measured at a time, subtracting the effects caused by such interfering substances as water and by other substances to be measured. The ATR crystal measures the values of the substances; an IR detector determines the changes in beam intensity; and its output goes to a strip chart. An oscilloscope also could show the results, Kaiser says.

As development progresses, he intends to provide computer evaluation with a unit contained on a few plug-in printed-circuit boards. Each tester would undergo a calibration process against a sample of blood, and for subsequent analysis, the operator would compare the display with a standard chart, or in the case of computer analysis, the calibration figures would be stored in memory.

The institute sees the method as a valuable and accurate tool in the



No blood. In experimental blood analyzer, the subject presses his mouth to a plate, and infrared spectroscopy measures substances in the blood flowing through his lips.

How infrared spectroscopy works

Spectroscopy is the measurement and interpretation of the electromagnetic radiation absorbed or emitted when molecules, atoms, or ions change from one internal energy level to another. Such a change could be caused by incident radiation of the kind supplied by a laser.

In the case of molecules, the wavelengths corresponding to the energy transitions that occur are mainly established by mechanical motions like rotation and vibration. These motions show up in the infrared region of the spectrum—from beyond the red end of the visible region at 0.8 micrometer to about 100 μm, where the microwave region begins. The molecule's electrical properties determine the intensities of the energy transitions.

Energy-level changes in the IR region are always absorptions rather than emissions; that is, radiation is absorbed from the incident beam as a function of its wavelength. Energy given off by the molecules is not a factor.

In order to determine whether a given type of molecule is present, it is only necessary to pass a range of IR wavelengths through the substance and note the position and intensity of the peaks and valleys of the detected beam. Use of a spectrum "dictionary" then shows what materials are present.

early diagnosis of many diseases and in other uses. For example, it can measure the blood's alcohol content to within 0.001%. However, the institute cautions that much development work is needed before the tester will evolve from its present rather unwieldy setup into a handy little unit.

"The test could be part of mass examinations of large groups of people," Kaiser says. "Those whose blood values deviate from the norm could be screened and forewarned." Diabetics also could use the analyzer to determine the glucose content of their blood easily and painlessly.

Besides medical applications, he foresees some industrial uses for his method. Examples are around-the-clock tracing of sulfur in waste water coming from paper-making plants and monitoring of the level of a substance in chemical processes. ☐

The Netherlands

Ten billion bits fit onto two sides of 12-in. disk for optical data recorder

In the offing for computer archives may be a radically different storage concept. It is an optical data recorder that packs onto a two-sided 12-inch transparent plastic disk 10 billion bits that can be accessed in milliseconds.

Philips Data Systems unveiled its optical recorder [*Electronics*, Nov. 9, p. 64] early this month at the parent company's laboratories in Eindhoven, the Netherlands, where the system was developed. There is no plan to put the system on the market right away, so company spokesman at the moment will not come up with precise price and performance comparisons. But there is no doubt that costs per bit will be slashed.

The optical recorder already boasts a capacity at least double that of magnetic disks, and that advantage should become even greater as developmental work proceeds. What is more, the current 250-ms mean access time for the 5 billion bits on each side will be bettered. The best hard disks will store slightly more than 5 billion bits total, but they have a much better access time: about 30 ms.

Diode and disk. Crucial to the optical recorder are its diode laser and the grooved optical disks into which data is burned, points out Kees Bulthuis, who led the team that developed the system. The laser, a 0.1-millimeter-square chip of gal-

Light storage. Under development at Philips is an optical data recorder that uses a doubled-sided 12-in. disk and an ultracompact diode laser to store 10 billion bits.

lium aluminum arsenide, makes possible a compact optical system that weighs only 40 grams. The grooved disk, with a pitch of 1.67 micrometers for the tracks, provides access to data blocks in the disk without requiring a tracking system of near-absolute accuracy.

The optical recorder has much in common with the video long-play (VLP) disk system Philips is pushing for television. The data is stored as 1-μm holes on a surface of the disk and read out by reflection. Where there is a hole, the light level is low because the light passes through; where there is no hole, the light reflects back at a bright level. The lows and highs correspond to the 0s and 1s of binary data.

Writing data. To write data in, the diode laser is modulated to match the bit stream being recorded as the disk spins at 2.5 revolutions per second. The light pulses are focused onto the disk by the optical system—the laser develops about 50 milliwatts in 50 nanoseconds at a wavelength of 820 nanometers. Because of scattering, only some 12 mw gets to the disk, enough to burn micrometer-size holes in a 300-angstrom-thick layer of tellurium-based material that coats the disk. Readout by reflection, with the diode operating at much lower power, can follow immediately. The readout speed is also 2.5 revs/s.

Because the system has random access, data written into the 45,000 spiral grooves of the disk must be paired with an address so that it can be easily found again. To handle that, Philips divides each track into 128 sectors. Identification headings for each track sector are impressed into the disk when it is fabricated, using VLP mastering and replicating techniques.

These headings, which take up about 10% of the sector, are a quarter of a wavelength deep; the groove that follows for the remaining 90% of the sector is about half that. As many as 1,000 bits (including redundancy bits) can be written into each of the 45,000 by 128 sectors.

Actually, the disk is a sandwich of two 12-in. transparent disks separated by an air layer. The grooves with the tellurium-based sensitive coating lie on the inside, where they are protected from fingerprints, scratches, and dust. For the read-write operations, the laser light is focused through the 1-mm-thick disk onto the recording layer. ☐

France

Lab makes devices of organic thin films

Potentially practical applications of organic thin-film technology are under test in a French laboratory and show enough performance to interest several French instrument firms and users. Among the devices are a hygrometer, currently being examined by the French national meteorological office, capacitors, which "interest all French capacitor manufacturers," according to their developer, and photoresists.

The main work on the organic thin-film technology is being done in the French atomic energy agency's electronic research labs at Saclay, southwest of Paris. The engineer in charge of the research, Jean Messier, says the big advantage of organic films over the more widely known metal films is stability. "Organic films are naturally stable in very thin, even monomolecular, layers when compared with inorganic films deposited by such methods as pulverization under vacuum," he says.

Others. Though Messier's group is not alone in studying thin organic films for electronic applications, there are few other efforts. "General Electric at Schenectady, a few Japanese firms, and the University of Marburg in Germany are among the other groups involved," he says.

The work at the Laboratoire d'Etudes et Recherches Avancées (LERA) has involved a wide variety of organic substances. Among the simplest are those based on stearic acid or those with the behenate radical, lead or calcium for example.

One of the devices developed by the laboratory is a hygrometer. This device incorporates an organic film less than 300 angstroms thick and a very fine, water-permeable gold strip 150 Å thick. Messier is trying different types of organic substances, such as calcium behenate.

The hygrometer exploits the film's affinity for water—the ease with which water infiltrates into natural or induced faults in it—which in turn alters its dielectric capacity. The operating range so far achieved is about −20°C to 60°C. Messier says that the cost-performance ratio looks at least reasonably close to that of other approaches.

Another field where LERA thinks its work is showing promising results is in capacitors. Messier maintains that for high-performance applications, the organic thin films are better as a supplement to thick films, rather than doing the whole job themselves.

"Once the film has to be very thick, you are better off with a polyethylene layer," he says. In a combination capacitor, the organic film lowers the rate at which electrons can flow from the metal conducting surface to the dielectric.

One prototype developed by LERA

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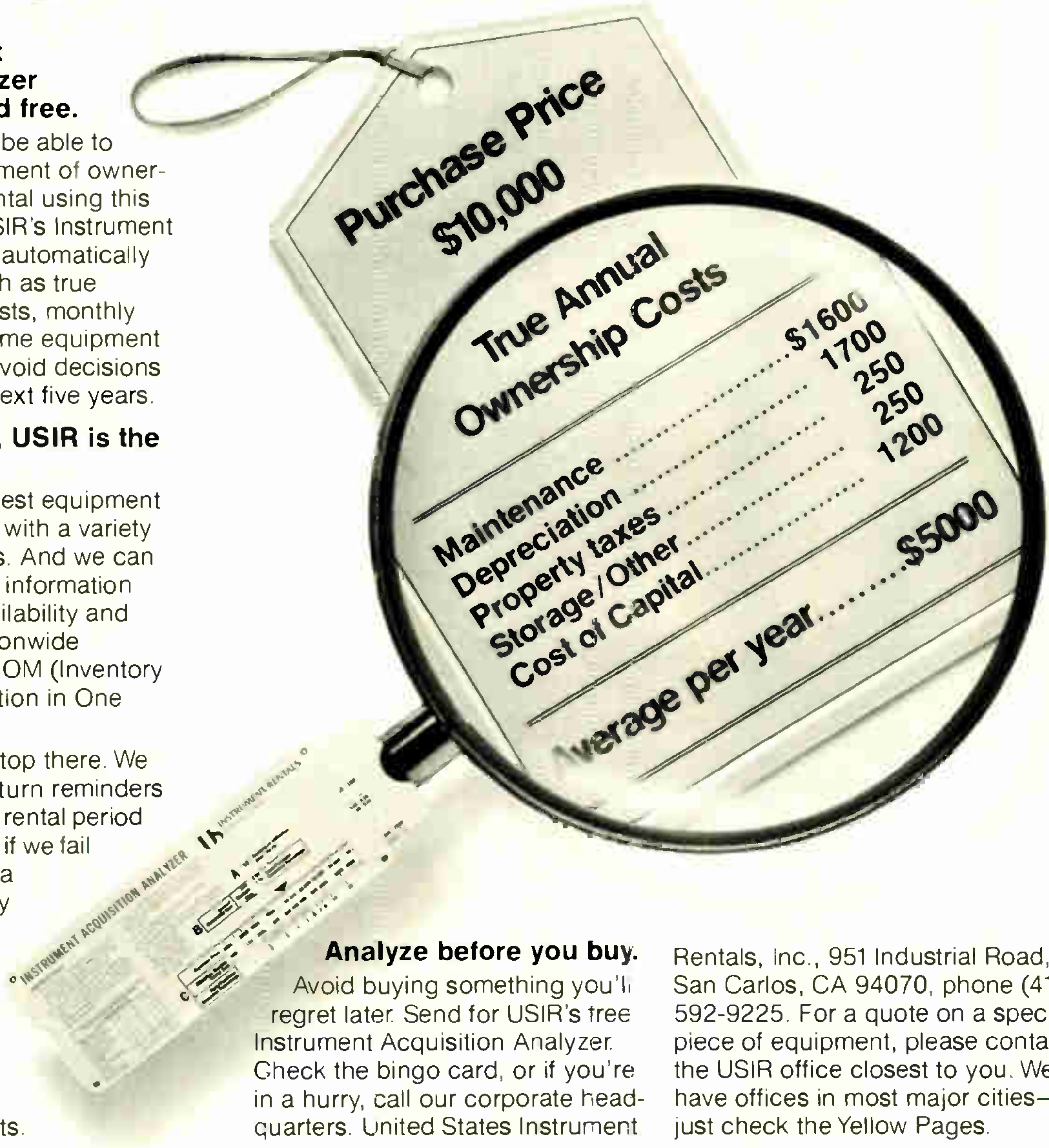

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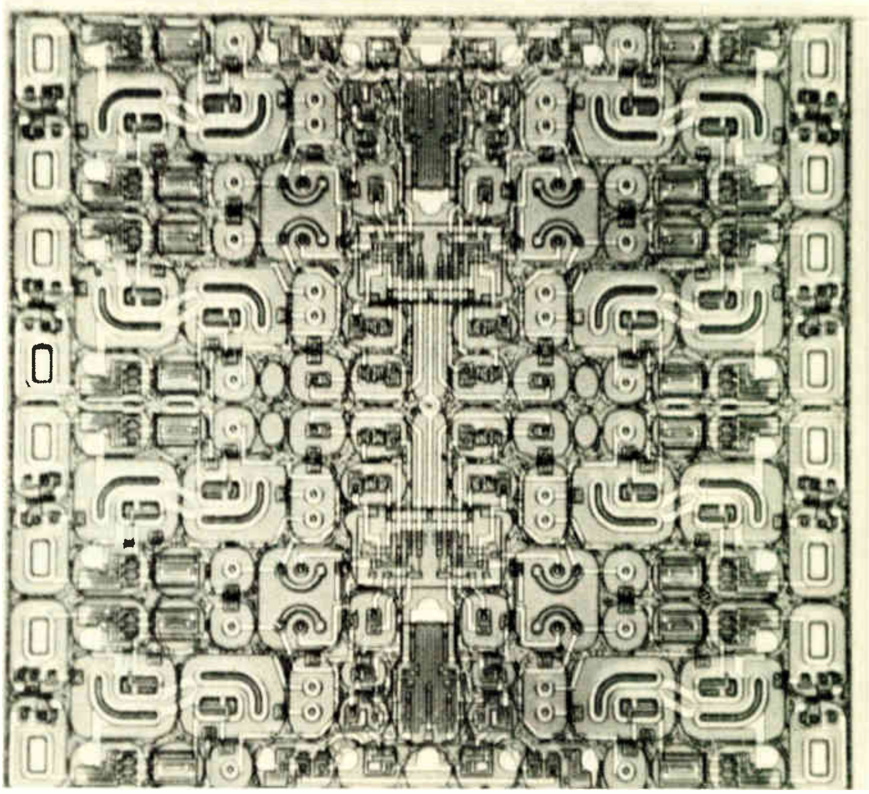
is made up of a sandwich of aluminum filled with an aluminum oxide layer and an organic film as the dielectric. The Al_2O_3 is 200 Å thick; the film a mere 25 Å.

Performances so far achieved are electric fields on the metal surface of 3 million volts per square centimeter. Messier believes that under operational conditions, a figure of more than 1 million volts would be more appropriate. Capacitance is 100 nanofarads per square centimeter.

The device should be easy to make in volume, according to Messier. Preliminary results show it should be possible to produce 800 of these capacitors on one silicon slice.

The lab is investigating the practicality of organic-film techniques for photoresists. Using X-ray polymerization, it has produced high-resolution 500-Å-thick photoresists.

So far the handicap is speed. "We have to find molecules that give you sufficient speed and sensitivity to make the process economic," Messier says. ☐



Switching chip. The Musashino Electrical Communication Laboratory is developing an integrated circuit, containing 16 switches, that has a voltage rating of more than 350 V.

Japan

Integrated switch holds four crosspoints

Under development for the Nippon Telegraph and Telephone Public Corp. is an integrated pnpn switching chip that may replace four electromechanical crosspoints in electronics exchanges. Engineers at the Musashino Electrical Communication Laboratory say their experimental switch can withstand voltages of more than 350 volts, a level that has not been attainable in integrated devices.

The high voltage rating is necessary to withstand electrical surges, including those caused by lightning. Moreover, the insulation resistance of a phone system's cables is tested with voltages on the order of 300 v. To achieve this, the chip's developers are paying careful attention to dimensions, doping, and dielectric isolation. They also added field plates to the 16 individual switches formed on the integrated circuit.

The individual switches are very large for integrated devices, with an effective area on the order of 250 square micrometers. Moreover, the p-gate-to-n-gate spacing is about 45 µm, and the depth of the individual n islands is an order of magnitude greater than in logic circuits. The doping of the n region is 14 ohm-centimeters.

Isolation. To provide dielectric isolation, the Musashino lab is using the Epic fabrication process, in which the silicon is etched to form n-type protrusions, followed by deposition of a thick polycrystalline layer. Then the original wafer is ground away, leaving only dielectrically isolated islands imbedded in a polycrystalline matrix.

The added field plates control the electrical field at the surface of the planar junctions and so increase breakdown voltage. They are extensions of the anode and p-gate contact metalizations.

As well as a high voltage rating, the experimental switch boasts good switching characteristics. On-resistance is on the order of 5 ohms, which reduces the attenuation of selected circuits to negligible values. Off-resistance is more than 150 megohms, which has a similar effect on crosstalk.

Memory. The chip contains low-voltage pnpn memory circuits that maintain driving information during crosspoint polarity reversals that could cause the pnpn switch to stop conducting. Also included are constant-current driving circuits, as well as error-protection circuits that decrease the sensitivity of the vertical npn transistor structure. This enables the switch to withstand voltage changes as rapid as 200 v in 100 nanoseconds.

Although there are 16 switches on the chip, they form only four crosspoints. Each circuit consists of two wires, so two switches are needed in the crosspoint. Another two are connected in reverse at each crosspoint so that connection will be maintained for either polarity of voltage. ☐

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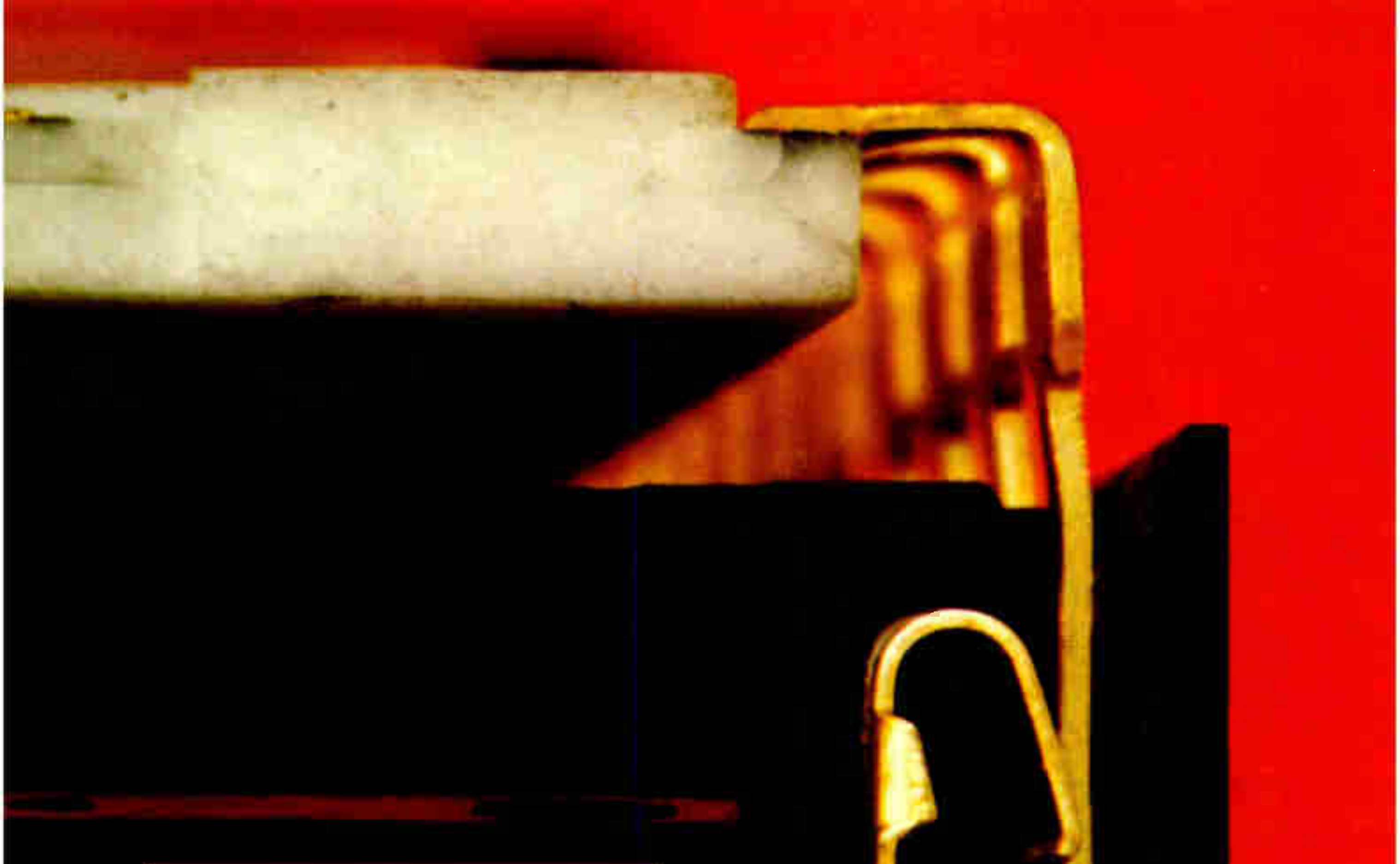
TEST DATA



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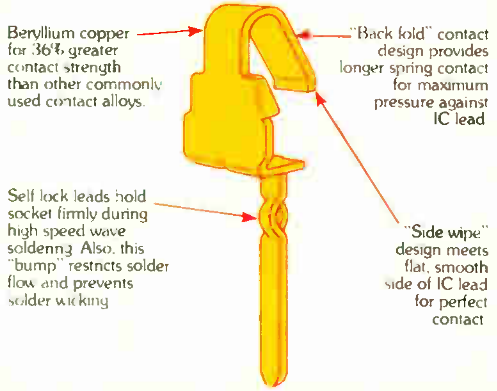
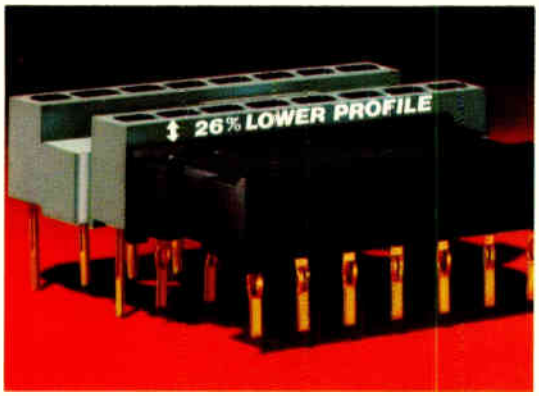


DEBUNKS

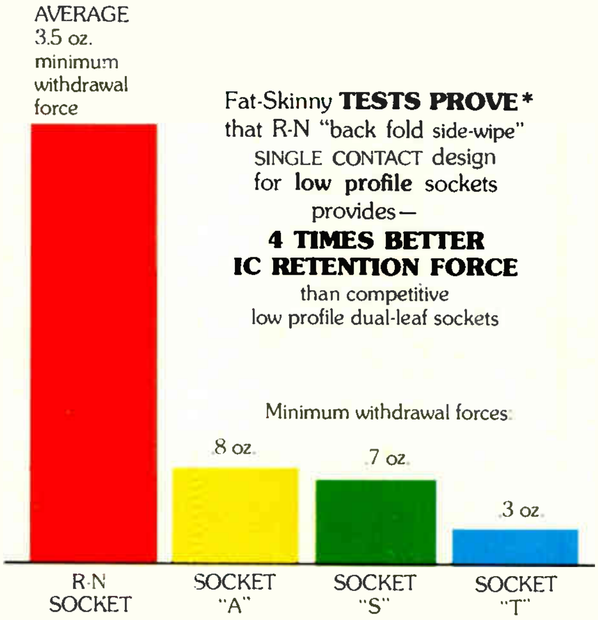
low profile DIP socket MYTH

"...TWO contacts are not more reliable than ONE!"

Surprisingly, a **low profile** (.150" high) DIP socket is a different breed of cat when it comes to engineering in contact reliability. Most standard DIP sockets have dual contacts. (R-N's dual "side-wipe" contacts are among the most reliable in the industry.) But, when you **shorten the contact length** to achieve the "low profile" you lose a great deal of contact force and IC retention strength. So, to achieve effective low profile socket reliability you must **redesign the contacts** and make them out of the **strongest contact material available.**



Low .150" profile of ICL socket reduces board density by 26%.



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2	465 grams
3	480 grams
4	465 grams
5	395 grams
6	425 grams
7	465 grams
8	395 grams
9	410 grams
10	425 grams

AVERAGE—430 grams

This force is 4 to 5 times greater than average dual contact socket NORMAL FORCE

* NORMAL FORCE means force perpendicular or at right angles to IC lead. The single ICL contact exerts this kind of force against the IC lead when inserted into the socket.

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Real-time bit mapping

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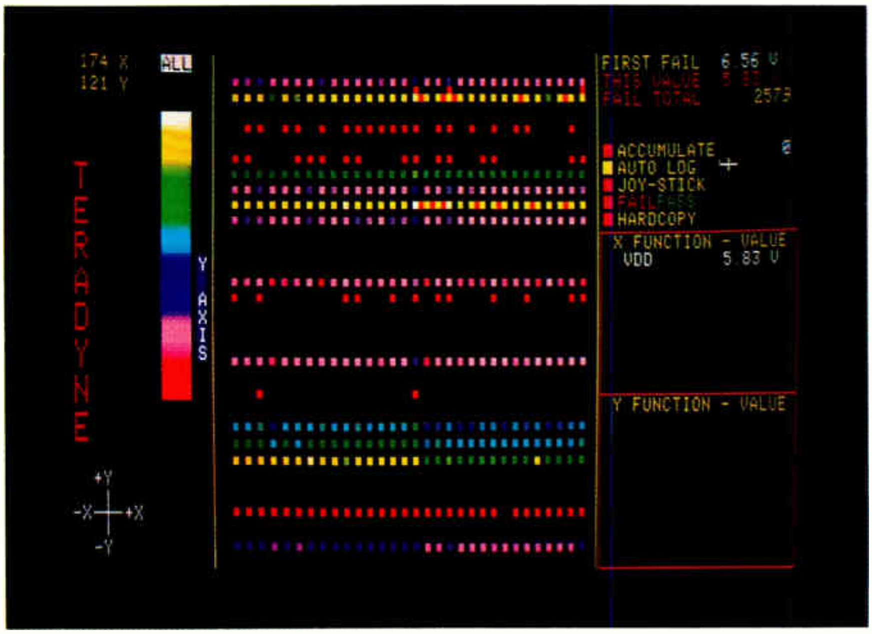


A visual presentation of failing bits under varying test conditions is essential to any understanding of a semiconductor memory's failure mechanism. To date, the most any test system has had to offer in this respect is a CRT raster scan, which displays failing bits in real time but which usually lacks any means for storing the data. As the dots disappear from the CRT screen, the data and any possibility of computer analysis disappear along with them.

Real-Time Bit Mapping, recently developed by Teradyne, goes so far beyond the conventional techniques for bit-fail analysis that it is sure to become *de rigeur* in any evaluation of memory performance. Beyond that, it is of major value on the memory production line, where it serves as a real-time monitor of device quality.

Available as an option with the J387 Memory Test System, RTBM permits on-the-fly modification of a test program (the standard production-test program, as a rule) and real-time display of the resulting bit failures. The display is in full color, with the accumulating layers of bit failures shown from one end of the spectrum to the other. An address descrambler ensures that the bits are shown in their correct topological positions. The operator uses a joystick to pilot a cursor around the screen, changing program levels and timing, selecting operating modes, recalling patterns, and in general feeling like Luke Skywalker at the controls. The display also reports operating mode, level values, x-y addresses, bit-fail counts, and various other items of interest. The 19-inch screen is big enough to serve as both scoreboard and bit map for most memories, but if greater resolution is needed, any portion of the display can be instantly expanded.

The color terminal and the joystick are the most spectacular aspects of RTBM, but the basic ability to catch, accumulate, and process bit-failure data is available with or without the color terminal. The RTBM capability opens up all kinds of possibilities. One can, for example, use it as a bit-masking device in a search for "soft" errors. One bit-fail pattern can be used as the mask for subsequent passes, or the mask can be inverted so that all bits except those masked are ignored.

But to the engineer, nothing can match the sensation of shifting into checkerboard and watching a kaleidoscope of bit failures change before his eyes. From now on, anything less will be distinctly second class.

TERADYNE

Probing the news

Analysis of technology and business developments

Equipment costs worry chip makers

Added to the costs of R&D needed to keep up with VLSI, prices could cause next shakeout of semiconductor companies

by William F. Arnold, San Francisco regional bureau manager

The skyrocketing cost of doing business, not a market downturn, will cause the next big shakeout in the semiconductor industry. That's the conclusion of many industry leaders, who believe that the soaring price tags of production equipment, coupled with the volume of research and development required to compete in the emerging era of very large-scale integration, will drive marginal companies out of the market.

The result, an industry dominated by several large chip suppliers, would have profound effects on the marketplace and even the pace of technological innovation itself.

"The day has changed and changed so rapidly that people outside the industry don't realize it," declares C. Lester Hogan, vice chairman of Fairchild Camera and Instrument Corp., Mountain View, Calif. Simply stated, he believes that only a handful of U.S. integrated-circuit manufacturers and an equal number overseas can come up with the ante needed to stay in the game.

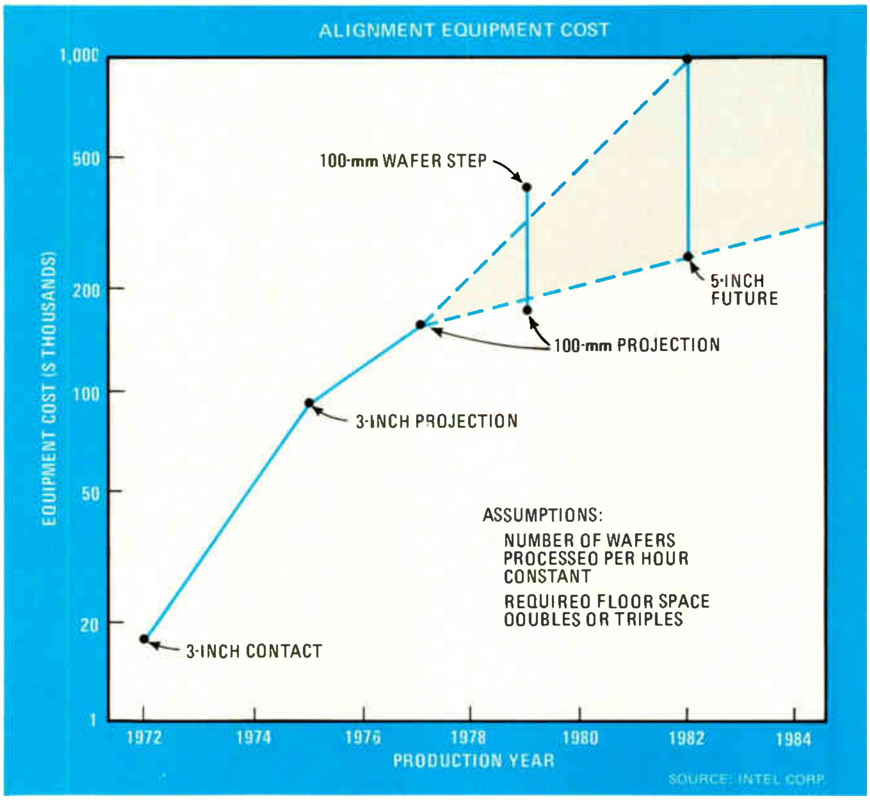
Agreeing, Pierre Lamond, vice president and technical director of National Semiconductor Corp., Santa Clara, Calif., says that as the industry becomes more capital-intensive, the odds favor fewer and larger semiconductor companies. But both he and Hogan think there will be room for small, specialized custom IC houses and companies with rich partners.

Big spending. To meet demand, stay competitive, and prepare for the future, semiconductor makers are already pouring scads of money into new processing lines and plant expansion. For example, Intel Corp., Santa Clara, Calif., which is growing 50% this year to reach an annual production of about $440 million, will spend $90 million to $100 million this year and the same again next year, according to Andrew S. Grove, executive vice president and chief operating officer.

National, a $500-million-a-year company, will spend $90 million this fiscal year, virtually all of it for new capital equipment, Lamond states. And Fairchild now has about two dozen projection aligners in its two Silicon Valley plants that cost $250,000 each with automatic alignment features, Hogan says.

As chip makers strain to swallow these expenses, they face the specter of even higher costs downstream. A wafer-fabrication production module that cost $2 million five years ago now costs about $10 million and will quintuple again in five years, estimates Willard L. Kauffman, director of Intel's component production. And, of course, companies need more than one. Ze'ev Drori, president of Monolithic Memories Inc., Sunnyvale, Calif., predicted at a recent Senate hearing [*Electronics*, Nov. 9, p. 46] that mask aligners would double in price to $500,000 each in the next several years, a high bill for a $38.5-million-a-year company to pay.

Obviously, inflation fuels the rise;



SOURCE: INTEL CORP.

but Jim Bagley, manager of automation systems at Texas Instruments Inc., Dallas, says that it is not fair to use increased costs as a measure of inflation. "What it does measure," he says, "is the cost required to stay at the leading edge of technology." He thinks that "everyone is concerned with the fact that the cost of equipment required to stay at the leading edge is going up very rapidly and that our ability to affect that cost is hampered by the fact that we're trying to expand the technology so quickly."

Others, such as J. Fred Bucy, TI's president; John Shroyer, assistant vice president in charge of process lines at Mostek Corp., Carrollton, Texas; and National's Lamond point out that the equipment coming on stream also boosts precision, capacity, and yield. Paul W. Reagan, group vice president for equipment maker GCA Corp.'s GCA/IC Systems group in Burlington, Mass., says "VLSI is clearly the forcing factor in equipment sophistication and equipment costs," but no more labor is required for 5-inch wafers than for 3-in. ones. "The yield increase means big economic gain," he says.

Not fast enough. Intel's Kauffman, however, disagrees. He says that although the number of good dice produced by new equipment is rising, it is not keeping up with the rise in equipment costs. Another cost factor, according to one semiconductor executive, is that "the market is sold out, and the equipment vendors are getting as much as they can."

Although most generally agree that rising costs are a problem, some differ on its magnitude and its consequences. TI's Bucy, for example, does not think small companies will necessarily be forced out of business. The ones affected will be "those companies that are not running an adequate return on investment. They might have to cut back, but that goes for big companies too."

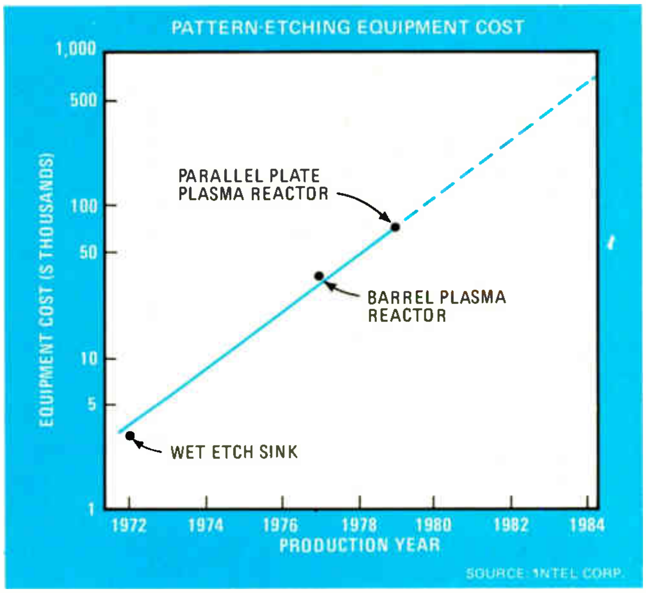
Rising costs are having an impact on both chip manufacturers and equipment makers, according to James Gallagher, senior vice president for operations at GCA. Speaking as president of the Semiconductor Equipment Manufacturers Institute, he says that there will be no proliferation of new IC makers, for one thing, and that the ones that exist now will have to do far more detailed analyses of proposed equipment purchases to ensure a good return on investment.

Effects on vendors. Probably the most notable impact of these rising costs on the equipment manufacturers themselves, as Gallagher sees it, is that in order to provide the evidence of that fast and certain payoff, they will have to give chip makers better support. "They will have to run some of the processes themselves to prove the benefits of the equipment," he says.

Moreover, device makers will increasingly insist on manufacturers training the former's workers on the equipment. "That will mean breaking down some of the traditional confidentiality of the semiconductor industry and make for a closer partnership between the two," Gallagher says. Agreeing is Ian N. Tainsh, controller of Perkin-Elmer Inc.'s Ultek division in Mountain View, Calif.

Fairchild's Hogan sees rising equipment costs as part and parcel of the whole problem that VLSI presents to chip makers. With the advancing technology, "it isn't as obvious today what to do tomorrow as it was yesterday," he says. With the increasingly more powerful circuits that the new processing technology is giving IC makers, Hogan believes it no longer will be obvious what to put onto the chips or how to sell them. He thinks that VLSI will force vertical integration and, with fewer companies, could tend to slow down innovation.

National's Lamond adds that companies also will "have to have the marketing strength to sell the volume" that the new equipment turns out. Also important, he believes, is that surviving companies will have to have the R&D commitment to keep improving yields to justify the equipment cost and compensate for lower chip prices. This favors large companies, he says. ☐



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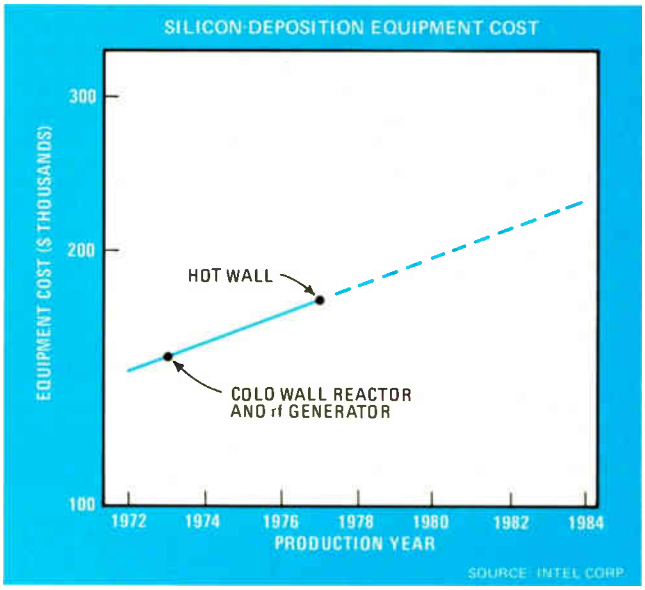

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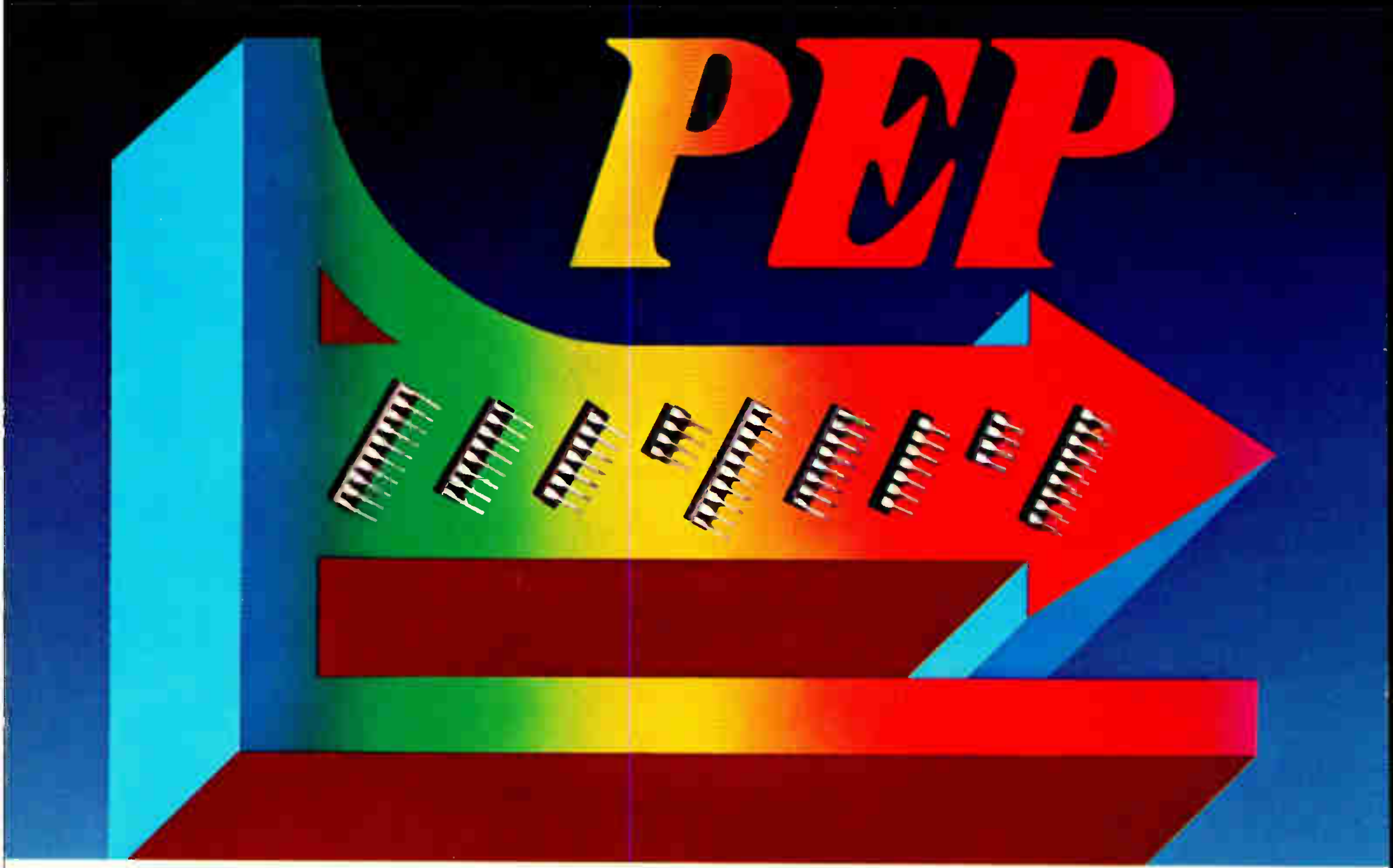

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TEST	CONDITION	GUARANTEED AQL %					
		BIPOLAR LOGIC		BIPOLAR MEMORY		LINEAR	
		PEP 1, PEP 3	PEP 4	PEP 1, PEP 3	PEP 4	PEP 1, PEP 3	PEP 4
Continuity	100°C	0.015	0.015	0.015	0.015	0.015	0.015
Functional	0°C to 70°C	0.10	0.10	0.25	0.25	0.10	0.10
DC Parametric	0°C to 70°C			0.65	0.65	0.25 (Note 1)	0.25 (Note 1)
AC Parametric	25°C (Note 2)	0.65	0.65	1.00	1.00	1.00	1.00
Fine Leak	1 x 10^{-6} Leak Rate	NA	0.65	NA	0.65	NA	0.65
Gross Leak	Step C-1	NA	0.40	NA	0.40	NA	0.40
Mechanical Defects (Note 3)	Critical	0.10	0.10	0.10	0.10	0.10	0.10
	Major	1.00	1.00	1.00	1.00	1.00	1.00

Notes:
(1) For linear devices, a 0.25% AQL at 25°C and a 0.65% AQL at 70°C apply.
(2) Sampled and guaranteed.
(3) Critical mechanical defects are those which affect device functionally. Major defects include problems not affecting functionality.

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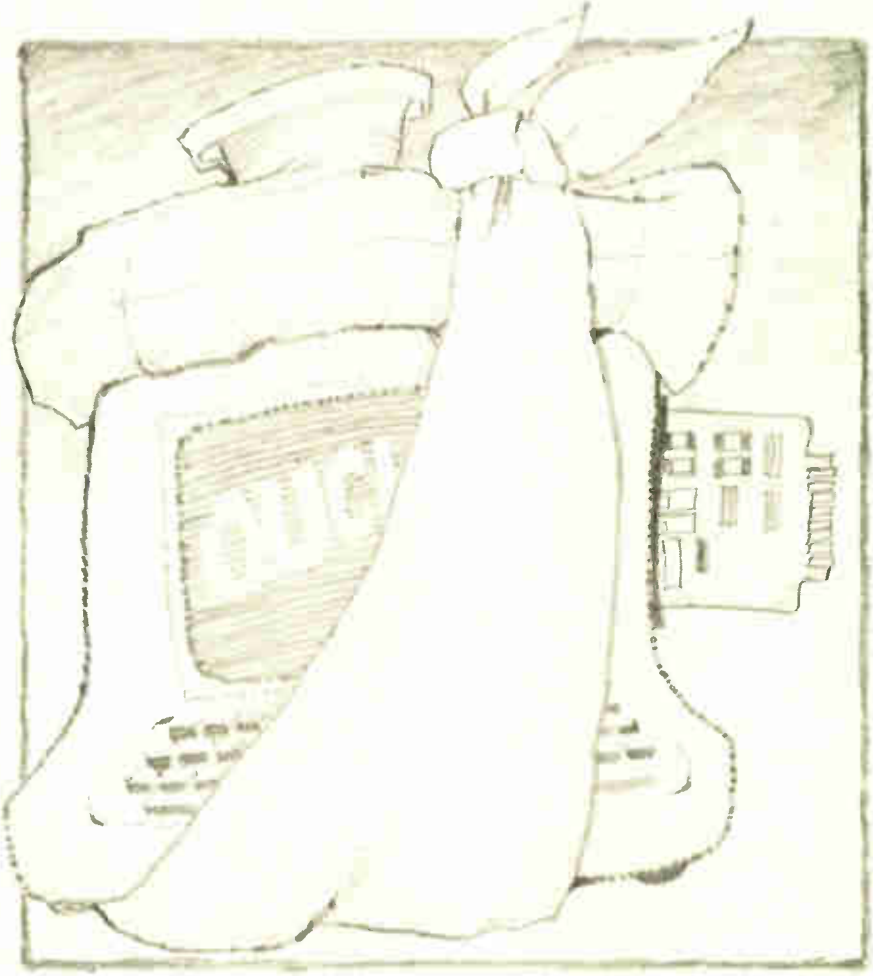
Testing

LSI boards give testers fits

Density of devices and interconnections leaves many commercial systems behind—and VLSI is coming

by Jerry Lyman, Packaging & Production Editor



All is not well with LSI board testing, and the people who make automatic testers can't agree with those who use them or with the manufacturers of the large-scale integrated circuits on the boards about what to do. But that's only part of the bad news; the rest is that VLSI—very large-scale integration—is only going to make matters worse.

The urgency of the problem was underlined earlier this month by the addition of sessions on board testing to the usually component-oriented Annual Test Conference at Cherry Hill, N. J. Hal Barbour, test systems marketing manager of GenRad Inc., Concord, Mass., put it all in perspective when he told his fellow conferees: "Today's LSI-laden printed-circuit boards are analogous to the complete digital systems we were testing two years ago. In fact, the new boards have the component and interconnect density of backplanes loaded with boards carrying medium- and small-scale ICs."

The fact is that the combination of component and interconnection density and the practice on most LSI boards of putting many ICs on a common bus is taxing commercial testers. Users have even been forced to go to labor-intensive manual programming when automatic program generation has been found wanting.

Mounting cost. In his conference keynote address, C. Lester Hogan, vice chairman of Fairchild Camera and Instrument Corp., Mountain View, Calif., predicted that by 1985 the most expensive step in producing computer systems will be testing. Hogan's forecast may, in fact, be a bit late: Alex Bazelow, member of the research staff at the Western Electric Research Center in Princeton, N. J., reports that Western already has products where that is the case.

Users' complaints generally take this form: "I have a tester that cost over $250,000 and I can't test a microcomputer board with 20 ICs. We simply cannot generate a program to test this board." Or, "We are finding some of our best LSI board designs untestable on commercial automatic test equipment."

Equipment makers tend to agree: with present techniques and equipment, writing test programs for increasingly complex LSI boards is becoming excessively expensive and time-consuming. Representatives also agree that the answer to the programming question is more complete information from the IC manufacturers on LSI and forthcoming

VLSI chips. That would lead to the development of more exact models or test patterns for the devices. Says one tester maker's representative: "We simply cannot do this with the information furnished now."

For its part, Zilog Inc., Cupertino, Calif., says that such patterns are available for the Z80, "but we have never been asked for them." Among other chip houses, Intel Corp. also has provided a program for testing its 8080 microprocessor. And large companies such as IBM Corp. and Bell Laboratories, which design their own LSI parts, create test patterns during the initial logic-design phase. Generally, though, the exact circuitry and logic configurations of ICs are simply not disclosed. In the words of Bell Labs' Robert Davidson, a member of the technical staff at Murray Hill, N. J., "We simply must get more vocal with the semiconductor industry or we will reach the stage of virtually untestable boards."

At what speed? A second conundrum for the tester fraternity revolves around speed. Manufacturers of test equipment, except for those making gear for testing LSI memories on boards, have taken the position that traditionally it is unnecessary to test LSI boards at their actual operating speeds. At lower frequencies, the argument goes, most of the failures in high-speed boards can be detected. Not so, say device makers. Zilog and Intel both insist that their microprocessors must be tested at their rated speed and even suggest parametric board testing for microcomputer boards.

Allied with them is Ed Donn, a project manager at Fluke/Trendar Corp. in Mountain View, Calif., who says that when LSI boards are not tested at speed, a user just cannot be sure of their reliability. Subtle problems may occur on buses at high speed that would not be picked up by testing at a tenth the operating rate, he says.

Perhaps the dimensions of the problem can be defined by the hypothetical situation described by one user of testers. "You are in an F-18," he says, "where electronics is loaded with high-speed LSI. All logic boards have been checked at one tenth rated speed. Are you ready to take off, or do you want the boards tested at rated speed?" In response, a typical vendor of testers says that military testing is a special case.

The bottom line on test problems seems to be that boards containing LSI, and later VLSI, chips can no longer be viewed as boards. Rather, they should be treated as systems and submitted to system testing. That outlook seemed to be gaining a consensus at the Cherry Hill meeting, where several solutions were advanced.

One is to build in testability circuitry right at the chip level, an approach that would mean committing some 20% of the chip to test and self-test circuitry. IBM, for one, is already investigating this concept, but until it is embraced by the independent IC makers, cost will probably keep it in the idea stage. Much simpler and cheaper is to build test features into a logic board; IBM, again, and Sperry Univac and Amdahl are already doing this by putting test-committed circuitry on digital boards.

It is interesting to examine the approach taken to testability of microprocessor boards used by tester makers in their own equipment. Gene Foley, a design engineer for Teradyne Inc. in Boston, says that engineers there added 9 ICs to the 54 already on a microcomputer board. The extra circuits start the test sequence and run through it step by step, after which a built-in microcode for self-testing and -diagnosis exercises the board at its rated speed. The test includes a check sum—the stored result of an arithmetic operation on the words of program memory—for the read-only memories and a complete test of the random-access memories and of the board's input/output ports.

The self-test firmware indicates that a board is healthy by turning on a light-emitting diode. A failure causes diagnostics to be read out at a test terminal. Teradyne now uses this approach in all its microprocessor boards and plans to have the self-test exercise other boards in the same system. □

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Probing the news

Solid state

Is GaAs the answer to data traffic jam?

Lockheed and others believe that speed and temperature advantages make GaAs ICs necessary in space

by Robert Brownstein, San Francisco regional bureau

What if it took a week to get satellite information on tomorrow's weather? Absurd? Not really, considering that the National Aeronautics and Space Administration estimates that of the 10^{15} bits of data per year churned out by the 100 or so satellites in orbit, only about 1% can be processed quickly enough on the ground to do users any immediate good.

The alternative is to have the satellites do a large share of the data processing before transmitting to earth, and that will require the development of large-scale integrated circuits using gallium arsenide, Lockheed, TRW, Rockwell International, and others believe.

"Faced with an expected data load of 2×10^{16} bits per year by 1986, earth-station processing centers are in for a full-scale bottleneck," says D. Howard Phillips, manager of the microelectronics center at Lockheed Missiles and Space Co. in Sunnyvale, Calif. He will discuss his company's approach to building gallium-arsenide ICs later this month at the American Institute of Aeronautics and Astronautics Conference in Hampton, Va.

Upping the speed. On-board processing of the growing amount of raw data from satellite sensors demands higher speeds than contemporary LSI technologies can achieve. Other types must therefore be developed, Phillips says.

Why gallium arsenide? "It's faster than silicon, works at higher temperatures [350° versus 200°C], and lends itself more to radiation hardening," he answers.

However, there are some hurdles that must be overcome along the way. For one, unlike silicon, which can be fabricated at high temperatures with no molecular instability, gallium arsenide, a compound, does become unstable. This has caused problems in the annealing process.

One solution requires capping the surface with a dielectric material; another is to perform the annealing in an arsenic atmosphere with the vapor pressure in equilibrium with that on the substrate surface. Still a third involves using short pulses of laser energy for the annealing in order to avoid decomposition of the material.

Choosing a process. As in the evolution of silicon ICs, decisions must be made concerning what process to use. Currently, the majority of the researchers are working with metal-semiconductor field-effect transistors. TRW Inc.'s microelectronic's center in Redondo Beach, Calif., has already moved from small- to medium-scale integration with these logic elements, according to Thomas G. Mills, department manager of compound semiconductor and microwave devices.

MESFETS present an obstacle, however. The metal-semiconductor (or Schottky) contact cannot be biased strongly in the forward direction without danger of damaging the devices, and therefore, according to Phillips, enhancement-mode (normally off) transistors that can accept the usual logic input signals—2 to 5 volts—are not possible. LSI requires low power dissipation per device, which means enhancement-mode or mixtures of enhancement- and depletion-mode (normally on) devices.

Metal-oxide-semiconductor FETS, on the other hand, are not limited by a gate-junction forward-bias voltage, Phillips says. Also, recent progress in anodic-oxidation processing has resulted in enhancement-mode gallium-arsenide MOSFETS that can handle 2- to 5-V signals.

Up to now, though, high speeds have been demonstrated only with depletion-mode GaAs MOSFETS. These power-demanding devices would limit circuits to SSI or MSI densities.

Fundamental problems? Furthermore, the GaAs MOS approach is plagued with unstable gate dielec-

SILICON VS GALLIUM ARSENIDE: 1985

	Silicon	GaAs metalized semiconductor field-effect transistors
Speed projections		
logic integrated circuits	200 ps	25 ps
charge-coupled devices	250 MHz	1 GHz
transistors	4 GHz	40 GHz
Optical devices		
FET-laser integration	no (indirect)	yes
High-temperature operation	200°C	350°C

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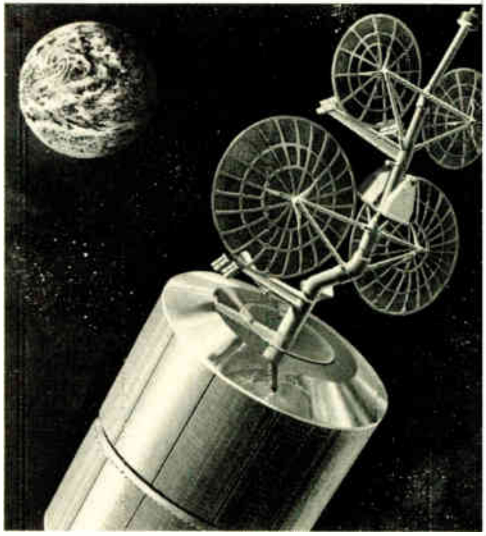

The problem. Communications birds such as this Intelsat model are pouring out data.

trics, high leakage current, and high surface state densities. "It is still unclear whether these are fundamental problems with GaAs or whether they are materials problems," Phillips states.

Fred A. Blum, director of solid-state electronics at Rockwell International Corp.'s Sherman Oaks, Calif., science center, is more optimistic about using MESFETs despite the low voltage restrictions. "We've taken a fresh approach using a silicon-like planar scheme and are achieving gratifying results," he declares.

Compared with power dissipations of 30 to 50 milliwatts per gate typical of the "epitaxial and etching" MESFET approach, Rockwell's planar approach is turning up MSI parts with several hundred microwatts per gate, Blum says.

This power consumption, combined with delay times of only 80 to 150 picoseconds, yields a power-delay product of 0.03 to 0.05 picojoule, attained using 1-micrometer optical lithographic techniques, according to Blum.

"We are hoping to demonstrate LSI feasibility within two years," he says. He adds, "The main obstacle now is to make a smooth transition from these 50-gate parts up to parts having thousands of gates. We're not sure which will impede us first—processing technology or material quality." ☐

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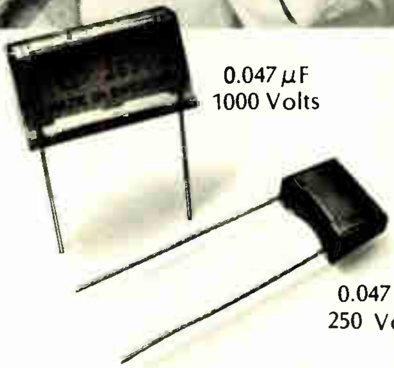

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Communications

AT&T stalled technology, U. S. says

Justice Department claims predatory pricing, preselling, and other tactics were used to block better, cheaper products

by Ray Connolly, Washington bureau manager

The Justice Department sought this month to shatter the image of American Telephone & Telegraph Co. as an innovative leader in telecommunications technology. Instead, Federal antitrust prosecutors pictured AT&T as excluding a wide range of technologically superior and sometimes cheaper products of U. S., Japanese, and European manufacturers from the American equipment market.

The Government allegations are in a 629-page "First Statement of Contentions and Proof" filed in the District of Columbia's U. S. District Court with Judge Harold H. Greene. He recently moved to speed the four-year-old antitrust case (see "The plan for dismantling AT&T," below) after the litigation had been bogged down by pretrial maneuvering.

AT&T has until Jan. 1 to respond. The company's first reaction, from Harold S. Levy, general solicitor, was anger and surprise at the size of the filing. In addition to complaining that the charges lacked substance, Levy said that "it would take 10 years of trial time to complete this case, which involves virtually every Bell System action and tariff in the 20th Century."

To preserve and expand its service and equipment monopoly, the Justice Department asserts, AT&T abused the regulatory process before the Federal Communications Commission and state regulatory bodies as a means of delaying competition. Western Electric Co. and Bell Laboratories, AT&T's manufacturing and research arms, respectively, used the time gained to catch up, the Government claims. The company also "engaged in predatory pricing, refusals to supply transmission-service, preselling, and other marketing and operational practices available to it as the monopoly supplier of long-distance service."

Datran. The private-line digital data market for computer users is cited in the document as one example of AT&T's "exclusion of potential competition." The now-bankrupt Data Transmission Co. (Datran), formed by University Computing Co. of Dallas, now Wyly Corp., filed in 1969 for an initial coast-to-coast net of 244 microwave stations to serve 35 cities, with spur routes to be added later to accommodate growth. AT&T's response was its Digital Data Service, described in the accusation as "an unprecedented crash program" that included "a comprehensive effort to preannounce and presell its system in order to freeze the market for itself."

Development of data-under-voice technology, needed for use of existing intercity transmission facilities for the service, was not made until "more than a year" after AT&T's announcement of DDS, the court was told. Datran, which had difficulty raising capital, was frustrated for nearly a year by AT&T's insistence on selling, rather than leasing, local distribution facilities designed, built, and operated by the telephone giant. Lease negotiations were ultimately resumed, but the Justice Department says the telephone company then turned to other delaying tactics.

After AT&T filed with the FCC in October 1972 for DDS, it proposed "rates so low that they insured no market penetration by Datran," based on "a seriously flawed market study" and "a cost/revenue study that was replete with factual errors,

The plan for dismantling AT&T

The Justice Department has gone substantially further than many telecommunications specialists anticipated in its first filing of specific charges of monopolistic practices by American Telephone & Telegraph Co. The Antitrust division team of nine lawyers headed by Kenneth C. Anderson also proposes breaking up AT&T into many more pieces than anyone guessed.

Not only would the Long Lines division responsible for long-distance transmissions be separated from the 23 Bell System operating companies, but some or all of these companies would be required to be independent. Local operating companies would be prohibited from owning any intercity facilities, eliminating any incentive to deny interconection.

On the manufacturing side, the Justice Department wants Western Electric Co. spun off from AT&T and perhaps divided into several separate parts, since "a divested Western would start with such a large market share." Western Electric is the nation's eighth largest industrial corporation and owns half the stock in Bell Laboratories, the world's largest industrial laboratory. AT&T owns the other 50%, as well as Western Electric's stock.

The Government filing is the first of four statements each side will make. Each will have 60 days to respond to charges and issues raised by the other, with the goal of progressively narrowing the issues and bringing the case to trial by the summer of 1980.

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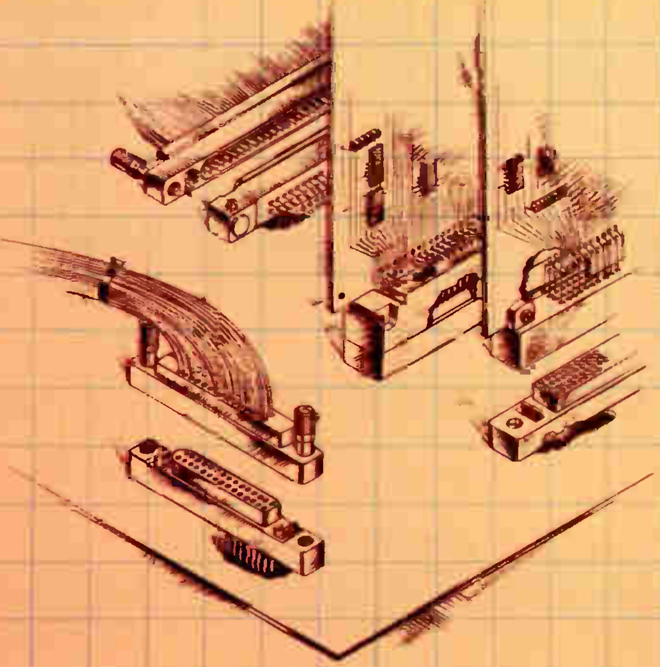

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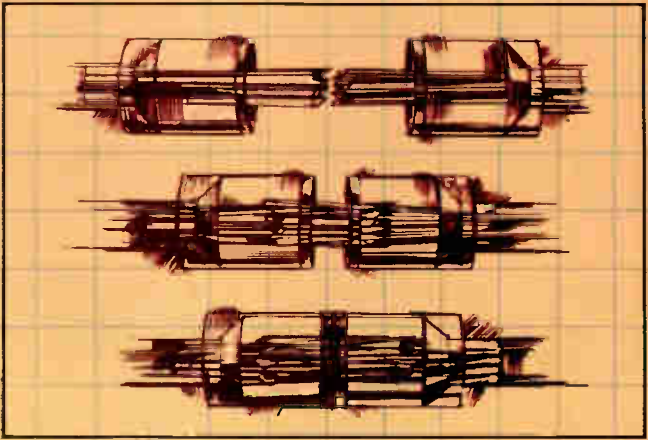

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omissions, and inappropriate or unsubstantiated assumptions." Datran's subsequent collapse, the Justice Department document says, "leaves AT&T with virtually all of the . . . business."

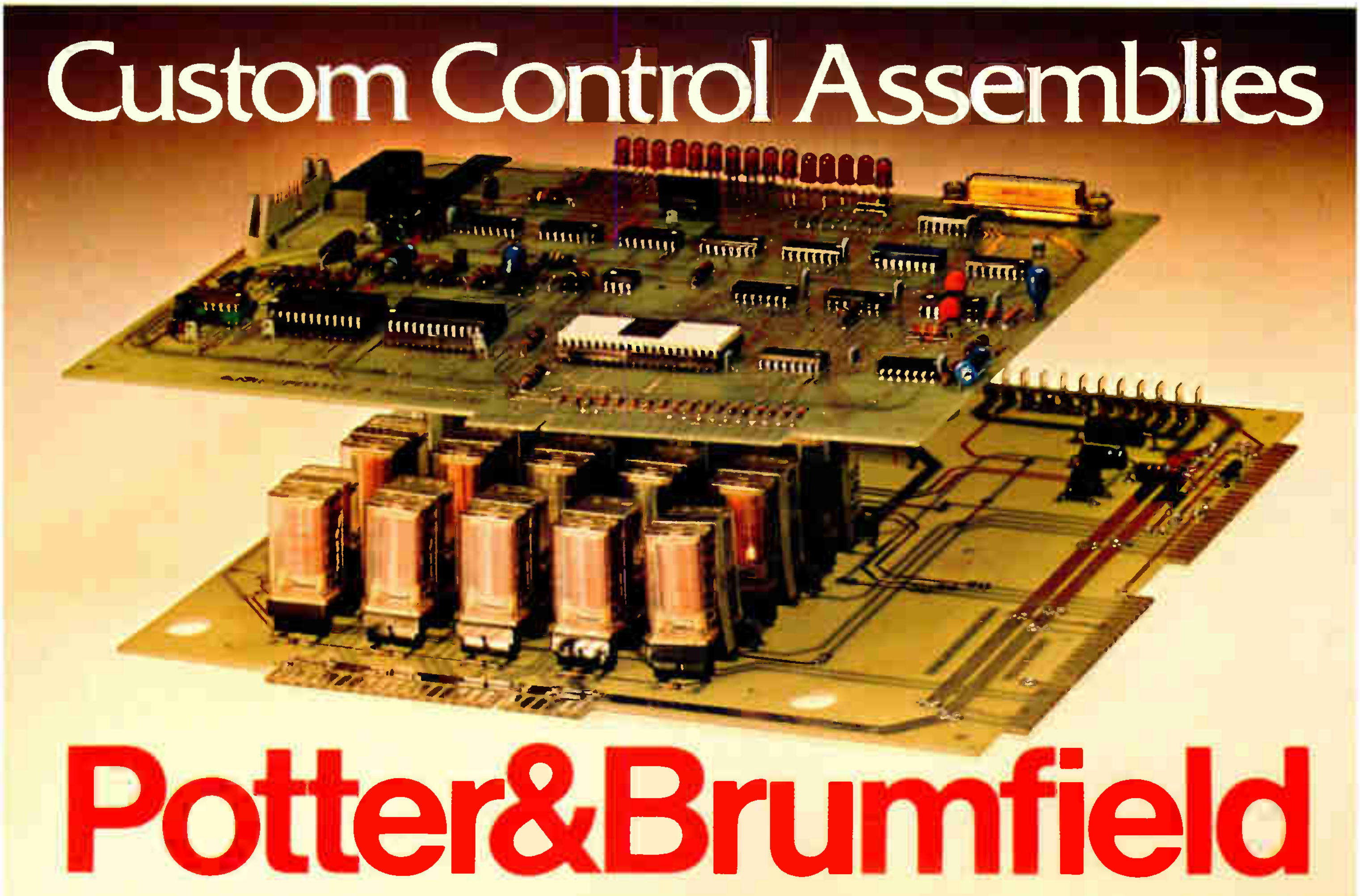
Central-office switching equipment is another area where the Government charges AT&T and Western Electric sought to maintain a monopoly by excluding competition ranging from Japan's Hitachi Ltd. and Nippon Electric Co. and Canada's Northern Electric to International Business Machines Corp. The Southern New England Telephone Co., 83%-owned by outside parties, has become a particular thorn in AT&T's side by successfully buying and operating non–Western Electric hardware, the filing shows. A notable example deals with community dial office switches for 3,000 telephone lines or less.

Southern New England, headquartered in New Haven, Conn., bought four NEC NC-23 switches at the beginning of the decade after being told by Western Electric, AT&T, and Bell Labs that it could not use a Hitachi C22D portable system then under test by New York Telephone Co. Southern New England found it saved $180,000 on each of the NC-23 electronic units by 1971, compared with the obsolete electromechanical Western 355A, and planned to buy five more. Bell operating companies had bought or expressed interest in at least 31 Nippon and Hitachi switches by 1970, plus three others from Northern Electric, the filing says.

To foreclose competition, the complaint contends, AT&T ordered Western Electric to build a competitive switch, the 5A, which succeeded "not because it was better or cheaper than the competition, but because it was built by Western." When a market developed concurrently for a very small community dial office switch that Western did not have, Northern Electric responded with its SA-1, which had "extreme success in Canada," while NEC offered its NC-1. Both failed in the U.S., the Justice Department says, because AT&T told Western to develop the 5B, later named the No. 3 crossbar. "It quickly foreclosed all others from the market" because "it was a Western product AT&T wanted the Bell operating companies to buy," says the filing.

AT&T's "wait-for-Western mandate" to its operating companies, coupled with "price manipulation" of the 5A to a level necessary to beat Nippon, succeeded, the filing charges. Initial price of the 5A was 110% of the NC-23, but it succeeded because Western added a 25% to 40% markup on the equipment, like the NEC switch, purchased outside for operating companies. Even at the higher price, the 5A's manufacturing costs "were at least 18% higher than the engineering estimates on which the price had been based," with the result that Western "incurred tremendous losses" in 1973–74.

ESS and IBM. Development of the first large electronic switching system, the No. 1 ESS, was also "an expensive failure" for AT&T when the system was put into the field



without testing; it operated only at 25% of promised capacity, the court was told. Citing an ESS switching proposal to AT&T in 1961 by IBM that was a variant of its System/360 computer series, the Justice Department says, "Had AT&T not foreclosed IBM from the market, this costly and time-consuming venture might never have happened." Before AT&T told the Armonk, N. Y.-based firm in 1965 to terminate its ESS effort, senior management of both companies met numerous times, according to the Government. "IBM's proposed ESS was superior to that being developed by Bell Labs," it says.

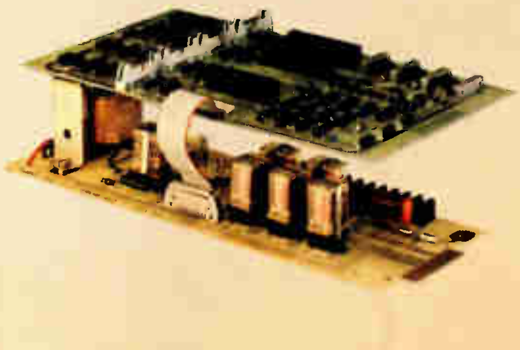
AT&T's rejection of IBM is allegedly "the result of an expected and consistent policy of doing everything to keep competitors (even IBM, which clearly had superior knowledge and experience) both out of the central office market and away from the operating companies."

Switchboards. The private branch exchange, or PBX, is the second largest terminal market after single-line telephones, accounting for $134 million in 1974 shipments, or 16.5% of the terminal market, the Justice Department says. Commercial significance is even greater than the sales volume indicates, however, "since 'behind' each PBX are substantial numbers of telephones and key sets." AT&T began to experience competition in this market after the FCC's Carterfone decision permitted interconnection of non-Bell equipment with the Bell System.

The maverick Southern New England again proved difficult for AT&T, collaborating with Japan's Nippon Electric in 1969 to modify its NA4-08 to produce the standard medium-capacity NA4-09 PBX. "SNET became aware of other Nippon products, and eventually also adopted the Nepax-100, a small PBX with a capacity of up to 100 lines," the filing says. Instead of waiting for Western to come up with its electronic PBX still in development, Southern New England went with NEC and figured in 1970 that it saved $2.1 million by not buying available Western Electric models.

Rather than buy the available NEC hardware for Bell System use, however, AT&T documents show that it called for Western to "press forward" on its electronic 800 series "as rapidly as possible to fill important voids in our present offering." After estimating a development time of about six years, AT&T elected in 1970 to shift to a 10-month crash development program on a new model called the 770A, calling it a "true measurement of how the Bell System can respond." In the view of the Department of Justice prosecutors, however, "the 'response,'" was to the threat of competition," rather than to customers' needs.

Moreover, the Government contends that the 770A was intended to be a copy of the NA4-09 of Nippon Electric. Even though the 770A cost more than its Japanese counterpart, it succeeded in keeping the medium PBX market for AT&T after 1971. Yet it proved "technically defective," costing more than $4 million in design changes and accounting in 1973 for 35% of warranty expense in its product line but only 7% of sales, the court was told. □



Companies

ICL, at 10, is sitting pretty

British computer maker has bounced back from low of several years ago to become strong factor in European market

by Kevin Smith, London bureau manager

Few companies can have better reason for celebrating a tenth anniversary than Britain's International Computers Ltd. In an industry that has seen the exit of some of the biggest corporations in the world, and in which simple survival is an achievement, ICL, with annual sales approaching $1 billion, has more than survived since emerging in its present form a decade ago.

Yet as recently as two or three years ago, few people in the industry would have rated ICL's chances of making it in its present form very high. A major reason for their pessimism was the company's supposedly greatest asset, the combined customer base created by the merger of ICL with English Electric Computers Ltd. back in 1968. The commitment to support both ICL's 1900 series and the English Electric System 4 nearly wrecked ICL.

"I believe the merger was a mistake and that System 4 should have been dropped at the time," says Tom Hudson, ICL's chairman. Not only did the commitment saddle ICL with the tasks of supporting two series but it brought the added burden of developing a new one to bridge both. It took six years, $80 million of government funds, and the extensive use of pioneering microprogramming techniques before the first top-of-the-line 2980 and 2970 models could be pushed on stage in 1974. Even at that, their operating system performed badly on first installations, winning the family an embarrassing reputation it is only now living down.

Today, ICL's managing director, Christopher Wilson, firmly believes that the decision to go for a new series was right and will stand the company in good stead well into the 1980s. A major new series is bound to have teething troubles, he argues, pointing to IBM's System/360, and "if we had stayed with 1900 series architecture, it would be running out of steam by now."

The company designed the new system from the ground up, incorporating in it advanced features like a virtual machine concept, multilevel virtual memory addressing with a 4-billion-byte address range, and push-down stack processing. ICL's latest midrange 2960 and 2950 models have been a success.

One reason ICL is still around today is Geoffrey Cross, brought in by Hudson when he became chairman in 1972. With Cross came a team of executives that had worked with him at Univac. As managing director through 1977, Cross brought a new financial discipline and urgency to ICL and scotched rivalries between former ICL and English Electric factions. Cross also won ICL its biggest prize when, in 1976, he bought Singer Business Machines' overseas operations and Singer's Cogar Corp. operations.

More scope. The deal gave ICL scope in three main areas. First, it took the company into the fast-growing market in small business systems. Second, it gave ICL a manufacturing base in the U. S.—important to keep in touch with American technology—and third, it gave ICL a real market presence throughout Europe. There was also a more subtle psychological change: "The company began to think internationally," comments one executive.

Where does ICL go from here to become a $2 billion company within the first half of the 1980s? The answer seems to lie partly in the Old World and partly in the New. Already $260 million of ICL's income comes from sales of small business systems to continental Europe. Now it must increase its minimal customer base of midrange 2900s.

As for ICL's U. S. presence, ICL Inc. was formed in January 1977 and since has closed some of its offices. Chairman Hudson says: "We have not really attacked the U. S. market, nor will we for six years. One needs to write a check for $200 million to exploit that market." So ICL will be pursuing a low-key approach, building on System 10 and 1500 sales from Singer and its new 9500 point-of-sale terminal and test-marketing its 2903. ☐

Forging ahead. ICL managing director Wilson likes launching of new series.

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Canstar fiber optic systems and products are being used in a variety of applications, some of which are described here.

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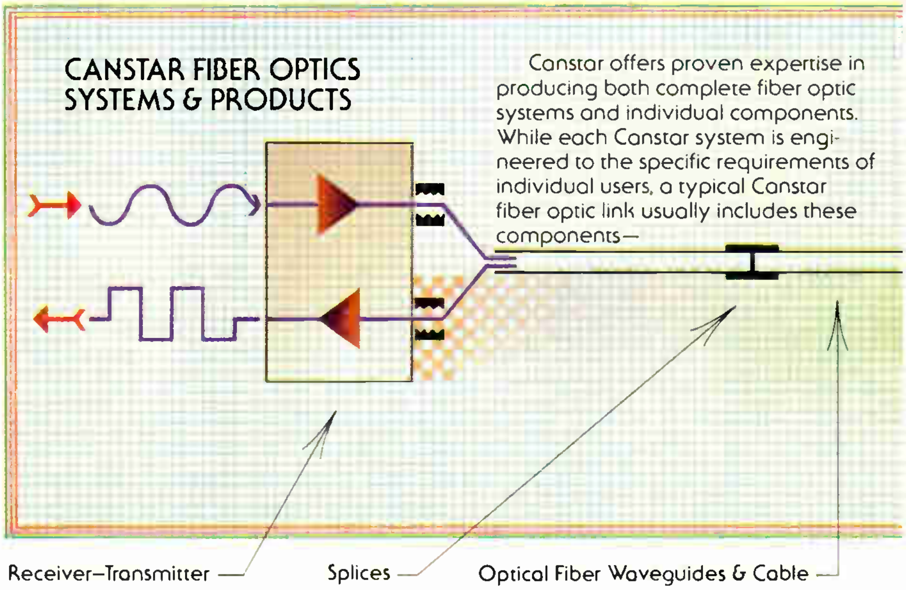

Canstar offers proven expertise in producing both complete fiber optic systems and individual components. While each Canstar system is engineered to the specific requirements of individual users, a typical Canstar fiber optic link usually includes these components—

Telecommunications

A telephone company uses a 50km fiber optic system from Canstar to create one of the world's longest high-capacity transmission links. This direct-burial installation, follows a field test, which used conventional plow-in techniques and proved the strength and crush-resistance of Canstar fiber optic cable. The field test also proved that our systems can endure extreme temperature ranges.

Another Canstar telephone application involves a broadband distribution facility using fiber optics. The system integrates TV and other services with normal telephone service to homes in a rural community.

Transportation

An international airport is using a Canstar fiber optic link to carry radar signals from a remote radar receiver to a computerized control center. The fiber optic cable is immune to electromagnetic and radio signal interference. Its small size, along with the much greater information-carrying capacity of fiber optics, means that upgrades of communications systems can be achieved more easily and economically. Airports, railroads and urban traffic control systems can all benefit from Canstar fiber optics—now!

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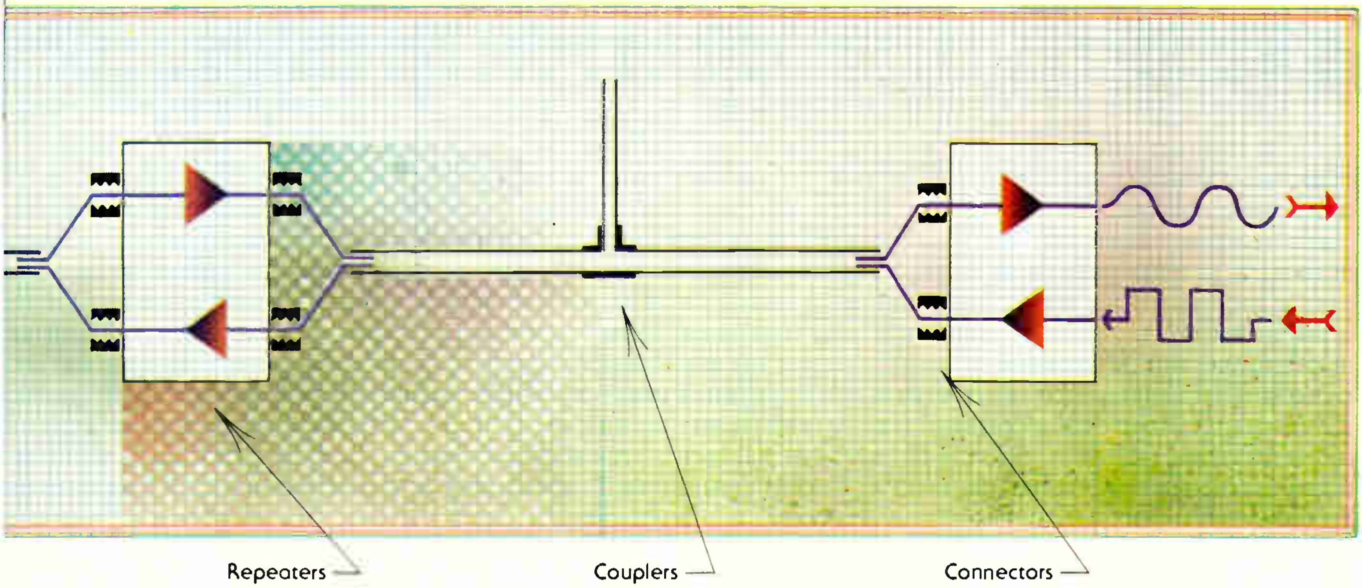
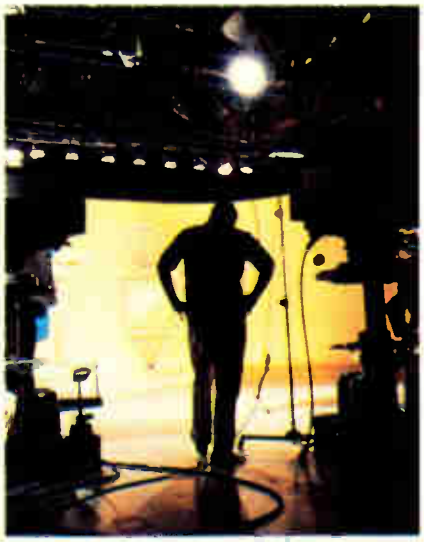
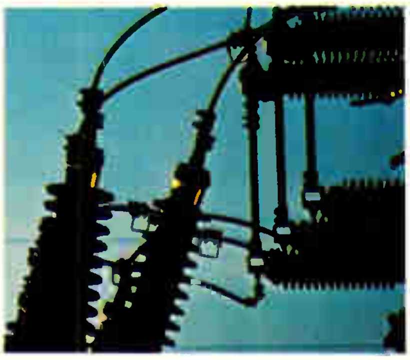


CATV

The world's first operational fiber optic CATV supertrunk using digital transmission employs Canstar's technology and products. Five cable TV companies are using Canstar fiber optic cable for the simultaneous transmission of 15 TV and 12 stereo FM channels. This system contains pole-mounted, in-duct and buried sections. It will initially serve a large metropolitan area and can be expanded to serve rural communities that are beyond the range of existing analog systems.





Energy

A major electric utility used Canstar cable as a communications medium in a substation to carry voice, video, and digital data signals simultaneously. This successful monitor-and-control project in a very "noisy" environment proved the operational reliability of Canstar fiber optic systems by demonstrating the immunity of fiber optics to electromagnetic interference, to induced voltages, and to false indications from control systems.

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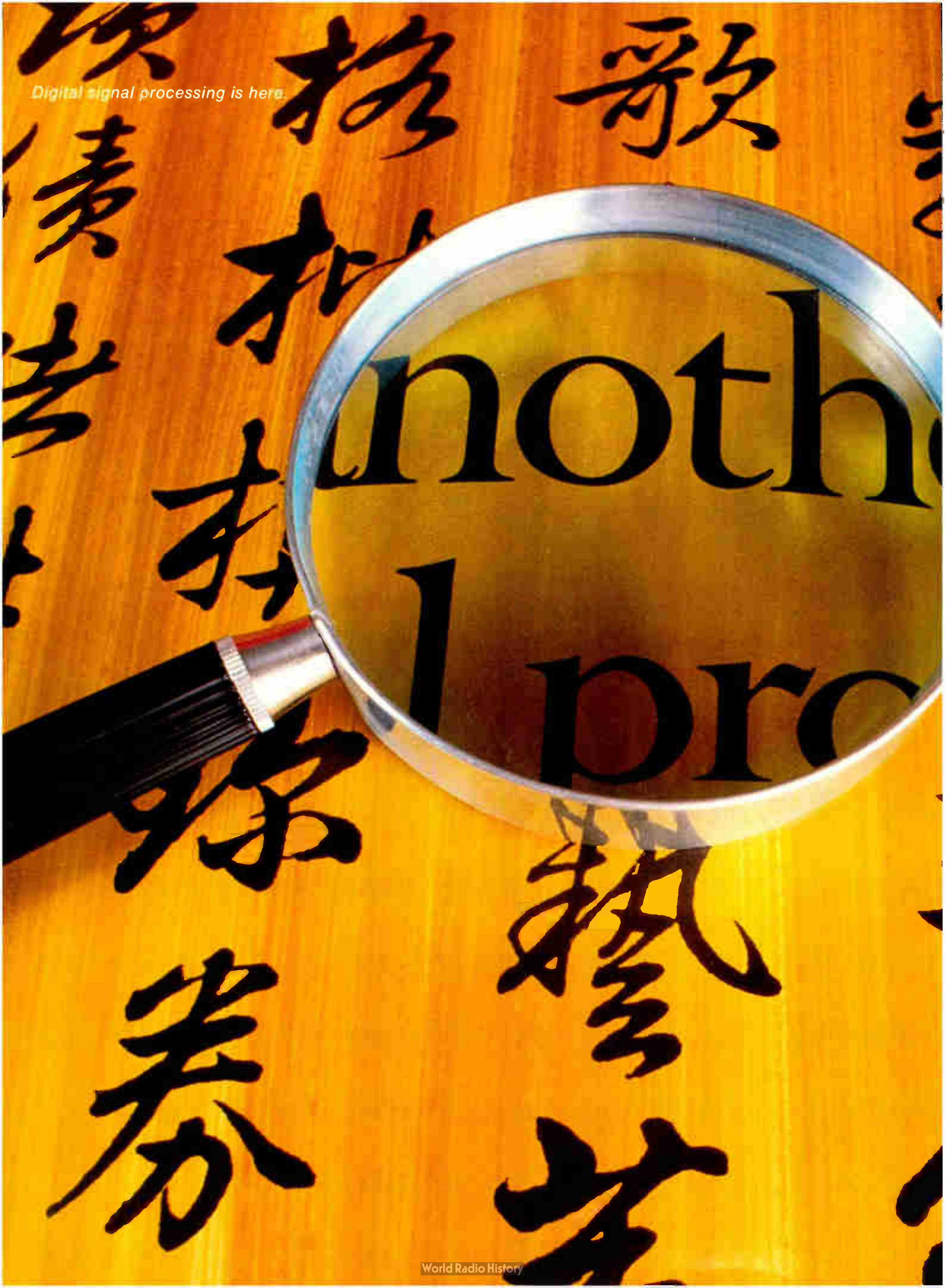
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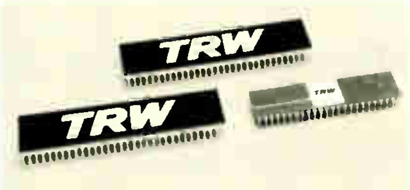
Because they displace a whole rack of sophisticated hardware, our multiplier/accumulators (MAC) can help small computer systems perform highly complex correlation functions. You can use these correlation functions to recognize the written word, the printed word and visual images of all sorts. Once recognized and captured, you can subject the characters to various computer manipulations, and even translate them into other languages.



You simply use one of our multiplier/accumulators to multiply a digitized image against a repertoire of anticipated patterns stored in memory. A high degree of correlation results in a numerically high product; a lack of correlation reduces the product value. You set upper and lower thresholds on the accumulated result and you vary the thresholds according to your required degree of flexibility or security.

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In addition to the 16-bit MAC, our second generation family also includes a new, 12-bit multiplier/accumulator—the TDC-1009J. It operates twice as fast as the original TDC-1003J—just 95 nsec for a complete 24-bit product plus a 27-bit accumulated sum. Like the 16-bit MAC, the TDC-1009J is packaged in a standard, 64-pin DIP. It uses just 2½ watts.

TDC-1008J is the designation of our 8-bit multiplier/accumulator. It generates a 16-bit product and a 19-bit accumulated sum in a snappy 70 nsec, uses only 1.2 watts and is housed in a standard, 48-pin DIP.

For increased flexibility, all our new MACs feature control pins that defeat the accumulators and allow them to operate as conventional, n-by-n-bit multipliers. Even more than that, they all feature on-chip input and output registers; their accumulators have the ability to subtract as well as add; they provide a useful pre-load function that lets you set the accumulator contents to any value and they all run on +5 volts only. All our multiplier/accumulators are radiation hard.

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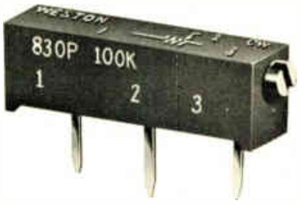
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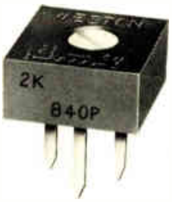
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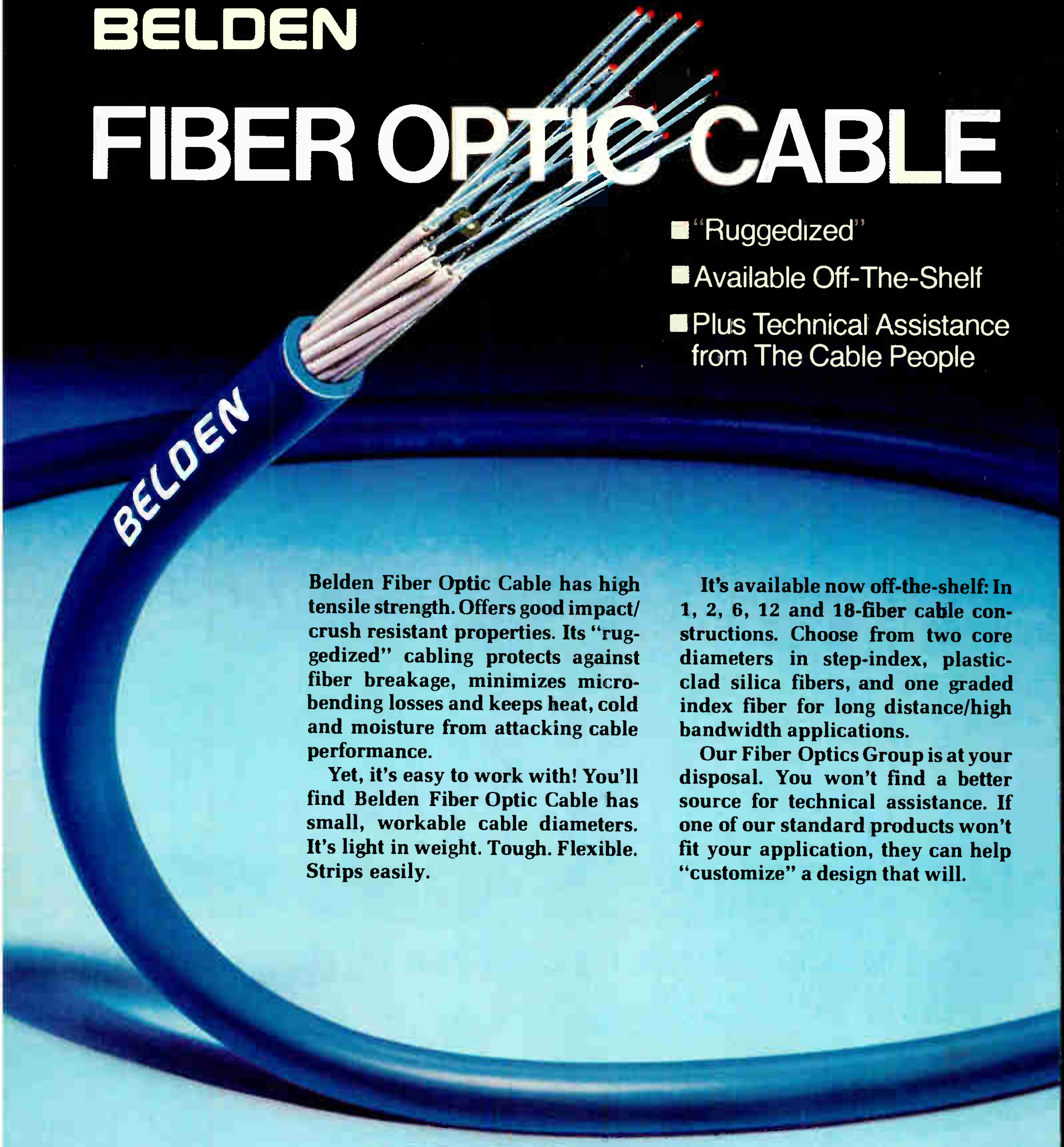

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Tackling the very large-scale problems of VLSI: a special report

by Raymond P. Capece, *Solid State Editor*

☐ From tens of devices per chip to tens of thousands—the increase over the last few years in the number of transistors in an integrated circuit has been nothing less than explosive. But the growth process has been evolutionary, not revolutionary. Continual process improvements and the confidence gained with the production of hundreds of thousands of chips per month have enabled manufacturers to shrink transistor dimensions and increase producible die sizes.

But now the increasing complexity of logic circuits, layout topology, and lithographic processes have compounded to create a design-management problem of mammoth proportions. Anticipating unprecedented design problems and greater risks of investment capital, manpower, and development time than ever before, leading-edge semiconductor manufacturers have initiated long-term programs to address the challenge of what has come to be called very large-scale integration.

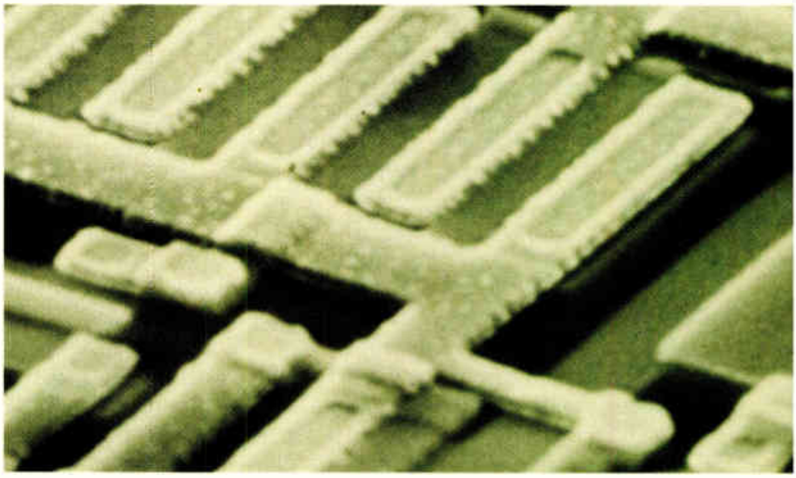
Interestingly enough, the programs that are under way at Intel, Fairchild, National Semiconductor, Texas Instruments, Rockwell International, and a host of other manufacturers have clear-cut goals, despite the fact that they are looking out as far as 1985 and beyond.

And what sort of chips might those be, with 100,000 devices or more? Besides higher-density memory parts (see "The 1-megabit RAM," p. 115), two trends are now apparent: fixed-function parts that will carry out complex operations to produce a not-so-complex result; and programmable parts, carry-overs from today's microprocessors, but faster and more complex.

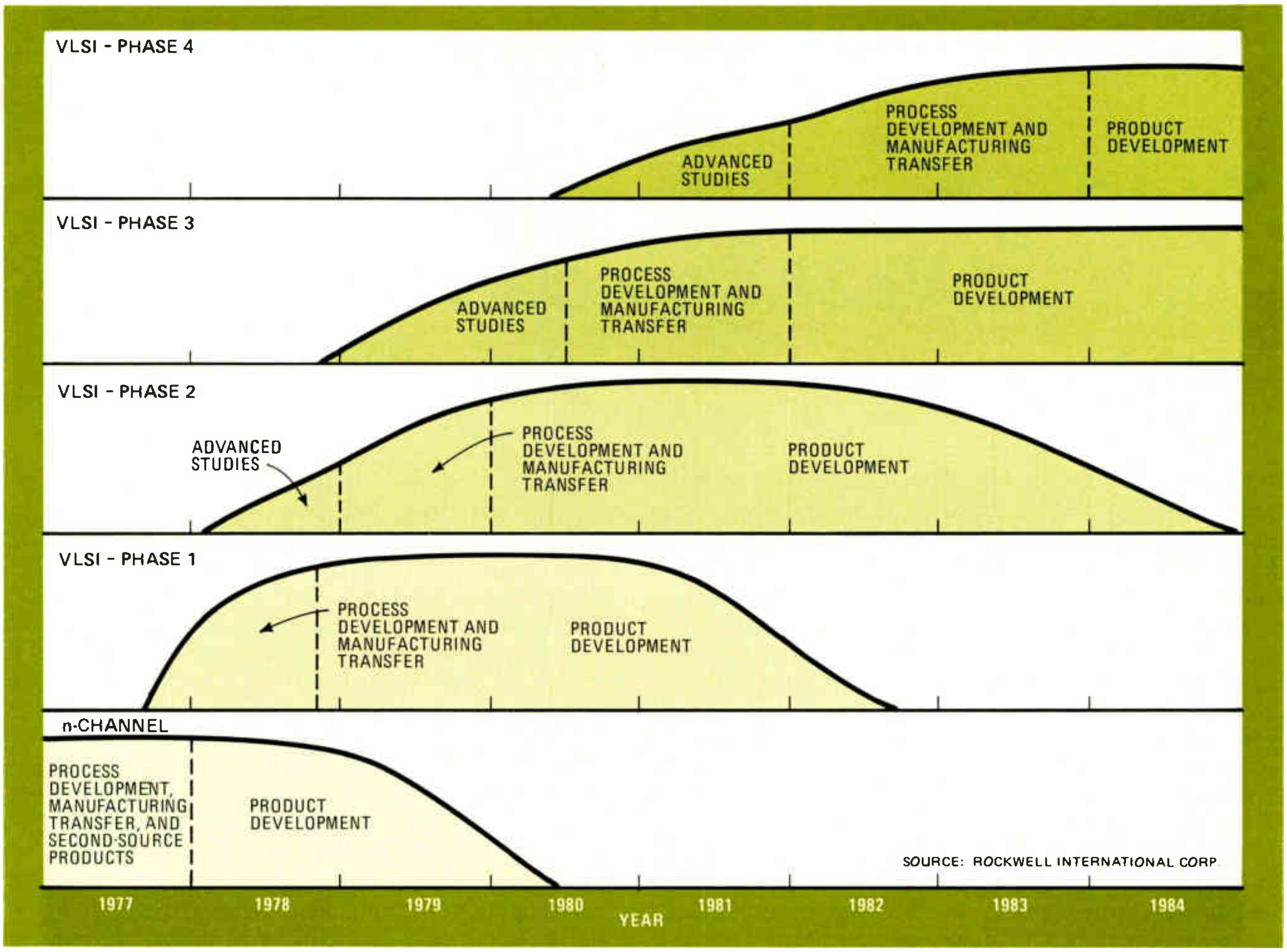
"Right now, it looks as if the principal use of VLSI will be for specialized functions, like speech synthesis and handwriting recognition," says William Howard, vice president and director of strategic operations for the Integrated Circuits division of Motorola Inc.'s Semiconductor Group, Phoenix, Ariz. Such parts would not suffer the functional definition and pin-out problems that complex data-processing chips will.

But at Zilog Inc. in Cupertino, Calif., president Federico Faggin says that programmable microprocessors and microcomputers will dominate with "special-function chips becoming more and more important as the number of gates required by the function increases."

"I don't see why those special-function circuits can't be programmable also," observes Gordon Moore, president of Intel Corp. in Santa Clara, Calif. He thinks the bulk of Intel's business, and probably the industry's as well, will be in programmable devices, "mainly to justify the design costs for a components house." Howard, too, believes programmable devices will be first, on the



Shrinking. VLSI drive toward smaller chip features is exemplified by IBM's 1-μm logic (above). Dramatizing dimensions are influenza viruses, shown approximately to scale (courtesy of V. Racaniello, Mount Sinai School of Medicine, Dept. of Microbiology, New York.



SOURCE: ROCKWELL INTERNATIONAL CORP.

1. Stretchout. Planning VLSI products for the next decade means a program of multiple, overlapping phases to many semiconductor manufacturers. In a four-phase program at Rockwell, development-time stretchout tracks the growth of circuit complexity.

grounds that the leading edge of VLSI must serve the computer user. "If we use the VLSI technology to design anything but computers," he submits, "we will have failed. But the real trick will be defining hardware that a nontechnical person can use."

With these major chip houses unsettled on the main thrust of VLSI product development, many computer manufacturers are developing VLSI capabilities in house. Computer makers feel their applications pose unique problems in the design and use of the higher density parts. Says Lloyd Cali, vice president of engineering and manufacturing at Burroughs Corp., Detroit, Mich., "There's no way a guy with chip technology can determine what we want on a chip. That's why we need our own microelectronics effort."

And Barry R. Borgeson, director of research and technical planning for Sperry Univac, Blue Bell, Pa., thinks that that effort should not stop after design. "Our volume requirements for VLSI chips will be low, so the semiconductor industry won't be interested in making them for us." Univac is among several mainframe and minicomputer manufacturers who are developing in-house fabrication capabilities.

But in Minneapolis, Control Data Corp.'s vice president of research and advanced design, Donald B. Bondstrom, sees no evidence of the semiconductor houses refusing to fabricate chips designed by the computer makers. "The management of the semiconductor companies grew up in a time when the computer industry was their best customer and told them where to aim their technology. Markets such as automobile electronics may now offer higher volumes, but they don't provide any technological push."

A problem critical to the computer industry is the limited pin-outs on VLSI chips. Because of the complexity of mainframe computers, more than one type of chip will be needed—even with VLSI. The chips will have to communicate with each other, and that poses the question of how to partition the logic to make the most efficient use of the limited number of input/output paths between chips. Lin C. Wu, director of machine technology at Amdahl Corp., Sunnyvale, Calif., cautions that the "pin-out problem is not only at the device level, but also very significant at the board level."

Jack Halter, senior vice president of the products group at Signetics Corp., Sunnyvale, Calif., predicts that many of the non-microprocessor VLSI circuits will be specific-function parts for analog signals. "A television chip that carries out all the processing of color signals is just one example," he says. "A circuit that complex has to be considered VLSI."

Analog VLSI is an area that David A. Hodges, professor of electrical engineering and computer science at the University of California at Berkeley, believes should get more attention. "Analog circuits have only improved by an order of magnitude in the time digital circuits have been bettered by three orders of magnitude," he contends. Hodges accuses the industry of prematurely handing over certain circuit functions to digital designs that "simply don't serve the function as well as analog circuits."

Filters, in particular, are built better with analog circuits, Hodges says, and he is promoting the integration of analog with digital devices on VLSI chips. He adds that there will be many specific-function VLSI circuits with hundreds of thousands of transistors that will be involved with some sort of signal processing. Included in his list are voice-synthesizer and -recognition chips and radio circuits.

Planning—a risky business

How can manufacturers plan long-term goals firmly, when just a few years ago the 64-K random-access memory was a gleam in the industry's eye? Necessity is the answer—development time for VLSI products like the million-bit RAM and the 32-bit microprocessor is several years, having stretched from less than a year for LSI devices (Fig. 1).

In the case of memory chips, where increased density is always desirable but must be achieved at a cost per bit comparable to that of less dense designs, development-time stretchout comprises the needs for materials and equipment improvements, process expertise, and to a lesser degree, circuit design advances. Fortunately, memory parts require little time be spent on functional specification: their job is to store data, and the strategies of product planning involve, at worst, only variations in refresh schemes for dynamic memories.

In the case of random-logic designs like microprocessors, development time becomes a compound problem: before any of the physical design can be undertaken, the function of the parts must be determined. Planning VLSI parts will be a far riskier business than LSI ever was—after all, who can be sure which parts will be in demand five years from now? No semiconductor manufacturer makes that claim, though all acknowledge that a circuit with 250,000 transistors might take that long to design, be it a high-level language microcomputer with mainframe capabilities or a fixed-function circuit block like a speech processor or radio or TV circuit. The 32-bit microprocessor may very well be a 50-manyear effort; that is not to say, however, that 100 designers given the job can complete it in half a year—any more than nine women can collectively bear a child in one month.

It is this labor-intensive aspect of random-logic circuit design that will hold back VLSI parts. Such parts will appear only if they are profitable to their makers, and buried in that premise are many immediate problems that must be overcome. Still, the consensus among the chip manufacturers is that none of the foreseeable snags is insurmountable.

Producing integrated circuits that contain hundreds of thousands of transistors entails two development efforts: circuit design, which encompasses both the functional design of the circuits and the physical layout on silicon; and fabrication, which comprises lithography, wafer preparation—including etching, doping, and deposition—packaging; and testing.

These two areas must be well coordinated, since one strongly affects the other. A very complex circuit conceived by the logic designers, for example, might result in an uneconomically large die size at present levels of buildable lithographic resolution. Or a tightly optimized VLSI chip might be so difficult and costly to test that it cannot be marketed.

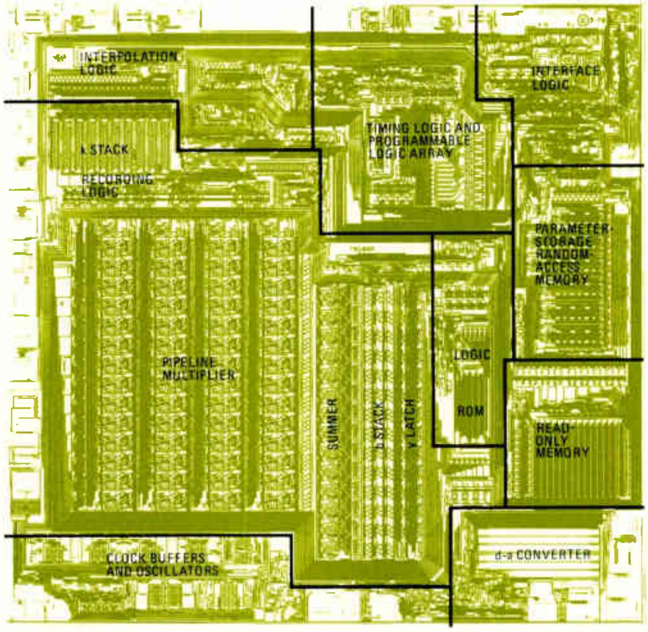
In planning for VLSI, coordination of design and fabrication will be the greatest change from earlier technology programs. According to Carver A. Mead, professor in the computer science department of the California Institute of Technology in Pasadena, the topology, or layout of the lines on silicon, must be considered even in the early stages of architectural design. "The people doing the top-level architecture must get involved in the real world of silicon" says Mead.

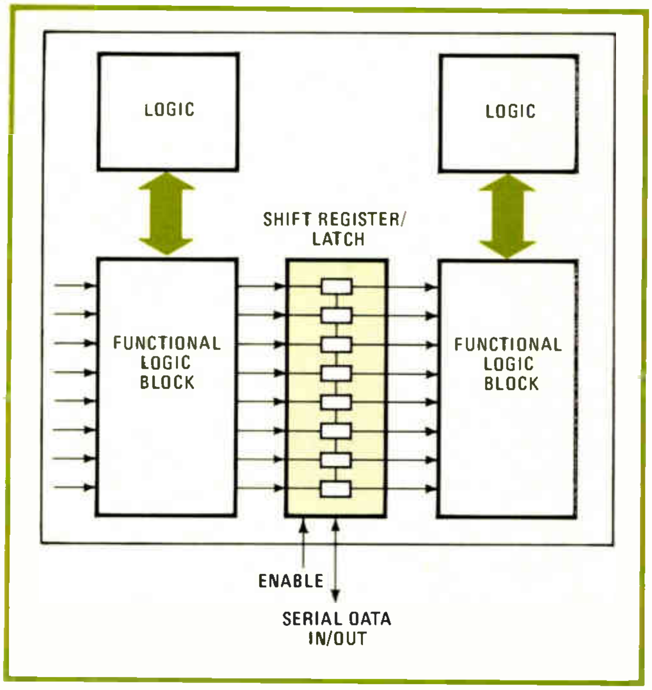
The problems of design

The design and checking of random-logic circuits will govern the progress of VLSI devices. Mead likens the situation to that of computer programmers 15 years ago: "The programs grew in size and complexity to such an extent that one person could no longer keep the design in his head." Now, as then, the problem becomes basically one of management.

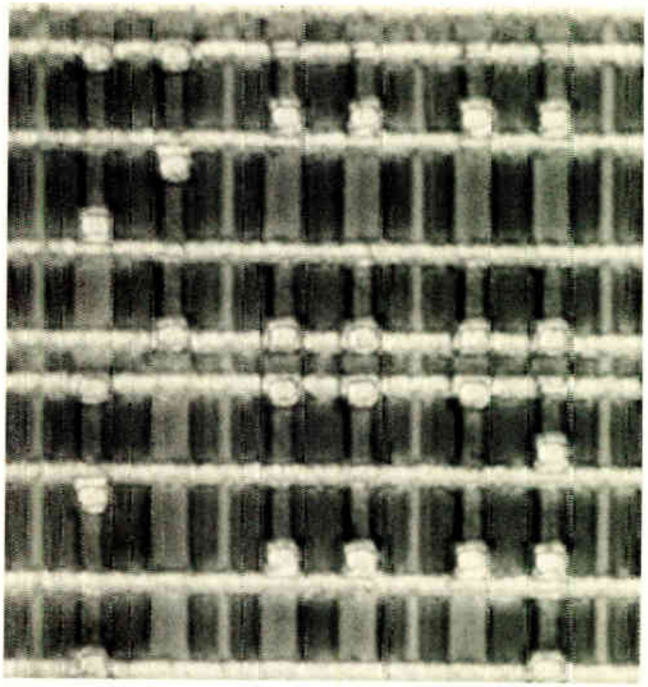
Hollis L. Caswell, director of applied research at IBM Corp.'s Thomas J. Watson Research Center in Yorktown Heights, N. Y., suggests that the problem be addressed the same way that programmers are doing it. "The design must be partitioned into segments of manageable size," Caswell maintains. "And one way

2. Macros. This speech-synthesizer chip from Texas Instruments Inc. is an example of the macro concept, which partitions complex designs into functional blocks. The technique may make complex VLSI circuits manageable.





3. Testability. Inaccessible nodes buried within complex chips greatly hinder testability. IBM's level-sense scan design, which adds shift register/latches to bring out (and enter in) parallel bit test patterns through a single pin, may be one solution.



4. Micrometer PLA. Design-easing programmed logic arrays will become significant as they get faster and smaller. This is part of an experimental PLA with which IBM has built an 8-bit microprocessor having 1-μm gates and speed comparable to random logic designs.

that can be done effectively is with macros."

The macro concept, an example of which is shown in Fig. 2, partitions systems into well-characterized functional blocks. Ironically, the concept was used back in the days of the early calculator chips—the arithmetic/logic unit, display-driver circuits, and storage registers were in blocks that could be seen on the chip even by the naked eye. "The problem is that chip manufacturers aren't willing to settle for those macros," explains Caswell. "They're so pressed to get performance out of the machine that they custom-design each part."

That attitude reflects the influence of the semiconductor house circuit designers who, says Caswell, would like to bang out microprocessors much as they do low-cost "jellybean" ICs. "But as you move to the high end, it's very questionable as to whether the custom trend is even architecturally possible," he adds.

According to Berkeley's Hodges, macros appear to be the only salvation for VLSI circuits with 100,000 or more devices on a chip. "But the problem is getting the semiconductor manufacturers to 'freeze' a given functional block into a well-characterized macro," Hodges asserts. "Unless they agree to settle on an ALU block, or filter block, instead of eagerly optimizing each circuit into a custom design, they will be strangled by their own inability to test the VLSI circuits they build."

One good thing about the macro approach is that it is independent of the hardware. "Macros can be used with various lithographies and functional-block sizes," explains James C. McGroddy, director of semiconductor science and technology at IBM's Thomas J. Watson Research Center. "They allow circuit designers to design the same way people actually design the cars they buy—choosing a radio or tape deck. Detroit can make a million cars a year, and each is different. That's how a macro-based system works as well."

Macros are just one example of how VLSI-circuit designers can and must discipline themselves. "We're going to see a time when designers are no longer given complete freedom," IBM's Caswell adds. "They will have constraints put on them that will yield a better tradeoff between ease of design and ease of manufacture."

Other examples of such design constraints have already begun to appear. At IBM, a design technique called LSSD, for level-sense scan design, mandates that the designer cannot use any feedback loops in his chip—all the feedback loops must be broken and replaced with serial shift register/latches, as shown in Fig. 3. The latches are then brought out to pins, thereby allowing access to previously unreachable nodes within the chip. Having the shift-register pin will also allow a test pattern to be entered into the chip register. "This is one of the schemes that will make it possible for us to live with VLSI," Caswell adds.

Another technique that will aid the design of complex circuits is the use of programmed logic arrays. Although PLAs often are slower and take up more chip real estate than random logic, they are a faster way to implement a logic function and are far simpler to troubleshoot and to change once in production. They are appearing in microprocessors: Intel Corp.'s 16-bit 8086, for example, uses a PLA for its control store, which makes the device much like a microprogrammable chip that can be altered simply with a metal-mask change. The 8-bit microprocessor developed by Bell Laboratories in Holmdel, N. J., also uses a PLA for program control. "The PLA really simplified the MAC-8's design," says Robert C. Fletcher, executive director of the Integrated Circuits Develop-

The 1-megabit RAM

Though even functional specifications of random-logic very large-scale integrated circuits that use a quarter-million transistors will be difficult, memory parts are setting a steady course of higher densities. And though the time it takes the dynamic memories to quadruple in density may become longer than the by now traditional two years, the 256-K random-access memory will follow this year's 64-K (barring interim parts like a 128-K) within two years and the million-bit RAM will be here in the mid-1980s.

None of the major memory makers looks forward to the development of a megabit RAM. As with VLSI logic, "to get there, basic questions of device physics will have to be answered in the next two years or so," comments Motorola's William Howard. He questions the possibility of building very small devices free enough of leakage to be able to store charge on capacitors. "Not only will we have problems with alpha particles," he says, "but unforeseen second- and third-order effects will start to surface."

The problems encountered in the transition from 16,384 to 65,526 bits on a chip—timing skews, soft errors, an increase in the number of refresh cycles, packaging—will beset the next two generations of memory chips in spades. Even after the design of a memory part is complete, a year or two may pass before confidence in the process appears.

Gene Miles, National's director of memory components marketing, expects the 1-megabit RAM to surface in 1985, "but it will cost several million dollars to build that first chip." He adds that the doubling and quadrupling of memory densities has become a far thornier problem than the scaling down of individual device geometries. "Getting to 256-K will take a good many design innovations, and there will be again as many in going to 1 megabit," he predicts. National is currently investigating stacked-capacitor memory-cell structures that could be the building block for the megabit device. "Economics will dictate that the 1-megabit RAM can be no larger than 50,000 or 60,000 square mils," Miles explains, "and that calls for some real innovative cell design."

At Bell Laboratories, Martin P. Lepselter sees the increase in memory density tracking directly the reduction in lithographic features: "There's really no need for exotic structures—if the 64-K is built with 3-micrometer lines, then it is reasonable to expect that the 256-K will be built with 1.5-μm lines and the 1-megabit RAM will use 0.75-μm features."

Similarly, Intel's Gordon Moore and Zilog's Federico Faggin believe that RAMs creeping towards the million-bit level—at about 1986, they concur—will be made basically from extensions of present two-dimensional techniques rather than multilayered stacking of data or multiple-voltage-level storage. "Multiple-level storage schemes are too complex," says Moore. "It is likely that scaling alone will allow us to reach that level," Faggin explains. "But there's still room for cleverness in structures, which will help," he adds.

Fairchild's Thomas A. Longo thinks that producible die sizes will have grown by then, and that "we'll eventually be building chips that are 90,000 square mils or more." Such a large die size, however, means packaging problems for the 1-megabit RAM—not in terms of the number of pins, since the multiplexed design would allow access through 16 pins, but in terms of the chip's aspect ratio, which may force it into a square package. "Unless we can be relieved of the 2:1 aspect ratio of the 16-K and 64-K chips, the packages will have to change," says Miles. "Certainly, 300-mil-wide packages, which have only a 140-mil-wide cavity, can't be used."

The opinion at IBM's Thomas J. Watson Research Center, however, is that a very serious limitation will be reached that could radically change the memory picture in the mid-1980s, switching the emphasis from dynamic types to static. According to Arnold Reisman, computer simulations have shown that at about an 0.8-μm gate width, the FET switch can no longer be turned off. "That means you cannot store the charge on a capacitor plate as dynamic memories do," he explains. The 0.8-μm limit is only at room temperature, however, since the culprits that hold the transistor on are thermally generated carriers. "Cooling the device greatly lowers the limit," Reisman adds, "and at liquid-helium temperatures, you also get a boost in speed by as much as three times, since carrier mobilities increase." The upshot, says IBM's Hollis L. Caswell, is that the straight-line curve of memory densities versus time "will have a plateau when the changeover is made from dynamic to static memory designs." Static cells, Caswell points out, do not suffer from the thermal-carrier problem.

ment division, "but it's almost too easy to change—changes can mean real problems when a heavy commitment has been made to a large software base."

At next year's International Solid-State Circuits Conference, IBM will unveil a PLA technology mapping a microprocessor cross-section that exhibits performance levels equal to or better than what has been done with random logic. The technique uses two types of PLA designs: static and dynamic. The static is the faster one and, with IBM's 1-μm logic (Fig. 4), it actually comes out ahead of random logic in speed. Such improvements in PLAs are bound to increase their popularity.

Currently, semiconductor manufacturers are reluctant to employ such design techniques as LSSD and PLAS because they increase the size and complexity of chips. The shift register/latches of LSSD take up a lot of additional real estate, which cannot be justified by the complexity of current circuits. But the ultimate adoption of such techniques is inevitable. Says IBM's Caswell: "Once the semiconductor manufacturers are given a tenfold increase in integration capability, they will be driven to do that type of thing in order to make their devices testable."

Designing in testing

"We've only begun to address the problem of testing VLSI now," comments William C. Holton, manager of the Semiconductor Research, Development and Engineering division at Texas Instruments in Houston, "but it will have to be solved by the early 1980s." Most semiconductor manufacturers have come to the sober realization that large random-logic devices with tens of thousands of inaccessible internal nodes will be almost impossible to test. Halter at Signetics adds that analog products are not easy to test either: "We found out from some of our complex analog products, which take a minute or more each to test, that test time can kill you."

Several techniques are being considered to reduce the problem to a more manageable one. One is the incorporation on the chips themselves of circuits that will perform self-checking routines. Another is the addition of shift registers on the chips to bring out inaccessible data in serial fashion, much like IBM's approach in its level-sense scan design.

Of the two, the latter is emerging as the more viable. Since computer test-pattern generation is practical only for a device with a limited number of nodes (testing time varies as somewhere between the square and the cube of the number of nodes), separating the large random-logic device into functional blocks and using techniques like IBM's LSSD reduces the problem to a manageable one.

Some of the testing problem has resulted from continued reliance on manual layout techniques. Manual layout has led to what Cal Tech's Mead refers to as the "spaghetti" school of design, a technique that was used to develop the first microprocessors—lots of logic in a random layout pattern that was not only difficult to draw but nearly impossible to trace. Such layouts have lower production yields than regularly patterned devices like memories. And because the logic was so random, Mead adds, there was no physical mapping of what signal was close to other signals that might have interacted with it. "None of the circuits built this way can be tested for defects in the simple manner that we test memories," he concludes.

Mead points to another school of design—the "tinkertoy" school—whose designers try to string together LSI circuits by awkwardly interconnecting blocks of gates. "Both schools suffer a combinatorial explosion," says Mead, and consequently the design becomes unmanageable. Again, the problem sounds like one that software designers faced 10 or 15 years ago.

5. Symbolic layout. At American Microsystems Inc., a computer-assisted design program is under way for symbolic layout of ICs. In it, symbols representing gates are drawn and automatically checked by computer. Multicolor interactive graphics speeds the design.

Says one Control Data spokesman, "You can't design VLSI on the back of envelopes—you have to use large computer simulations. But indoctrinating logic designers in the use of computer-aided design is like trying to convert someone to another religion."

Actually, much work is being done using computer tools to automate the design process of VLSI circuits, but most of it is now being directed toward the physical layout—going from the logic design to masks that are automatically checked for design rules and even checked against logic. "There's been much less success in going from a high-level functional description of the machine going through the partitioning, and so on," says Caswell. "Most of that is still done manually."

Mead concurs that the synthesis part of design, as it is called, has simply not received the attention that the physical design part has. "There is currently no worked-through design methodology that will let us build circuits larger than those built today."

Design automation

At Rockwell International Corp. in Anaheim, Calif., computer tools rank as high in priority as the process technology. As its capability analysis shows (Table 1), it regards computer-assisted design as less in need of development than fabrication techniques. Rockwell like nearly all of the semiconductor manufacturers who have initiated CAD programs, is writing all its own software. Each manufacturer's requirements are often unique, so the competitive situation hinders the spread of information on CAD. The major universities with strong computer science departments are doing most of the work. That is why companies like Rockwell, Intel, and Burroughs are funding research at the California Institute of Technology, for example.

Rockwell has for the last ten years been developing a symbolic layout program that allows designers to lay out a circuit on a single level using only symbols—like an X to represent a contact or an O to represent a gate. Its bank of five IBM 370/168 computers then takes over drawing the many masks that produce a chip.

Even with symbolic layout, however, Rockwell's drawings are still done by hand on Mylar. At American Microsystems Inc., which is also using symbolic layout (an expertise it acquired with former Rockwell employees), the CAD group is promoting the use of interactive graphics terminals for layout, as shown in Fig. 5. AMI is calling its program SLIC, for symbolic layout of integrated circuits. Rand Ivey, manager of Rockwell's CAD group, comments that it is easier to diddle on a CRT screen than on Mylar, but the problem is getting a good look at the overall picture." Still, he says, Rockwell is looking at interactive color graphics, especially since it plans to increase the number of colors for its symbolic layout—currently, the computer printouts are in red and black.

"But the really significant thing," says Dave Peeters, Rockwell's microcomputer logic manager, "is that the design data base for our layout CAD is completely automated—we can go through and trace an entire circuit and verify it against the logic diagram automatically." Peeters claims that as early as next year, Rockwell will be building parts with masks generated directly from MOS circuit layouts using its CAD programs.

Fabrication

One of the main reasons that semiconductor manufacturers are planning their VLSI programs in stages is that the progression toward smaller and smaller transistors will require the introduction of several new types of lithographic equipment. Each type will be phased in only when economically practical (Fig. 6). U. S. manufacturers agree that optical lithography will remain the dominant approach for many years to come.

The previously believed resolution limit for optical systems of 2 micrometers has been reappraised: Intel's Moore says, "I suspect, and have for a long time, that we can get down to 1-μm lines." Moore attributes the improvement to techniques employing partially coherent light, which combats diffraction effects; the introduction of retrofittable deep-ultraviolet light sources and companion resists that are sensitive to wavelengths as short as 2,400 angstroms, or 0.24 μm; and laser alignment schemes.

Even more optimistic is Motorola's Howard. "It now looks as if the 1-μm level is within reach and acceptable," he reports, "and even ½ μm is possible," albeit at diminishing returns. Howard explains that shallow ultraviolet light at 200-Å wavelengths is so near the absorption edge of quartz that "it can no longer get through the lens." Moreover, he says, such wavelengths require a vacuum environment.

Currently, most U. S. semiconductor manufacturers are switching integrated-circuit production of their densest parts from contact or proximity printing, where the wafer touches or is kept within a few micrometers of the mask through which it is exposed, to projection printing, in which the wafer is exposed through a reticle several millimeters above it that is often larger than the actual image. Contact printing has several drawbacks: because of the mask-wafer contact, masks wear out and must be replaced after from 25 to 75 exposures; also, yield decreases with each use of the mask. "But there's practically no difference in resolution limitations between contact and projection printing," says Zilog's Faggin. "The current practical limit for production is about 3 μm." Faggin reflects that in larger circuits, however, proximity techniques provide poorer yields than projection methods.

Oddly, contact printing is still favored by the Japanese. Fujitsu Ltd., for example, even contact-prints its 64-K RAM, which is built with 3-μm design rules. Apparently, they have overcome the problems of mask and wafer damage. "They're very clever, and especially good in optics," comments IBM's Reisman. "But you can't say that the Japanese are not going to use step-and-repeat lithography," comments L. J. Sevin, chairman of Mostek. "They're buying those machines, too."

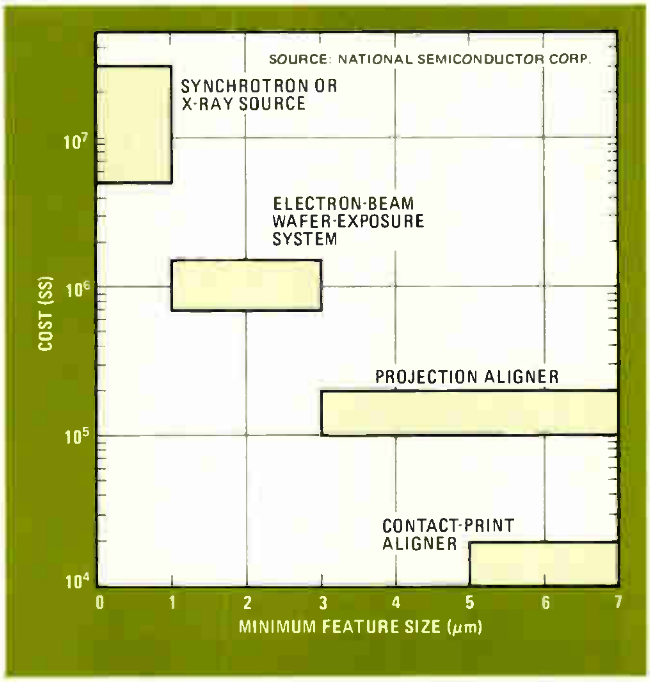
The next generation of projection printers from Perkin-Elmer Corp.'s Optical Group in Norwalk, Conn., to be available the middle of next year, is directed at 2-μm design rules. Resolution beyond that depends on the expertise of the user; the present generation of machines, directed at 3 μm, has been used successfully by several manufacturers in the production of chips with design rules as fine as 2½ μm. But the new machines will perform better (even without the use of deep-UV light), as a result of several improvements, including better optics; thermal regulation; and environmental control, especially reduced mechanical vibration, which has proven to be the limiting factor in Perkin-Elmer's current generation of projection systems.

Even so, new lithographic problems constantly arise as new semiconductor processes are developed. A good example of this is the trend toward double and even triple layers of polysilicon for new memory cell designs. Such processes create a terrain of hills and valleys that makes processing more difficult than ever before (Fig. 7). Excursions extreme as those require a focusing depth of field of several micrometers or more. The semiconductor manufacturers therefore have given a new definition to depth of field: the amount that can be tolerated before a critical dimension is lost.

Future lithography

Most impressive are the objectives of Perkin-Elmer's third-generation 1:1 scanning projection system, which is now in its final stages of development for the 1980–81 timeframe. The machine is directed at 1-μm design rules, will accommodate wafers as large as 5 inches, and has an overlay registration within ±0.25 μm. In addition, the machine will be built with a computer interface,

6. Equipment costs. With the progress of VLSI toward smaller device geometries, the cost of lithography equipment will skyrocket to resolve those tiny transistors: $1 million electron-beam equipment will be succeeded by particle accelerators costing 10 times as much.



VLSI Europe

Lest U. S. semiconductor manufacturers be caught looking too long over one shoulder, VLSI is not standing still across the Atlantic either.

In West Germany, for example, the man responsible for VLSI programs in the components division of Siemens AG, Hugo Rüchardt, says that the Munich-based firm is building up its VLSI capability with several technologies. One direction Siemens is taking is with very fast bipolar arrays using subnanosecond logic—parts that at this point do not sound much like VLSI, but "will when built with integrated-injection-logic–like circuits," he says. The modified I²L designs will also lend themselves to mixing digital and analog systems, Rüchardt adds. Another technology the firm is pursuing is V-groove MOS. In development right now is a 64-K random-access memory built with V-MOS that is expected to come out early next year.

N-MOS first. Siemens' strongest VLSI effort at present, however, is in double-polysilicon-gate n-channel MOS, using advanced optical lithography coupled with plasma-etching and local-oxidation processes. "Starting more or less from pure scaling, we are working on further process refinements like self-alignment techniques," Rüchardt says. For its n-channel process, Siemens expects next year's gate delays of 2 nanoseconds and power-delay products of 0.2 picojoule to dwindle to 0.8 ns and 0.04 pJ by 1983. In terms of physical size, next year Siemens will put 5,000 transistors of 2.5-μm channel lengths into a square millimeter, and it hopes by 1983 to squeeze 20,000 1.5-μm devices into the same space.

Over in Eindhoven, the Netherlands, N. V. Philips Gloeilampenfabrieken is also investing most heavily in n-channel MOS. "But we also have a major VLSI program aiming at I²L technology," says Hans Heumer, product marketing manager for integrated circuits at Philips' components and materials division. Understandably, Heumer does not want to give absolute investment figures. He does say, however, that a sum equal to 30% to 40% of what his company will spend for MOS VLSI activities will go for I²L. As for specifications, Philips is aiming at MOS channel lengths below 2 μm. The density by 1979 or 80 should be 6,000 transistors on a 1-mm² area, and that density should double by 1983, Heumer says. He believes that going to 1-μm dimensions will require a major and fundamental breakthrough in technology.

Elsewhere, n-channel silicon-gate MOS is also getting the heaviest play, at least for the short term, at the Sescosem Semiconductor division of Thomson-CSF, the top native semiconductor producer in France. "It is good for up to 100,000 transistors per chip," insists Michel Joumard, who heads the company's digital applications group. In the next few years, Sescosem expects to market VLSI circuits fabricated in n-MOS with propagation times better than 1 nanosecond and with a power-delay product between 0.5 and 1.0 picojoule. The supply voltage will be less than 5 volts, perhaps even 3 V. The geometry limit will be 3 μm and the density between 1,000 and 2,000 transistors per square millimeter.

GaAs, too. Much later, Sescosem could get into VLSI circuits in gallium arsenide. At parent company Thomson-CSF's central research laboratory a team is researching on enhancement-mode GaAs-FET integrated circuits. "They could have higher density than MOS chips and a much better speed-power product—a few femtojoules," predicts Guy Convert, head of the components group at the lab. The work, Convert emphasizes, is experimental as far as VLSI is concerned, but the team has successfully integrated less complex circuits of about 80 transistors.

Sescosem has government backing for its VLSI effort and so does EFCIS (Société pour l'Etude et la Fabrication de Circuits Integrés Speciaux), owned jointly by the French nuclear energy agency and Thomson-CSF. For EFCIS, the predominant VLSI technology will be C-MOS on sapphire. This technology is being developed for EFCIS by a nearby laboratory (both are in Grenoble) of the nuclear-energy agency, Laboratoire d'Electronique et de Technologie de l'Informatique (LETI).

Joseph Borel, head of LETI's applied microelectronics group, expects EFCIS will be on the market with 2-μm circuits by mid-1982 and move on to 1.5-μm circuits a couple of years after that. Already, LETI has fabricated test circuits—ring oscillators with 500 stages. These circuits have a density of 2,700 transistors per mm². The silicon epitaxial layer atop the sapphire substrate is 0.45 μm thick and the gate oxide is 500 angstroms thick. Propagation time for the ring oscillator is 1.5 ns per stage, and the speed-power product 0.14 pJ. Borel predicts the C-MOS-on-sapphire approach will produce circuits with speed-power products well below 0.1 pJ—something like 0.05 pJ for a divide-by-three circuit operating at 100 megahertz off a 3-V supply.

Fabrication. Both Sescosem and EFCIS will use optical lithography techniques for their initial VLSI circuits. At Sescosem, the feeling is that 2 μm is pushing the limit. However, Borel says that 1 μm line widths seem feasible. LETI expects delivery soon on a direct-writing step-and-repeat machine, a GCA Corp. 4800 photorepeater. But a special French-made objective will get his limit down to 1 μm, Borel feels.

As for the practical limit of optical lithography of 2-μm dimensions, Philips' Heumer points out that the alignment accuracy and the spread of equipment parameters play a bigger role than the resolution of 2 μm itself. "We have developed an alignment system we believe will carry us below 2 μm," says Heumer, referring to the "silicon repeater" system [*Electronics*, May 12, 1977, p. 32]. He adds that "below 2 μm" is an understatement. For full-wafer proximity printing, Siemens' Rüchardt sees 4-in. wafers with 2-μm line widths as the limit. "This should be the case even for X-ray proximity concepts," he adds.

Heumer, like many others, thinks that direct writing on the slice with electron beams might be the ultimate solution. "We feel that the loss in throughput can be compensated for by other effects, like better yields, which would result in less expensive circuits." So, too, is the feeling at Thomson-CSF's central laboratory, where the French company is currently building electron-beam equipment. Heumer claims that Philips has an electron-beam equipment program going that rivals those of the Japanese. Its electron-beam pattern generator, EBPG-3 [*Electronics*, Nov. 9, p. 68], produces lines as narrow as 0.4 μm. And Rüchardt at Siemens agrees with the long-term investment value of electron-beam research "if 'long-term' means about seven years from now." During this time, he says, the factors that are limiting advances in electron-beam technology the most, namely writing speed and throughput, will not be all that significant because electron-beam will be applied mainly to mask-making and fabrication of small-quantity special products.

VLSI Japan

The very large-scale integration project that the Japanese began in March 1976 is now well into its third year, and just over a year away from the 1980 goal of developing VLSI technology for next-generation computers having a cost-performance ratio 10 to 20 times better than those of IBM's 370 designs. Conservative guesses are that over $175 million of the estimated $250 million combined private-funding and government-subsidized operating capital has passed under the bridge. But it is still too early to tell just how the cooperative program of Nippon Electric Co., Tokyo Shibaura Electric Ltd., Hitachi Ltd., Fujitsu Ltd., and Mitsubishi Electric Corp. will affect the digital components market now dominated by U. S. semiconductor manufacturers.

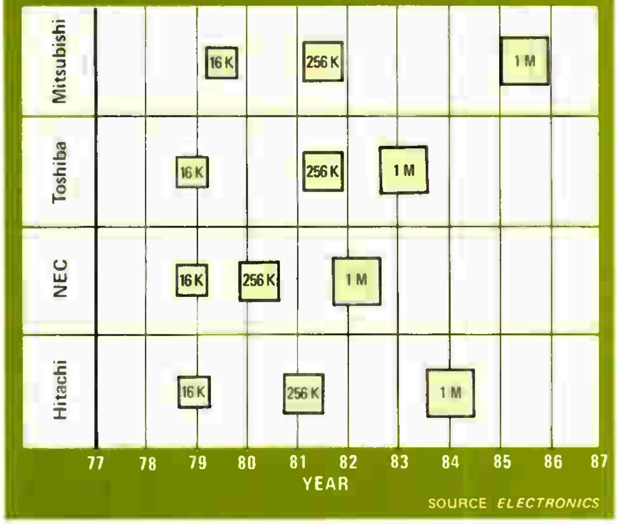
The tables below disclose the Japanese manufacturers' own estimates of their progress in fabrication technology and dynamic random-access memories. It can readily be seen that despite the cooperative effort, expected arrival dates of million-bit RAMs from the various Japanese manufacturers span nearly a four-year range. Moreover, queries about what kind of technical advances are needed to build the 1-M RAM elicited several different responses from the program's chip makers: NEC is looking at multilayered vertical-storage structures, while others see a direct scaling of present geometries, for example.

The Japanese semiconductor manufacturers are equally unaligned in their opinions of the major obstacles in the development of VLSI devices. NEC and Mitsubishi are in agreement that chip circuit design is paramount, with the problems of testing running a close second; Toshiba however, ranks testing as the number-one problem and says that the impact on the market—what the VLSI designs will be used for—is nearly as much of a puzzle. Hitachi fears the impact on the market most, and puts chip design as the next most serious problem.

Such mixed reports point up the realization that although Japan's five major chip (and computer) manufacturers and the Electrotechnical Laboratory of the Ministry of International Trade and Industry are sharing the Cooperative Laboratory, group developments are far less expedient—and burn research and development funds far less efficiently—than heated competition between manufacturers. That's why many U. S. manufacturers are not overly dismayed by the program.

Still, the Japanese report loud cries from among certain industrial segments in the U. S. that claim Japan is rocking the boat by competing unfairly in U. S. markets. So they've arranged a mission to the States this month to resolve misunderstandings. Its goals are to establish that the Japanese will do their best to abide by the rules of free trade, that the Japanese semiconductor industry has lagged so far behind that there is no way in the foreseeable future that it will overtake that of the U. S., and that the Japanese will make available to the rest of the world all patents developed under the VLSI program.

SAMPLE AVAILABILITY OF JAPANESE DYNAMIC RANDOM-ACCESS MEMORIES



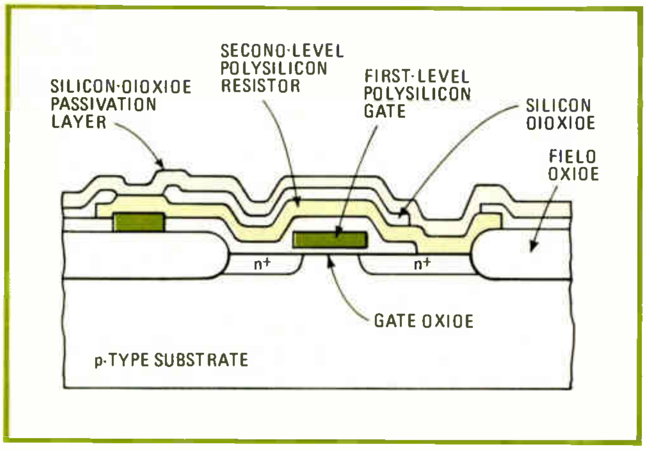
SOURCE *ELECTRONICS*

JAPANESE MANUFACTURERS' PROCESSING GOALS

Parameter	Process	Manufacturer	Year		
			1979	1980	1983
Design rules (μm)	D-MOS	Mitsubishi	2.5	2	1.25
		Toshiba	4	3	2
		NEC	3	2	1.5
		Hitachi	3	2.5	1.5
	C-MOS	Toshiba	4	3	2
		NEC	3	2	1.5
		Hitachi	3	2.5	1.5
	I^2L	Toshiba	4	3	2
		Hitachi	5	3	2
Gate delay (ns)	D-MOS	Mitsubishi	1.5	1	0.5
		Toshiba	1.4	0.7	0.5
		NEC	1.5	1	0.6
		Hitachi	1	1	0.4
	C-MOS	Toshiba	8	6	4
		NEC	1.0	0.7	0.5
		Hitachi	2	2	0.8
	I^2L	Toshiba	2	2	2
		Hitachi	5	2	0.8
Power-delay product (pJ)	D-MOS	Mitsubishi	2 – 4	1 – 2	0.5 – 0.25
		Toshiba	–	–	–
		NEC	0.1	0.07	0.05
		Hitachi	1	1	0.3
	C-MOS	Toshiba	–	–	–
		NEC	0.02	0.01	0.007
		Hitachi	0.1	0.1	0.03
	I^2L	Toshiba	0.1	0.06	0.04 – 0.01
		Hitachi	1	0.3	0.06
Density (devices/ mm^2)	D-MOS	Mitsubishi	1,200	1,500	2,500
		Toshiba	200	300	450
		NEC	3,000	4,500	8,000
		Hitachi	3,000	6,000	12,000
	C-MOS	Toshiba	160	240	350
		NEC	2,500	4,000	7,000
		Hitachi	2,000	4,000	8,000
	I^2L	Toshiba	–	–	–
		Hitachi	200	300	550

NEC = Nippon Electric Corp.

SOURCE *ELECTRONICS*



7. Rough terrain. One effect of higher packing density of devices is an increasingly vertical structure. This Matsushita 16-K static-memory cell puts load resistors on top of transistors. Hilly structures demand greater depth of field from lithography equipment than ever.

allowing fully automatic, unattended operation for the first time.

Diffraction effects, which hinder the use of visible or even deep-UV light, are not a problem when X-ray radiation, which has wavelengths on the order of 0.001 μm or less, is used. So X-ray lithography is being investigated by nearly all the semiconductor manufacturers, who fear that electron-beam exposure systems are still far off on the horizon because of limited throughput and extremely high initial cost.

The X-ray systems work much like those that use visible light: a flood of radiation exposes an entire wafer through a mask. As such, the process has a throughput potential equal to that of present optical exposure systems. But photoresist sensitivity has been a problem with X-ray systems. Present resists are not sensitive enough to X rays, and more sensitive X-ray-type resists are still under development. So the X-ray sources being investigated by Rockwell, Fairchild, and others must be very high-powered. These use accelerating voltages of 20 kilovolts or more, making them impractical.

X rays are generated when high-energy electrons bombard a metal target, which then emits radiation of a characteristic wavelength. For very high-energy X rays, the target material must be plated onto the edge of a heavy metal disk that rotates at very high speeds—tens of thousands of revolutions per minute—to cool the target. Such a heavy rotating apparatus is not suitable for an exposure system that must be vibration-free for accurate alignment, and this has fueled the case against X rays as the lithography technique for VLSI. Indeed, several manufacturers think that electron-beam exposure systems will eliminate the need for X-ray systems altogether.

A place for X rays

But at Bell Laboratories in Murray Hill, N. J., Martin P. Lepselter, who directs the advanced LSI development laboratory, thinks that there is a place for X-ray lithography, "although it's being squeezed from both ends—by optical and electron-beam systems." Lepselter is confident because his group has developed photoresists so sensitive that low-energy X rays can be used, eliminating the need for a rotating target and its consequent vibration. "We have done a lot of work on the resist materials, and we're no longer worried about them," he says. "Right now the masks are our worst problem."

Masks for X-ray lithography differ greatly from those used for optical systems. First, they must be extremely thin, so that the radiation passes effortlessly through them. Second, rather than blocking the radiation, the "opaque" areas use an absorber, usually gold, to prevent X rays from exposing the resist beneath. Such thin-membrane masks are difficult to make and may suffer distortion and breakage.

Bell's developmental X-ray exposure system, shown in Fig. 8, uses a palladium target material that emits X rays with wavelengths of about 4 Å which is resonant with the chlorine in the resist. It can produce 0.5 μm lines easily, and has generated the nearly perfect 1-μm lines shown in Fig. 9. What's more, it can be built small enough to fit on a desktop, according to Lepselter, and "may eventually be suitable for retrofitting to existing optical exposure systems."

Registration before resolution

Simply solving the X-ray resolution problem should be fine for making million-bit bubble memories, which require only a single mask. So it's a good bet that X-ray exposure systems will be used first for such devices. But many other semiconductor devices require multiple exposures, and it is the alignment or registration of masks for each process step that becomes the limiting factor in reducing geometries. It is for that reason that step-and-repeat optical exposure systems are gaining ground, and the technique may eventually be employed for X rays as well.

The step-and-repeat technique exposes an individual die or group of dies through a reticle that is several times larger than actual size. After an area is exposed, the stage holding the wafer is moved incrementally through the rows and columns of dies until the entire wafer is exposed. The advantage is a potentially better yield than full-wafer exposure system because of improved registration. The first step-and-repeat equipment from GCA Corp., Bedford, Mass., began delivery in June, and U. S. manufacturers have only begun their evaluation. Moore says it is still too early to tell how far steppers can take Intel, and Zilog's Faggin concurs: "We're very interested in step-and-repeat, but it may take a little time before we know whether it can do the job for us." He anticipates that the technique could be a stepping stone to electron-beam or X-ray lithography, "since it aims to achieve 2-μm geometries in a production environment."

A GCA model 4800 step-and-repeat exposure system is currently undergoing characterization at Hewlett-Packard Co.'s laboratories in Palo Alto, Calif. It has automatic focusing, but still requires manual alignment. Mostek Corp., however, has been using step-and-repeat lithography on its densest parts for some time. Its scaled Poly 5 process, which aims at 2½-μm channels, will use steppers to build the MK4801, an 8,192-bit static random-access memory that at 14,000 mil^2 will be half the size of current 4,096-bit RAMs.

Next-generation step-and-repeat machines will undoubtedly be equipped with automatic laser-aligned stages, like those employed in current electron-beam exposure systems, which align dies typically to within 0.03 μm. For 1-μm design rules on a 5-inch (125-mm) wafer, every die will have to be individually aligned, because of cumulative tolerances. The expansion of silicon with temperature is about 2 parts per million per °C, for example, and mask expansion can be as much as 10 times that figure, according to Bell's Lepselter.

Electron-beam systems: when and how?

Ultimately, direct electron-beam exposure of wafers will make its way into production because no other process can match its combination of resolution and automatic alignment. It has laid down lines as fine as 0.25 μm with no great difficulty, and it no longer suffers as badly as in the past from backscattering problems, in which electrons bounce off the resist material and expose nearby areas they should not. For the immediate future, though, few U. S. semiconductor manufacturers give credence to the necessity of electron-beam programs because of the equipment's extremely high initial cost and severely limited throughput. As Andrew G. Varadi, group director for memory components at National Semiconductor Corp., Santa Clara, Calif., puts it, "Electron-beam exposure systems have been coming in 3 years for the last 12 years."

The Japanese are picking up on the approach — maybe faster. Warns IBM's Reisman: "They have the upper hand already, since they started up only recently and are using the latest electron-beam equipment — U. S. semiconductor manufacturers are just clinging to antiquated processing equipment to save money." But both Faggin and Moore maintain that the Japanese at present have no edge whatever. "After all," Zilog's Faggin points out, "they bought their machines from the U. S." Still, he feels the threat and concedes, "There's no question that we'll have to watch their progress very closely."

It is likely that no U. S. semiconductor manufacturer is pouring more money into electron-beam research than Texas Instruments Inc. In its facility in Lubbock, Texas, TI has a special ultra-clean air track wafer-handling assembly line that has already built all-electron-beam parts, mainly as test vehicles for the new technology. Included are microwave transistors, 256-bit bipolar RAMS, computer-shrinks of TI's 4060 MOS RAMS, and undisclosed parts for the military.

According to Turner E. Hasty, director of the semiconductor research and engineering laboratories, TI's throughput goal — when electron beams will be used to build production parts — is six minutes for a 4-inch slice. "It's a problem of resist sensitivity," he says. "But the goal is not that far away." The main strength of the E-beam system, Hasty explains, is that in addition to being a slice writer, it is also a scanning electron microscope — so it can align itself. "Consequently, the real impact of the electron-beam system will be in large chips," he adds, "where the yield is more affected by alignment than defects."

At IBM, as part of its Micron-logic program, circuits have been fabricated with a totally automated electron-beam system that performs table stepping, registration to fiducial marks, and vector-scanned pattern generation. The minimum feature size is 1 μm. "It's true that there are problems with direct-write E beams as a production tool, but optical equipment is straining to get below 2 μm," Reisman notes. "It's nothing to do 1-μm lithography with electron beams."

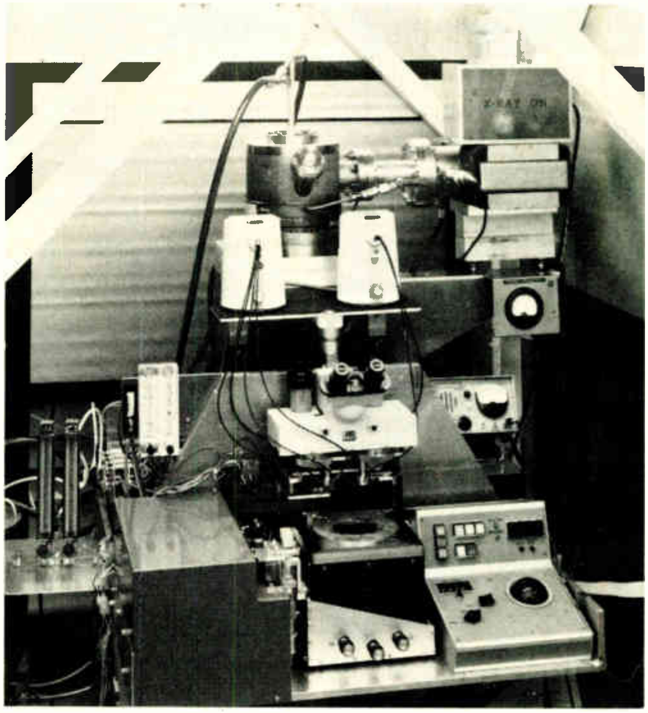
An important part of IBM's electron-beam work has been the development of new resists. A two-layer positive-resist structure makes for a good profile and helps curb backscattering effects. At IBM's Thomas J. Watson Research Center, there is confidence that the throughput problems of serially scanning individual dies will be solved through resist sensitivity improvements. The writing speed of the electron beam is nowhere near its limit and could easily be hiked well above the 20 megahertz now common. "A factor of five improvement in resist sensitivity would put electron-beam lithography right up there with optical exposure for throughput," says IBM's McGroddy, "and even that is not a very big improvement to expect."

Capital problems

The main drawback of electron-beam lithography has been the cost of equipment. No commercial systems yet exist, except for making masks (though, as IBM's Reisman notes, "10 years ago, there were no ion-implantation machines either"). And when such direct-write equipment becomes available, it is expected to cost no less than a cool $1 million.

"The semiconductor industry is becoming as capital-intense as the steel industry," comments Robert E.

8. Low-power X rays. Super-sensitive resist materials developed at Bell Laboratories have enabled it to develop low-power X-ray lithography. Unlike earlier, high-power X-ray systems, Bell's exposure system does not require a rotating target and is smaller.



Anslow, business director for LSI products at Rockwell's Microelectronic Devices division in Anaheim. Adds Pierre Lamond, vice president and technical director at National: "It's hard enough to get the investment capital just to stay involved, much less to start up. The industry will change considerably in the next few years, and there's one thing you can be sure of: there will be no start-ups in VLSI."

As shown in Fig. 6, the cost of key equipment capable of even finer pattern definition is skyrocketing. Beyond the million-dollar electron-beam apparatus that will be appearing in the early to mid 1980s, there will be far more exotic machines appearing in the late 1980s and costing 10 times as much. These will be synchrotrons—particle-accelerating systems using X rays or ion beams in a way that promises to eliminate several processing steps from VLSI fabrication.

At the Oak Ridge National Laboratories in Tennessee, for example, work is under way on a system in which a beam of ions, instead of electrons, develops and removes the resist simultaneously. (Normal processing requires that resist patterns, once exposed, be developed and then rinsed with a solvent that removes the unwanted resist.) Ion beams actually volatilize the unwanted resist material. X rays could be used in the same way.

Others, the Japanese in particular, are going one step further, working on what are called functional resists. Unlike the usual organic resist materials, such as KPR, which simply protect the silicon or metal beneath it from etchant, functional resists become part of the chip structure. Certain amorphous materials, such as titanium dioxide, will crystallize upon exposure; the uncrystallized TiO_2 can then be rinsed with a solvent.

Processing improvements needed

As for other fabrication developments, the completely dry process of plasma etching is vastly superior to wet-chemical processing but will eventually give way to faster, ion-milling techniques. In these the plasma itself is an active etch—chemically reacting with the material to be etched and at the same time physically blasting away particles. Etch speeds of about 1,000 angstroms per minute can thus be improved by a factor of four or five, according to Frank B. Micheletti, Rockwell's manager of physical sciences in the Electronics Research division in Anaheim. Micheletti adds that active etches are more selective—they tend to work on the right part of the wafer—but cooling off the wafers that get excessively hot during ion bombardment is still a problem.

As the preferred doping scheme, ion implantation is fast winning out—a trend that will continue in VLSI circuit fabrication. According to TI's Holton, the number of ion implants will swell from 7 to as high as 12 in the mid 1980s, with a variety of dopants being used. Separate machines might have to be devoted to each particular implant to gain efficiency; and while that poses no particular problem, it once again reflects the greater capital investment needed for VLSI.

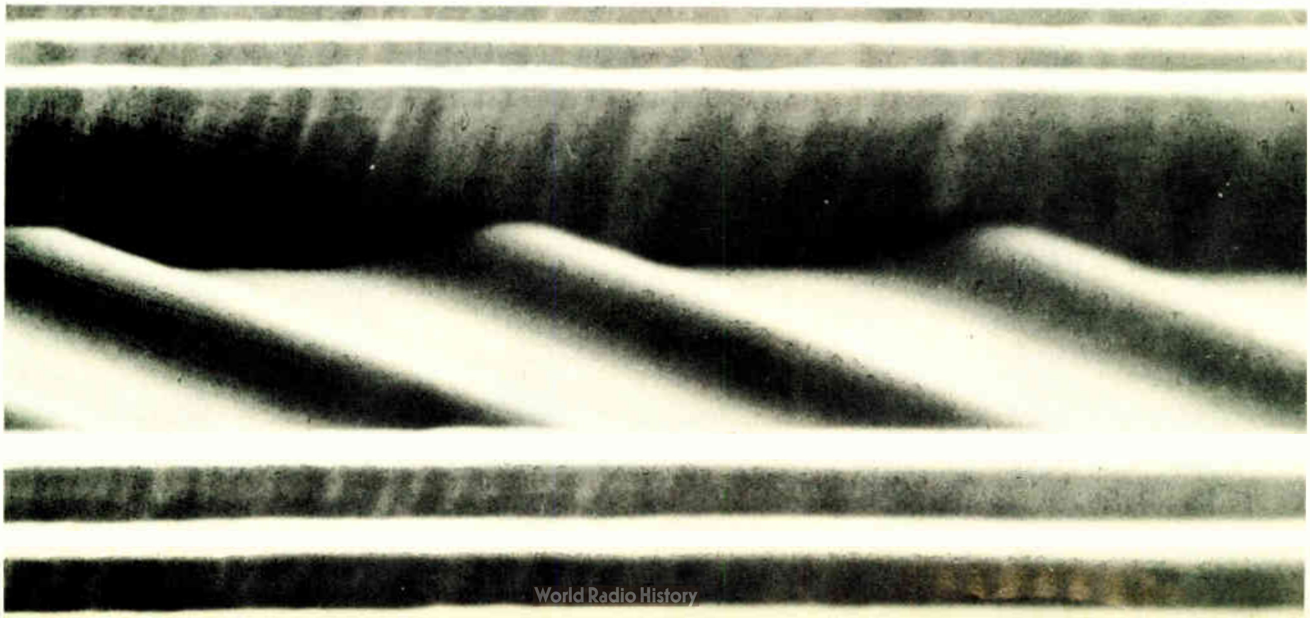
Device limitations

The size of the individual MOS transistor, fortunately, is not a theoretically limiting factor in the production of VLSI circuits—nor is there even a nearby limit to the reduction in geometries of bipolar devices. Both in principle can be made 10 or 20 times smaller, and both in theory have the same speed for a given active region size, since the switching speed of either is a measure of propagation time of carriers through the active region.

In practice, though, fabrication technology makes a difference. The critical dimension—the finest feature and speed-determining element—in a bipolar transistor is the base width, which is determined by a diffusion of impurities into the silicon. Diffusion laws are well understood and thus can be easily controlled and simulated. The critical dimension of a MOS field-effect transistor, however, is the gate width, which is determined by lithography. Lithographic tolerances will vary gate lengths among devices so much that, on a large chip, the 1-μm FET gate width can vary by as much as ± 0.5 μm.

Thus at present bipolars are faster because FET gate widths cannot be checked with a tight enough tolerance to make them as small as bipolar base widths. What's needed is a field-effect device whose gate width is inde-

9. Good coverage. Coupling new transfer techniques with its X-ray exposure system, Bell Labs has produced clean 1-μm lines. Note the excellent step coverage over the wavy polysilicon base, which can be seen between foreground and background lines.



VHSI—DOD's contribution to VLSI

What will be occupying the high-technology facilities of some of the major semiconductor companies for the next few months is a Department of Defense program for VHSI, or very high-speed integration [*Electronics*, Sept. 14, p. 81]. The Pentagon plans to spend $200 million over six fiscal years that began with October 1978 on meeting such silicon circuit goals as:

- The delivery of 1,000 2-megabit militarized random-access memories.
- The delivery of 1,000 military-specified bipolar or metal-oxide-semiconductor microprocessors capable of handling 1 million instructions or so a second.
- Establishing a minimum-feature size of 0.5 micrometer on devices as large as 400 mils on a side.
- The delivery of VHSI devices with stringent military specifications like failure rates of 0.1% or less per 1,000 hours at 125°C.

According to the VHSI managers, the first competitive awards will be announced around April of 1979. How many companies will be named is yet to be determined. Industry sources expect, however, that four or five will be chosen next spring for the first three-year phase but that only two will carry the ball through the entire program.

More big prime contractors, particularly those with an in-house semiconductor capability, are showing interest than smaller commercial semiconductor houses now operating with full order books. While military VHSI managers want to encourage interest from the big systems manufacturers like Texas Instruments, Motorola, IBM, Hughes, and Rockwell International, they are also troubled that some of the smaller semiconductor makers with the best design talent appear to be hanging back.

The VHSI program has established three committees that report to a fourth overview committee headed up by Larry W. Sumney, the VHSI project leader. Each of the three is chaired by a different branch of the armed services but includes members from all three branches:

- A fabrication committee chaired by the Army Electronics Command Center in Fort Monmouth, N. J., will deal directly with the delivery of the VHSI devices and will receive about half of the program's $200 million budget.
- A lithography committee headed up by the Naval Research Laboratories, San Diego, Calif., is to push submicrometer design rules on a quarter of the budget.
- A committee called DAST, for design architecture, software, and testing, is under the aegis of the Air Force and gets the other quarter of the six-year budget.

All three of the committees are currently listening to the views of qualified people in the industry in order to gain insight into where the technology now stands and what it will take to further the state of the art. On the basis of these and other recommendations from consultants, each will come up with requests for quotes from the likely bidders. All who wish to participate in the Government program will then have to submit a proposal.

Winning an award will give the successful company or companies an enviable shot in the arm, for they are likely to parlay the extra research and development funding into automated production techniques that could enable them to leapfrog industry competition in both technology and costs. Consequently, whether it is a reaction to Japan's cooperative program in VLSI or whether it is evidence of a more general Government concern that the U.S. retain its high-technology lead in very high-speed signal processing, the VHSI program is viewed as breeding healthy competition among the country's semiconductor manufacturers for the next several years. For the longer term, however, some fears are already being expressed by semiconductor analysts in both industry and Government. They want to know if VHSI's emphasis on automated production on a large scale will accelerate a semiconductor industry shakeout in which the big get bigger, with the ultimate tradeoff being the exchange of technological success for economic oligopoly.

pendent of variation in lithographic registration—but such a device has yet to be discovered.

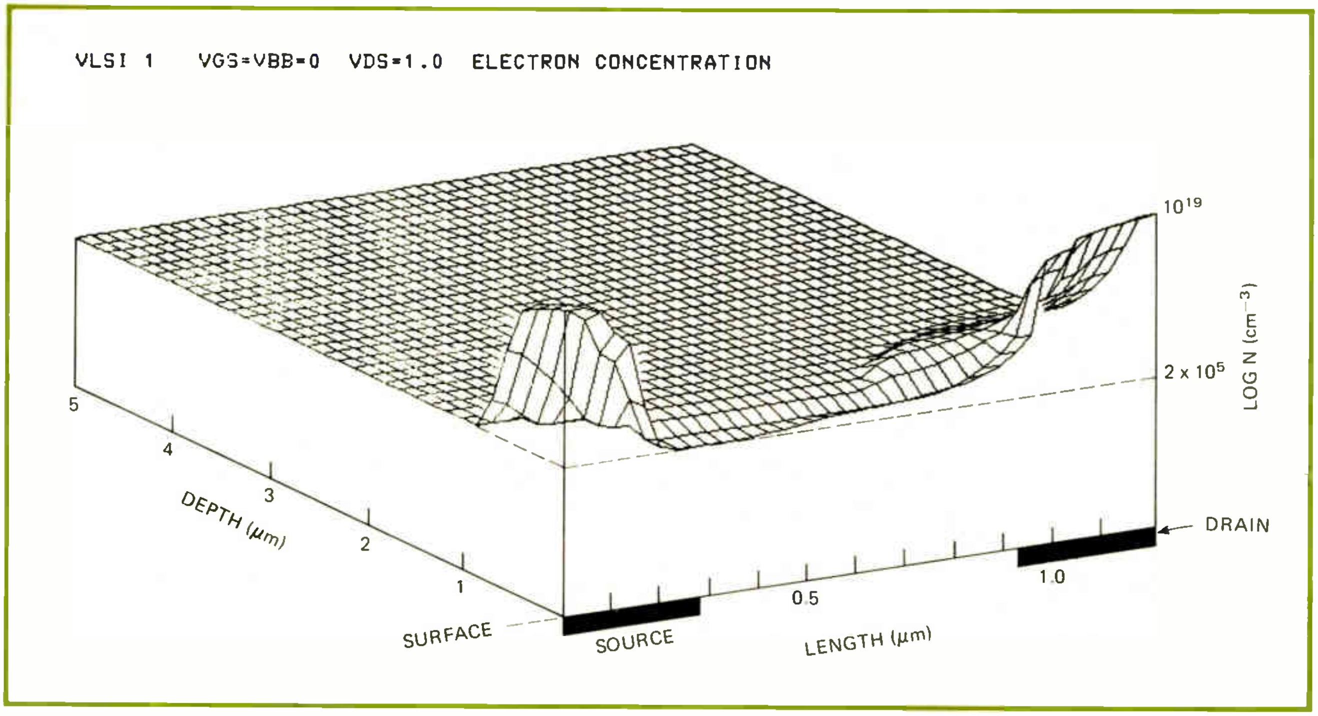
Meanwhile, not only have computer models predicted proper operation of an individual transistor with submicrometer channel lengths, but actual devices have been fabricated with direct-writing electron-beam systems that have 0.25-μm gates. Quarter-micrometer MOS transistors occupy a hundredth the area of current 2.5-μm devices; that means current die sizes could, in theory, contain well over 1 million transistors.

Modeling a must

The real difficulty with submicrometer FETs lies less in their fabrication than in their poorly understood behavior. Although work is advancing in computer modeling, only recently have two-dimensional models been employed that can accurately predict punch-through phenomena—the high-current breakdown condition that occurs when the depletion region around the drain of an FET extends to touch that of the source. Those models still use one-dimensional equations in the gate region, and the two-dimensional equations in the source-drain region are actually only one-dimensional and approximated for Y-direction dependency. Bipolar transistors with heavily doped base regions are even less understood.

As a result, device modeling will be an essential part of the CAD effort to usher in VLSI. Currently, most of the work being done is in the academic world, and it is already leading to a better understanding of the device mechanics. "For small- and medium-scale integration, it was enough to solve linear equations to give the threshold voltages, doping density, and other parameters," explains Moiz M. Beguwala, manager of IC device technology at Rockwell's advanced device technology laboratory. "But shrinking device sizes brings in second-order effects like short-channel and punch-through phenomena, requiring the solution of several simultaneous equations," which turns a simple problem into a horrendous one, he says.

Experimentation is difficult and requires comparison of the actual test results with computer predictions. "Right now it consists of controlling and tweaking the ion implant and watching the results," explains Robert W. Dutton, associate professor in Stanford University's electrical engineering department. Dutton believes that the Japanese have the edge in device modeling, evidenced by Hitachi Ltd.'s Caddet analysis program, which he feels is the best yet for two-dimensional device



10. Simulation. This equipotential-surface plot, made at Stanford University, shows punch-through in a 1-µm MOS transistor. Because of second-order effects that come into play at submicrometer geometries, computer modeling will be invaluable for VLSI.

modeling. The Caddet program was used in conjunction with Suprem, a program for simulating process modeling, to generate the electron-concentration plot for a 1-µm FET (Fig. 10). "Accurate two-dimensional models will be essential for VLSI," Dutton maintains.

Although there is currently some dispute in the industry, it is expected that supply voltages for VLSI circuits will eventually be reduced from the current 5 volts for transistor-transistor-logic compatibility to 2 or 3 V. "We will have at least one more generation of all-5-V parts because of the issue of compatibility," says National's Varadi, "although designers would like them to be lower right now." Varadi predicts that the 256-K random-access memory, a next-generation part, will still require 5 V. Daniel C. Hu, product line manager in National's Bipolar Memory division, thinks that voltages will come down, but that further on new interfacing schemes will be needed. "We'll have to convert the interface from voltage to current if we ever expect to get the speeds up," Hu says, "but MOS devices are voltage-controlled current sources, and referencing will be a problem in interfacing to current-controlled current sources."

Bell Labs' Lepselter, however, argues that even with 1-µm design rules MOS devices can be reliably operated with 5-V supplies "if they're doped right," since the avalanche breakdown of silicon is on the order of 10^5 V/centimeter. But others say that the point is moot, since a reduction in voltages would benefit speed and power consumption as well. Dynamic circuits are capacitive, and their power consumption varies as $\frac{1}{2}CV^2f$; reducing the voltage by half in such circuits, then, quarters power dissipation.

Because no limiting factors mark off any process, be it bipolar or MOS, from the others, all manufacturers will develop VLSI versions of their processes in the next decade. Likely to lead the way are n-channel MOS, complementary MOS on sapphire, and the bipolar injection logic processes.

Because n-channel MOS is the most familiar and already the densest process today, it will crowd more devices on a chip than any other process. Next year will see 16-bit microprocessors with more than 50,000 devices as design rules dwindle to 2.5 µm and below.

But hard on the heels of n-channel is integrated injection logic. At Fairchild, Thomas A. Longo, vice president and executive officer, pits his Isoplanar I^2L, or I^3L, against MOS in density: "We're now putting 3,000 gates on a 20,000-mil^2 chip with no effort at all." He adds that the speed-power product of the bipolar I^3L excels that of n-channel MOS and in fact he sees power dissipation as one of the chief obstacles to n-channel progress. "Even if you could dissipate 5 watts in a single package, a 100,000-device chip would have to have a per-gate dissipation of 0.05 milliwatt." Today's n-channel gates dissipate more than 10 times that much.

The producers of n-MOS in effect agree. At a recent conference, William Lattin, engineering manager of microcomputers at Intel's microcomputer components division in Aloha, Ore., said: "Most of our energy is devoted to keeping the power down in larger and larger devices." The problem is not in the scaled-down devices at the heart of a random-logic LSI circuit—the power dissipation in those scales proportionally with the square of the linear dimension and the power per unit area remains constant (Table 2)—it is in the output-drive transistors which cannot be scaled down.

It is on power dissipation that makers of complementary-MOS and C-MOS-on-sapphire devices are building a case for use of their technologies for VLSI. The low power dissipation of C-MOS is not questioned, but whether its

TABLE 1: VLSI CAPABILITY ANALYSIS

				Techniques							
				Etching		Lithography		Doping		Deposition	
Circuit requirement	Short-channel — MOS-device modeling	Computer-aided layout	Advanced circuit-design	Plasma	Ion milling	Optical	Direct-write electron-beam	Diffusion	Ion implantation	Open-tube deposition	Low-pressure deposition
CPU complexity	⧄	🟨	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜
CPU clock frequency	⬜	⧄	⬜	⧄	⧄	⧄	⧄	⧄	⧄	⧄	⧄
ROM capacity	⧄	🟨	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜
Static RAM capacity	⧄	🟨	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜
Relative density	⧄	🟨	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜
Power supply	⬜	⧄	⬜	⧄	⧄	⧄	⧄	⧄	⧄	⧄	⧄
Minimizing line width	⧄	⧄	⧄	⬜	⬜	⬜	⬜	⧄	⧄	⬜	⬜
Minimizing channel length	⬜	⧄	⧄	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜
Minimizing dielectric thickness	⬜	⧄	⧄	⧄	⧄	⧄	⧄	⧄	⧄	⬜	⬜
Self-aligned contacts	⧄	🟨	⧄	⧄	⧄	⧄	⧄	⧄	⧄	⧄	⧄

Knowledge required

- ⧄ Little
- 🟨 Moderate
- ⬜ Substantial

SOURCE: ROCKWELL INTERNATIONAL CORP.

TABLE 2: HOW IC PARAMETERS VARY AS LINEAR DIMENSIONS SHRINK (n = SHRINKAGE FACTOR)

Linear device dimension	$1/n$
Supply and logic voltage	$1/n$
Current	$1/n$
Parasitic capacitance	$1/n$
Gate delay	$1/n$
Power dissipation	$1/n^2$
Device density	n^2
Power-delay product	$1/n^2$

SOURCE: *ELECTRONICS*

TABLE 3: C-MOS-ON-SAPPHIRE PRODUCT GOALS

Parameters	1980	1982
Process innovations	buried contact double polysilicon	electron-beam photolithography
Design rules	3½ μm	2 μm
Die sizes (typical)	5 mm^2	6 mm^2
Wafer sizes	4-in. square	5-in. square
Defect density (per level)	1/cm^2	½/cm^2
Die complexity (typical)	80,000 transistors	150,000 transistors
Potential products	16-K RAM 8-K EE PROM 64-K ROM 16-bit micro-processor	64-K RAM 32-K EE-PROM 128-K ROM 32-bit micro-processor

SOURCE: RCA CORP.

densities can ever approach that of n-channel MOS is widely doubted. Still, Carl R. Turner, vice president of RCA Corp.'s Solid State division in Somerville N. J., claims: "We can make, for the same geometries, a device the same size as one of n-MOS." (Because RCA's C-MOS is built on sapphire substrates, resulting densities are better than on bulk silicon, which requires diffusion wells to isolate transistors.)

Turner admits that they have not done it yet. But the use of the buried-contact silicon-on-sapphire technology and other process innovations (see Table 3) will, according to RCA, enable it to build a 32-bit microprocessor with over a quarter-million transistors using direct-write electron-beam lithography by the mid-1980s.

A technology not currently used in integrated circuits but which holds promise for the 1980s is the silicon MESFET, for metal semiconductor FET. Discrete MESFETS operating at microwave frequencies have been around for some time, but only recently have major semiconductor companies like IBM, TI, and Rockwell begun investigating their behavior in logic circuits. The excitement began when the discovery was made that the forward characteristic (or enhancement mode) of MESFETS is usable if the devices are made very small. That is why TI and others are pegging MESFETS as the VLSI technology of the 1980s—and predicting speed-power products as low as 10 femtojoules. ☐

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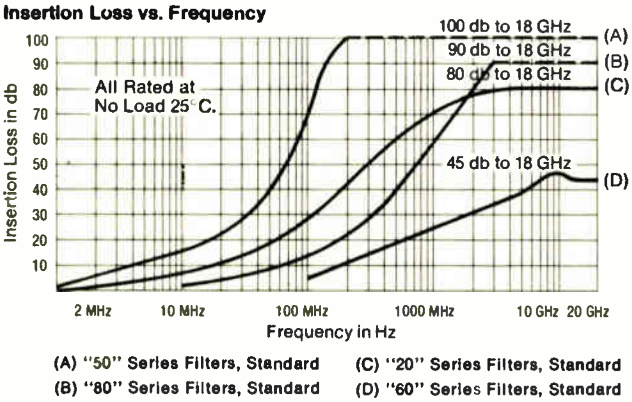

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Second-generation microcontrollers take on dedicated-function tasks

Two new series further reduce demands on microcomputer system's CPU, increasing system throughput and reliability while simplifying design

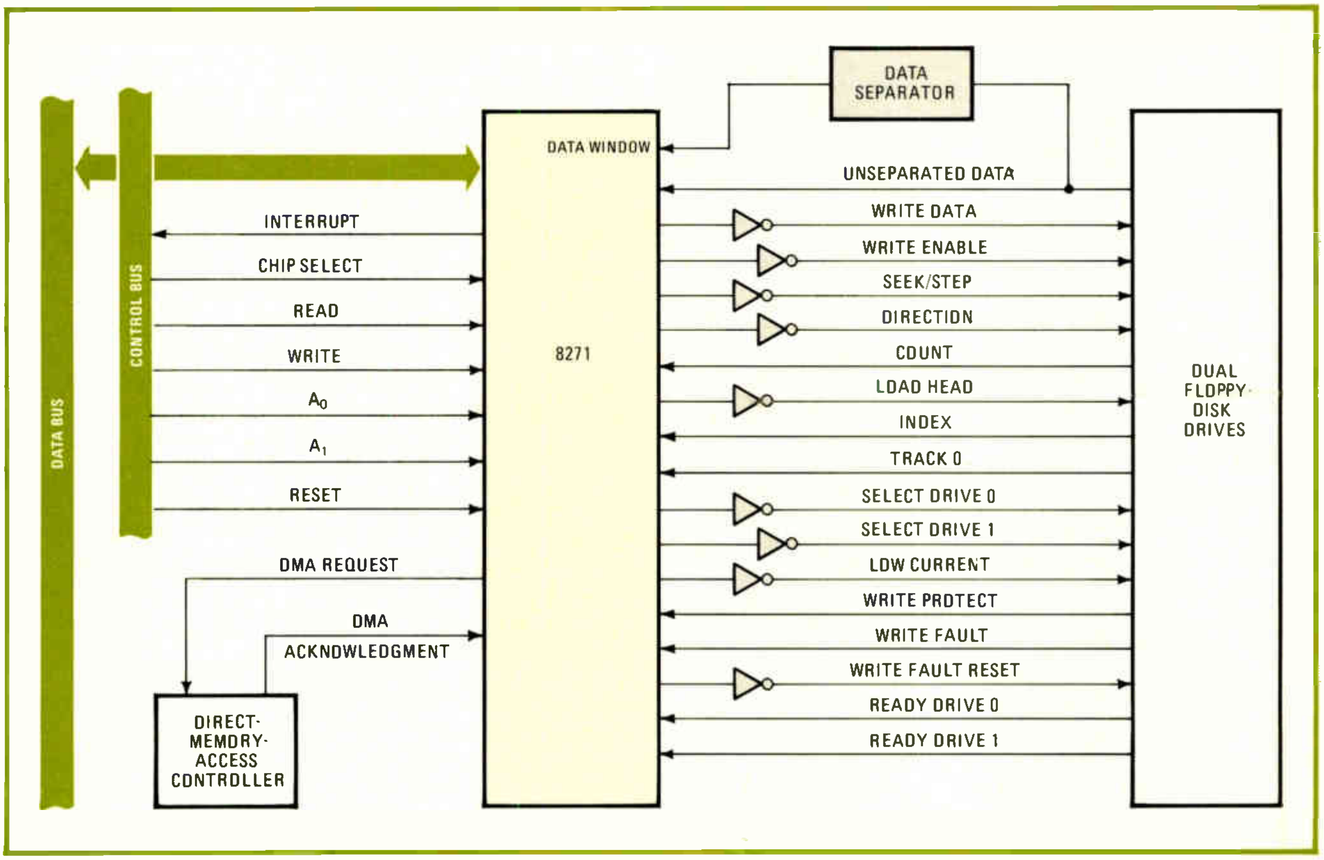
by John Beaston, *Intel Corp., Santa Clara, Calif.*

☐ The division of labor, characteristic of almost all forms of organization, is becoming basic to the development of the microprocessor as well. Some obviously have become the heart of the microcomputer. Others are being adapted to relieve their central-processing-unit cousins of the tedious task of controlling the various input and output devices that are part of a computer system. What's more, advances in the speed and density of large-scale integrated circuits have meant not only more powerful CPUs, but more powerful microcontrollers as well.

Among the most recent of the new generation of devices are six intelligent peripheral control chips from Intel: a floppy-disk controller, a controller for synchronous and high-level data-link protocols, two keyboard and display interfaces, a cathode-ray-tube controller, and a data-encryption unit. Combined with the company's 825X series of general-purpose programmable peripheral interface chips, the new 827X and 829X series of controllers provide powerful tools to reduce demands on the main processor, thereby improving system efficiency and easing the designer's task.

Dual processors

The 8271 floppy-disk controller and the 8273 unit for synchronous and high-level data-link control protocols share a common architecture. Both devices are called upon to handle high-speed serial data while also



1. Diskette driver. Drivers and a data separator are the only external circuits needed for connecting the Intel 8271 floppy-disk controller to dual-diskette drives. A phase-locked loop or a simple one-shot multivibrator can be used for the separator to provide the data window.

Peripheral controllers evolve

A new generation of peripheral control and interface chips is emerging. Essentially microprogrammed processors dedicated to performing a particular input or output function, the new parts reduce system hardware and software requirements. And because they remove from the main processor the responsibility for controlling the peripheral devices, they increase both the system's efficiency and its reliability.

In general, the new peripheral controllers operate as slaves to the main, or master, processor. They maintain this relationship despite the fact that some of them contain more logic than the microprocessor that functions as the host central processing unit.

The main processor communicates with the slave through registers that are physically located on the peripheral control chip. Although there may be numerous registers in any particular peripheral controller, they are usually of four types: command, status, data in, and data out.

The main processor issues commands for the peripheral controller through the command register. When the peripheral task is completed, the main processor is notified via the status register. Any data transfers required by the command are supplied by the data-in and data-out registers. Many of the controllers have a direct-memory-access interface for this purpose, to help further reduce main-processing overhead.

The first peripheral control circuits for microprocessors were oriented toward solving general application problems. The second generation solves dedicated-function problems. By placing the dedicated-function intelligence in the peripheral controllers themselves, the main processor is relieved of those functions and the system's efficiency is thereby increased.

Also, since the peripheral control microcode now exists in a pretested device, this software is no longer part of the main system software. That, of course, means less code to debug. It also means the remaining system software is easier to debug, since it deals with the peripheral controller on a higher level.

In addition to making the software designer's job easier, these new devices help the hardware designer as well. Obviously, because they replace a large amount of hardware, the design cycle is shortened and system reliability is increased.

performing byte-oriented operations such as character recognition. A dual-processor architecture was therefore developed consisting of a high-speed bit processor coupled with a character-oriented byte processor. Except for the microcode and some internal circuitry optimized for the particular application, the two parts are essentially the same.

The 8271 is a high-level device that handles many of the control tasks associated with a floppy-disk interface. For example, it can be programmed to initialize a soft-sectored diskette in the IBM 3470–compatible format. Many disk-drive specifications, like stepping rate, settling time, head-loading time, and head-unloading index counts, are also programmable, as are record lengths and data-transfer modes. Further, the cyclic redundancy code is generated and checked automatically. Thus the 8271 can be optimized for use with almost any floppy-disk drive available today. Moreover, it can maintain dual drives with minimal software overhead and can control up to four drives with the addition of some extra steering logic.

The 8271's commands are summarized in the table, along with those of the other five parts. As an example of how this controller operates, consider the read-data command. This command transfers data from a specified disk sector or group of sectors to memory. Once the main processor issues this command, the controller seeks and verifies the desired sector, loads the read/write head, and performs the data transfer. The command may specify that deleted data is either skipped or also transferred to memory. When the transfer is finished, the main processor is notified of the outcome by an interrupt or through the status register. Once the command is issued, there is no interaction with the main processor until the operation is complete.

Supplementing the standard read/write commands are two scan commands. These allow the user to specify a data pattern in memory and cause the controller to search the disk for that pattern.

Figure 1 shows the 8271 connected to a floppy-disk drive. Notice that the only external circuitry required are line drivers for the drive-control signals and a data separator to supply the window for decoding data. (The data separator is easily implemented with either a phase-locked loop or, for minimum cost, a simple one-shot multivibrator.)

The 8273 is a data-communications unit that implements both the synchronous and the high-level data-link control protocol. It operates in either half- or full-duplex mode at speeds up to 64 kilobits per second. It can also operate in an SDLC loop as the loop controller or as a secondary station. The zero-bit insertion required by these protocols and the generation and checking of the cyclic redundancy code are done automatically.

Programmable features include non-return-to-zero encoding and decoding, flag streaming, address and control field buffering, and the data-transfer mode. A digital phase-locked loop on chip facilitates clock recovery from the received data. In addition to the normal modem-control signals such as request to send, clear to send, and carrier detect, two user-definable control ports are available through seven extra input/output pins. Diagnostics in the form of both clock and data loop-back are also software-selectable to aid board and system checkout.

Like the 8271, the 8273 uses high-level commands to interact with the main processor. The case of the transmit-frame command demonstrates how the 8273 operates independently of the host CPU. The main processor issues the command, along with the length of the desired frame and the contents of the address and control fields. Once these parameters are supplied, the 8273 takes over control of the frame transmission. It activates a request-to-send signal, then waits for a clear-to-send signal

SUMMARY OF THE 827X's AND 829X's COMMANDS

- **8271 floppy-disk controller**
  - Scan data
  - Scan data and deleted data
  - Write data
  - Write deleted data
  - Read data
  - Read data and deleted data
  - Read sector identification
  - Verify data and deleted data
  - Format track
  - Seek
  - Read drive status
  - Specify
  - Reset

- **8279 keyboard and display controller**
  - Set keyboard and display mode
  - Load program clock
  - Read FIFO buffer or sensor RAM
  - Read display RAM
  - Write display RAM
  - Display inhibit or blanking
  - Clear
  - Set error mode

- **8278 keyboard and display controller**
  - Set keyboard and display mode
  - Read keyboard FIFO
  - Write display RAM
  - Read display RAM
  - Clear and blank

- **8273 data-link protocol controller**
  - Transmit frame
  - Loop transmit
  - General receive
  - Selective receive
  - Selective loop receive
  - Abort transmit
  - Abort loop transmit
  - Receive disable
  - Read input port
  - Write output port
  - Read output port
  - Set or reset data-transfer mode
  - Set or reset serial I/O mode
  - Set or reset 1-bit delay
  - Set or reset operating mode

- **8275 cathode-ray-tube controller**
  - Reset
  - Start display
  - Stop display
  - Read light pen
  - Load cursor
  - Enable or disable interrupt
  - Preset counters

- **8294 data-encryption unit**
  - Enter new key
  - Encode data
  - Decode data
  - Set mode
  - Write output port

before starting. When the latter is received, the 8273 transmits the opening flag, the address and control fields, and the information field of the specified length. (The data for the information field is retrieved from memory using either DMA or processor interrupts, depending on the data transfer mode selected during initialization.) After the information field, the 16-bit field check sequence and the closing flag are inserted automatically. The main processor is then notified of completion of the frame via a transmitter interrupt.

To recover clock information, a simple nonsynchronized clock at 32 times the desired baud rate is presented at the 32XCLK pin. The internal digital PLL uses this clock, along with the incoming data stream, to determine the center of the received bit cell and generates a pulse at the DPLL output pin. This signal is routed to the receiver clock input to allow the 8273 to decode the incoming data. The DPLL output may also be connected to the transmitter clock pin to provide timing for the transmitter data. Only a simple oscillator is required for complete data clock recovery and generation.

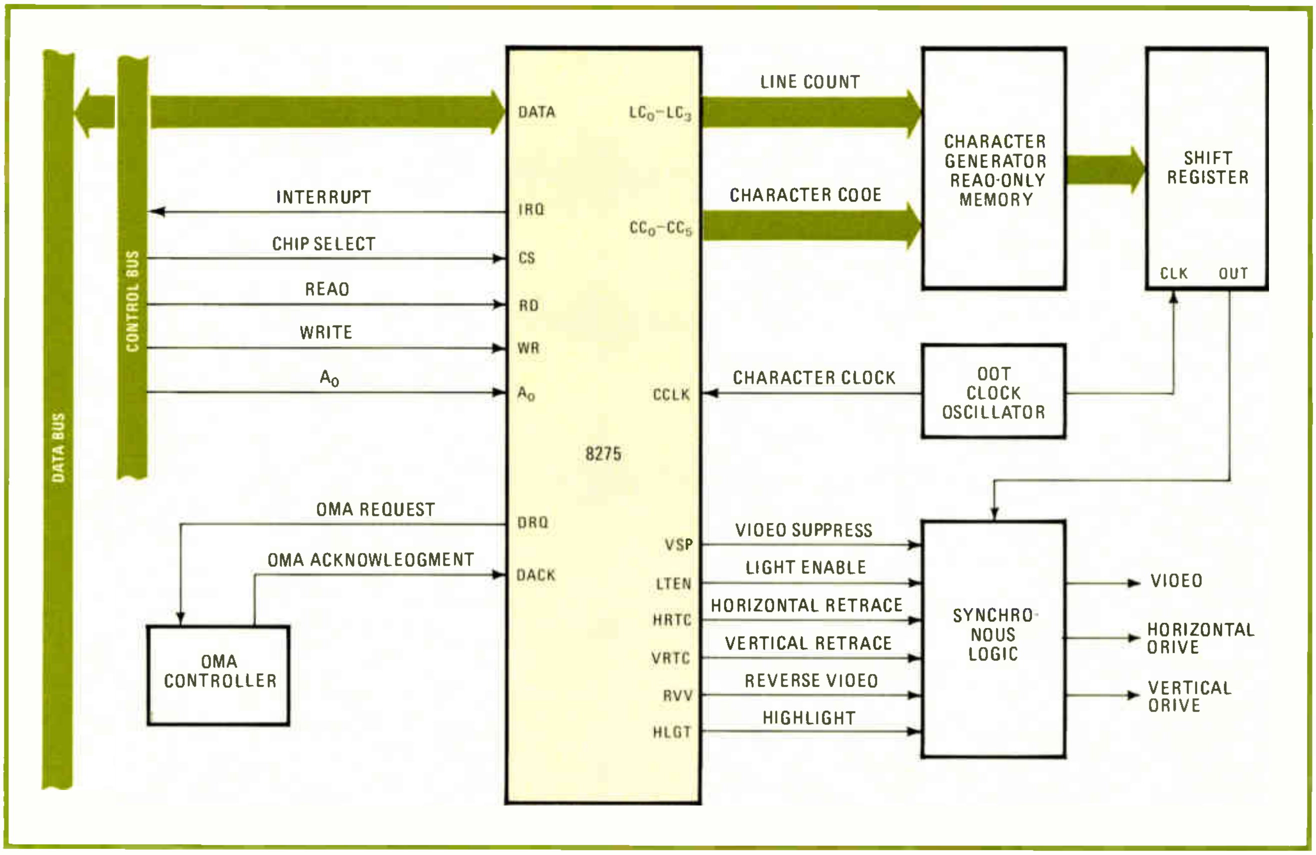
Dynamic displays

The 8275 cathode-ray-tube controller replaces conventional CRT display logic and memory subsystems. Because of the nature of CRT control, this chip does not need the dual-processor architecture of the 8271 and the 8273 devices.

The device provides display refreshing through DMA, tracks the display position, and offers a simple interface for almost any raster-scanning CRT display with minimal external hardware or software overhead. Screen and character formats are programmable, allowing up to 64 rows of 80 characters each and from 1 to 16 horizontal line sweeps per character row. A limited graphic capability is provided through 11 programmable visual character attributes; features such as underlining, blinking, reverse video, and highlighted video are accomplished using six independent visual field attributes. Four types of cursors can be selected.

The 8275 can also interface with a light pen consisting of a microswitch and a tiny light sensor. As the light pen is pressed against the CRT screen, the microswitch activates the sensor. When the raster sweep reaches the sensor, it triggers the light-pen output, which is connected to the 8275's LPEN input. When this input is activated, the row and character position coordinates are stored in a pair of dedicated light-pen registers, which may be read by the main processor on command.

The 8275 is normally used in conjunction with an 8257 DMA controller. The display memory is mapped into the main processor's random-access memory. To refresh the display, the 8275 contains internal dual-row buffers. One buffer holds the contents of the row currently being displayed. While that row is being refreshed, the 8275 is filling the second buffer, by means of DMA, with the contents of the next display row. This technique greatly reduces the number of DMA requests, since they are made only once per row. During the vertical retracing interval at the end of the display, the



2. Character synch. Data retrieved through direct memory access is converted by the 8275 CRT controller into the synchronization signals needed to drive a CRT display. A read-only memory acts as the character generator whose output is applied to a shift register.

controller issues an interrupt that allows the main processor to update the DMA controller if necessary.

Though the 8275 does not share the same internal architecture as the two previous devices, it also has high-level commands. Figure 2 shows a typical CRT system using the 8275 and the required external character generator (read-only memory). The inputs to this generator are the line-count and character-code outputs of the 8275. The CC inputs select the appropriate character, and the LC inputs determine which line of the character is selected. The selected character line is presented to a shift register, which is driven by an oscillator running at the desired dot frequency. The information coming from the shift register is then combined with the video-control signals supplied by the 8275 to form the actual video output. The video control signals determine the horizontal and vertical retracing intervals and any highlighting.

Keyboard, too

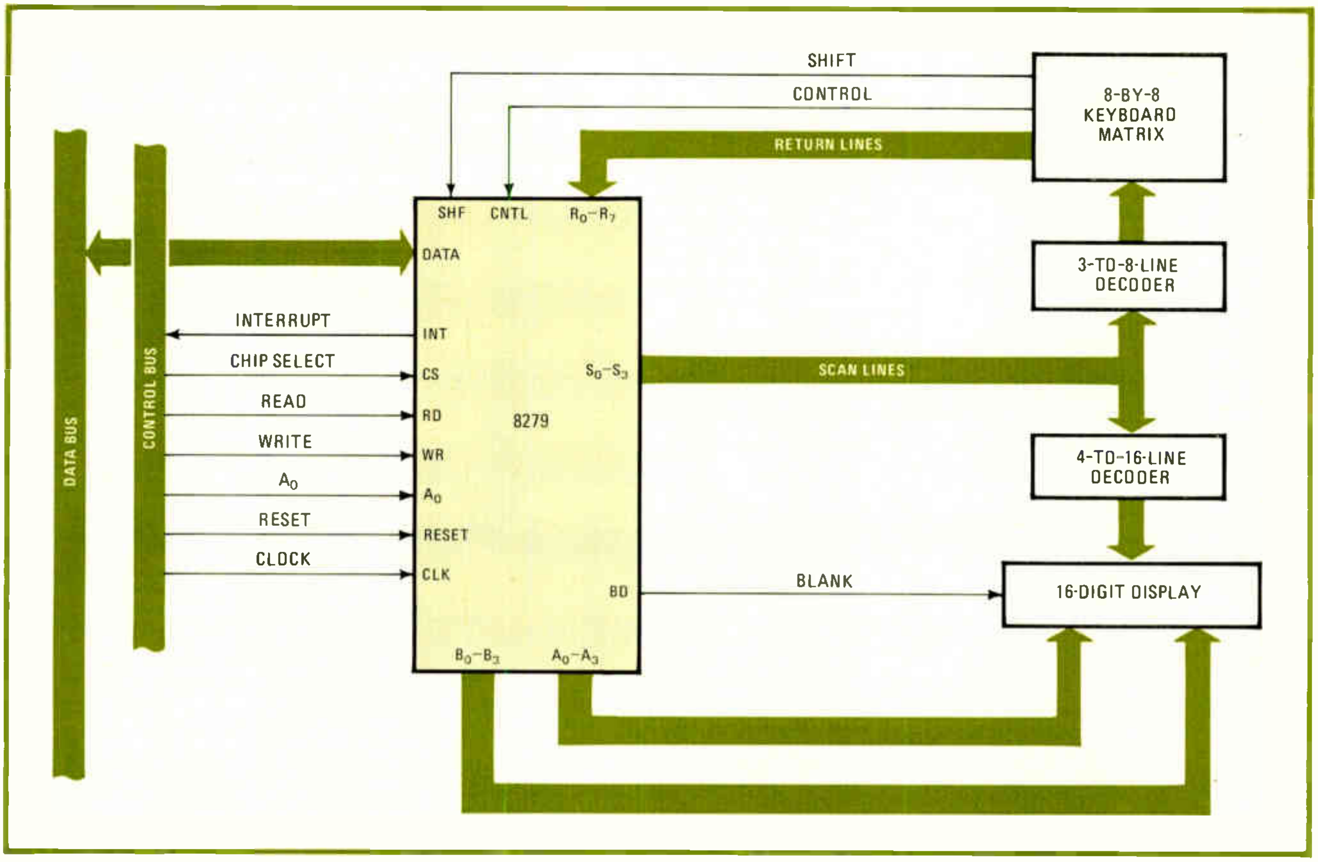
Controlling a keyboard or a light-emitting-diode display in a microprocessor system is usually rather mundane—the keyboard must be scanned periodically and the display updated with new display information while it is being multiplexed. Even though these tasks do not tax the capabilities of a central processing unit, they can be time-consuming, because each has to be repeated often enough to ensure a flicker-free display and to prevent missing a key depression.

Such tasks are perfect for a dedicated unit like the 8279 keyboard and display controller. This circuit provides the interface for keyboards with up to 64 keys and for seven-segment LED displays in either a dual 8-digit or single 16-digit format. The keyboard and display operations are performed simultaneously.

The 8279's circuit is basically divided between control of the keyboard and of the display. For the keyboard, it has three programmable modes: scanned keyboard entry, scanned sensor entry, and strobed input entry. Two-key lockout and N-key roll-over are available in the scanned-keyboard mode, with or without contact debouncing.

In either the scanned-keyboard or strobed-input modes, a new key closure sets a bit in the 8279's status register and supplies an interrupt output. The main processor can read the status register periodically to check for a new key closure or may be interrupted by the 8279's interrupt output when a closure occurs. To prevent the main processor from missing new information if it does not read the status register frequently enough or if its interrupt response time is slow, an eight-character first-in, first-out buffer is provided. This buffer allows the processor a large margin in actually servicing the keyboard.

The scanned-sensor mode is useful for controlling sensors that are often found in process control applications. In these applications, it is not just the contact closure that is important but also the contact release. The 8279 will scan up to 64 sensors—scanning time is programmable in all modes of operation—and notify the main processor with an interrupt when any sensor has



3. Scanning. The 8279 keyboard and display controller can handle up to 64 keys and a 16-digit light-emitting-diode display with either right-hand or left-hand entry. Metal-oxide-semiconductor drive-current levels and pin considerations make decoders necessary.

changed state since the last scan. The main processor may then read the internal sensor RAM of the 8279 to determine the location of the change.

On the display-control side of the 8279 is a 16-byte display RAM and its associated display address register. The RAM may be organized as 16 words by 8 bits for 16-digit displays or two units of 16 words by 4 bits for dual 8-digit displays.

The display address register is simply a pointer into the display RAM. To write a character for display, this register is loaded with the appropriate address, and the display data is supplied. The register need not be loaded every time, however, since it may be automatically incremented after each display is written. The display is programmable for either left-hand or right-hand entry, and the display address register takes the mode into account if incrementing is automatic.

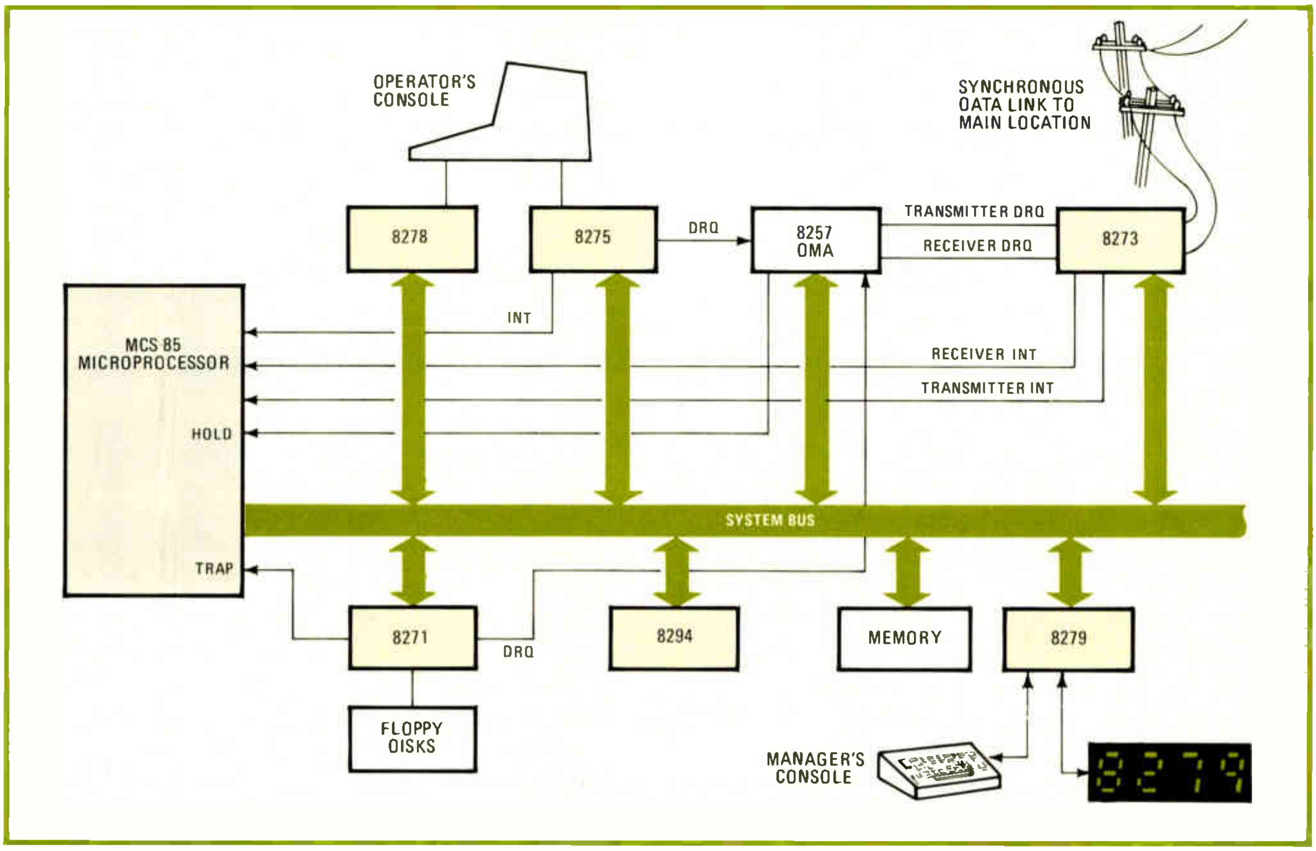
A block diagram of the 8279 controlling an 8-by-8 keyboard matrix and a 16-digit display is shown in Fig. 3. Because of the number of pins and the metal-oxide-semiconductor drive-currrent level, external decoders and display drivers are required.

Share and share alike

Like the 8271 and 8273, the last two peripheral-control chips also share a common architecture—both are derivatives of the universal peripheral interface 8041/8741 [*Electronics*, July 7, 1977, p. 109]. This device is a single-chip microcomputer containing an 8-bit CPU, 64 bytes of RAM, 1 kilobyte of ROM or erasable programmable ROM, an 8-bit timer-counter, and 18 I/O lines. A microprocessor bus interface is included to allow the UPI to act as a slave processor to the main CPU. Since the UPI is user-programmable, the designer may specify his own peripheral-control algorithm on the UPI chip itself, rather than on the main processor. This can greatly increase the overall efficiency of the system, because the UPI can handle the real-time interface while the main processor is performing other duties.

Conceptually, the 8278 is very similar to the 8279; however, it has been designed to interface with either capacitive-coupled or contact-type keyboards with up to 128 keys, instead of the 64 handled by the 8279. As with the 8279, an eight-character–keyboard FIFO buffers multiple keyboard entries, but the 8278 has an additional mode of operation that allows the keyboard entry to be selected on both key closure and key release. Also like the 8279, the 8278 can control LED displays of up to 16 digits with either left- or right-hand entry. Auto-incrementing of the display address is also provided. The 8278's commands are also very similiar to the commands of the 8279.

The last device illustrates the use of a preprogrammed UPI in a non-I/O application. The 8294 is designed to encrypt and decrypt 64-bit blocks of data using the algorithm specified by the Federal Information Processing Data Encryption Standard and has been certified by the National Bureau of Standards. It operates on 64-bit text words using a 56-bit user-specified key to produce 64-bit cipher words. The operation is reversible: if the



4. All together now. An intelligent terminal for bank tellers uses all the Intel peripheral controllers. They control a teller's keyboard and CRT terminal, a local floppy-disk unit, a smaller manager's console, and the necessary encryption and communications protocol.

cipher word is operated upon, the original text word is produced. The algorithm itself is permanently contained in the device, and the key may be changed at any time under software control. With a data-conversion rate of 80 bytes/second, the 8294 may be operated in either a DMA, an interrupt-driven, or a polled environment. In addition, it has a user-definable 7-bit output port.

Encrypting data

The 8294 is very simple to use. Just supply the 56-bit key and select either the encryption or the decryption mode. The 8294 then requests 64 bits of data to convert. These bits are supplied over the system data bus in response to a DMA request, an interrupt, or a status bit in the 8294's status register. Once the desired operation is complete, the processed data is returned via the system data bus and the next 64 bits are requested.

The advantage of the 8294 in systems that must implement the encryption standard is obvious: by off-loading the algorithm to the 8294, the main processor is freed of performing this time-consuming task. Also, as seen in the table, the 8294's commands are simple.

Putting it all together

To illustrate the use of all these new peripheral control circuits in an actual system, consider the design of an intelligent banking terminal. This is the type of terminal that could be found at the branch location of a large banking chain. The functions of the terminal include on-line entry of individual receipts with nonvolatile storage on floppy disk, CRT display, and high-speed data communications with the main banking processor, plus data encryption.

Figure 4 shows a block diagram of the terminal. The system consists of an 8085A main processor coupled with all the peripherals discussed. Besides showing the system structure, the block diagram illustrates a key point: the processor is not central to all of the control and decision-making functions, since many are actually performed by the interface devices. Instead, it assumes the role of a manager directing an intelligent staff: it issues instructions, but the I/O details are handled by the controllers themselves.

Because all data is of a financial nature, it must be encrypted. The branch manager enters a prearranged encryption key on his keyboard and display unit, which uses the 8279, at the beginning of the day. The tellers operate a larger keyboard and display console that uses the 8278 and 8275, entering each transaction on the 8278-controlled keyboard as it occurs. This information is processed by the 8085A, encrypted by the 8294, and transferred to the main location by the 8273 and an SDLC link. If a teller requests account data, it is retrieved at the main location and sent to the branch over the same serial data link. As each transaction is completed, the 8085A formats the information and the 8271 places it on a diskette. At the end of the day, the terminal transfers a summary of the day's receipts to the main location. Again, this data is encrypted and transmitted under control of the 8294 and the 8273. ☐

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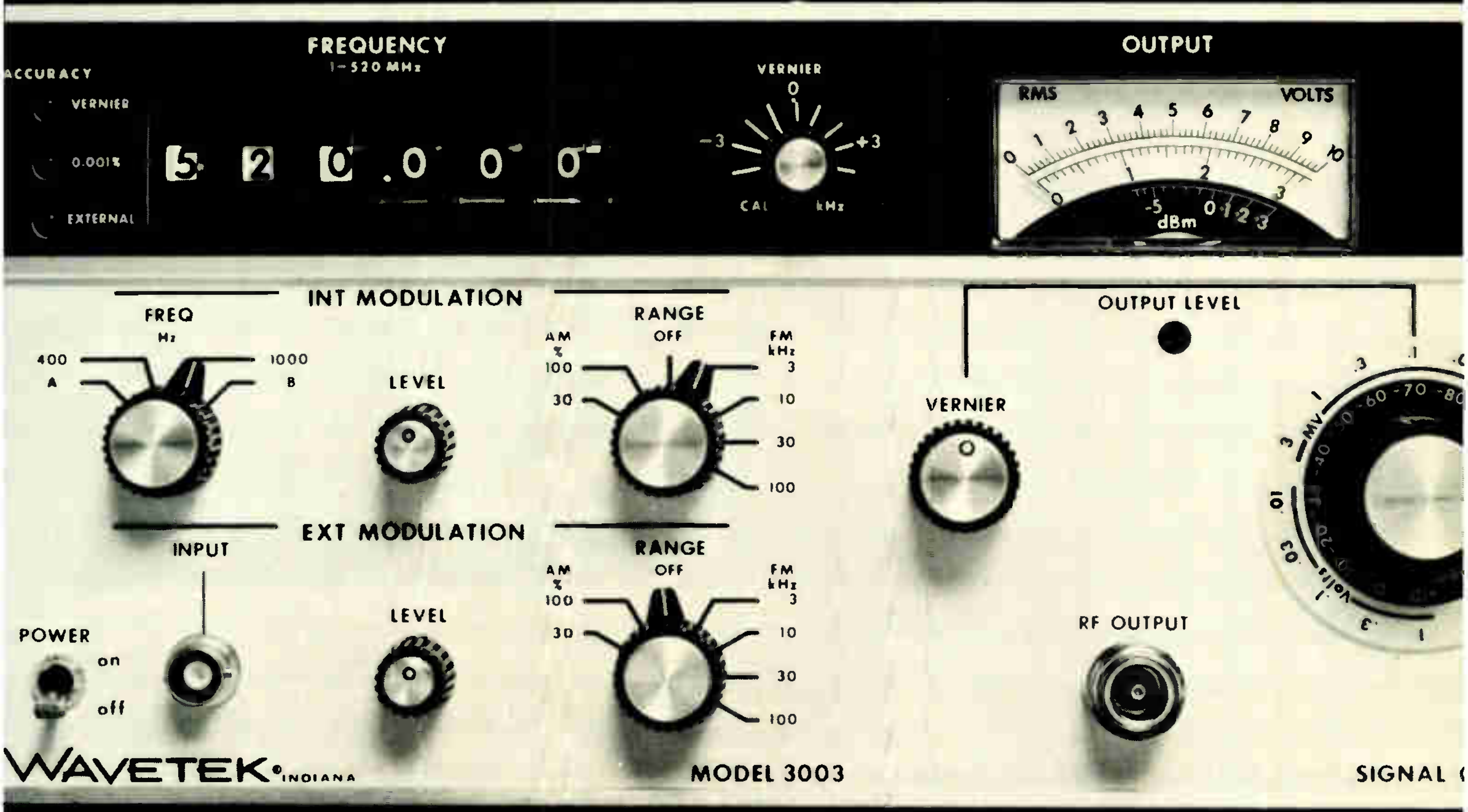

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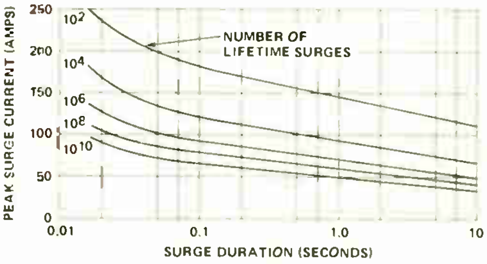

Figure 1. 25 Amp SSR Surge Life Under Various Current/Time Conditions.

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Charts simplify fiber-optic system design

Initial component selection can be done without in-depth knowledge, according to part 2 of this series on using fiber optics

by Albert Bender and Steven Storozum, *International Telephone and Telegraph Corp./Electro-Optical Products Division, Roanoke, Va.*

☐ When a designer takes the leap into fiber optics, what does he face? First, he must choose the fiber, light source, and detector most appropriate for his application. For a typical design, several different combinations of components and component quality can be selected from the rapidly growing array of devices and fibers. Ultimately, selection will require a detailed knowledge of available component performance, compatibility, and cost factors. But a system designer need not deal with all of this information to make a first-cut decision or when his goal is only to check whether or not fiber optics can fulfill a particular design.

The designer's job becomes much simpler once the key design equations are reduced to a set of easy-to-use charts. The charts presented here, which use readily available components as examples, will help the designer to determine the combination of component types that will best satisfy a system's requirements. At the same time, they allow him to specify standard system parameters, such as the most applicable, lowest-cost fiber, light source, and detector.

A typical fiber-optic system design requires the selection of an optical source (light-emitting diode or laser), the optical fiber bandwidth, the type of fiber (plastic-clad silica, step-index glass-on-glass, or graded-index glass-on-glass), the fiber attenuation, and the type of optical detector (avalanche or p-i-n photodiode). It is not difficult to take all of these factors into account using design charts, but there are some practical limitations. For example, various assumptions incorporated in the curves limit their application to first-order designs only. If a system designed using the curves only marginally meets initial design goals, selected components should be upgraded to provide a safety factor or, alternatively, a detailed system design should be completed using more sophisticated techniques.

Doing a design

The charts are based on a simple point-to-point link with two or three fiber connection points. Typically such a system can extend to 5 kilometers without repeaters. The items listed in the table and plotted on the design curves were chosen to represent the various types of components available, including both state-of-the-art and lower-performance, lower-cost, commercially available fibers and devices. Of course, the system designer can substitute any equivalent components for the ones listed in the table.

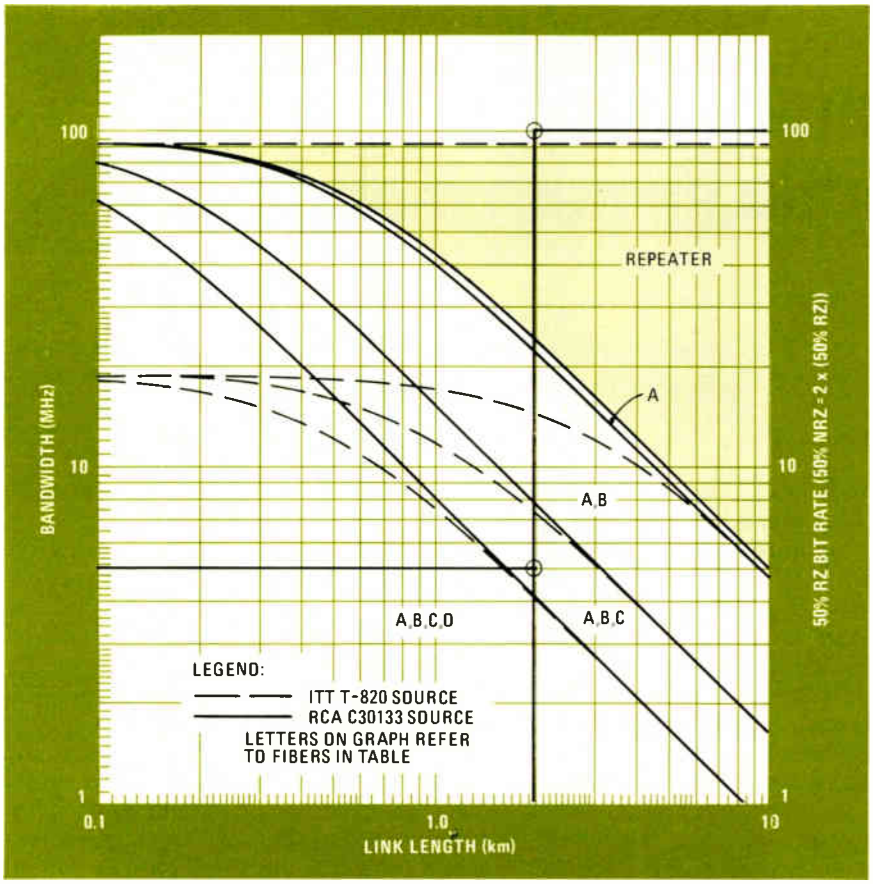
The first part of the design of either an analog or digital system is the tradeoff between type of source and type of fiber. This is based on system bandwidth constraints for the analog case (the left-hand Y axis of Figs. 1 and 2) and bit rate constraints (the right-hand Y axis) for the digital. The transmission line length (X axis), of course, is a variable in both calculations.

Figures 1 and 2 are divided into labeled regions by boundary curves. In each region the generic fiber types that can satisfy a combination of system bandwidth (ordinate) and link length (abscissa) for a premium source (solid lines) and for a standard source (dotted lines) are shown.

In the region labeled repeater, at least one repeater is needed. In the unshaded area at the top of Fig. 1, system requirements cannot be met with today's LEDs and therefore Fig. 2 should be used. It is clear, then, that preliminary tradeoffs can be made between light-source types

FIBER-OPTIC COMPONENTS USED IN FIGS. 1 TO 5

Components	Designations in Figs. 1 to 5	Type No.	Vendor
Light source			
LED		C30133 T-820	RCA ITT
laser		LCW-10 T-910	Laser Diode Laboratories ITT
Fiber			
1-GHz·km, graded-index	A		Corning Glass Works (Corning 1051 fiber attenuation assumed)
graded-index	B	T-200	ITT
step-index	C	T-100	ITT
plastic-clad silica	D	T-300	ITT
Detectors			
avalanche photodiode	APD	C30903E	RCA
p-i-n photodiode	p-i-n	5082-4220	Hewlett-Packard



1. Fiber selection. In designing a fiber-optic system, the first step is to select either an LED or laser source and an appropriate fiber for the required link length and bandwidth or data rate. The figure assumes the selection of an LED. Any combination of parameters whose coordinates fall in the shaded area calls for use of a repeater and should be avoided if possible. The unshaded area at top cannot be satisfied with an LED source.

and fiber types based on system bandwidth or bit rate.

It should be remembered that an LED is favored over the faster, higher-power laser when the application permits because of its longer lifetime, better linearity, and greater optical dynamic range. Moreover, a laser requires costly optical-feedback stabilization.

It is assumed in Figs. 1 and 2 that receiver bandwidth is twice the system bandwidth. Such a large bandwidth may not be universally called for, but it is convenient and errs on the conservative side for system design purposes.

More tradeoffs

Once the fiber/source alternatives based on system bandwidth constraints are known, tradeoffs between source output power, source-to-fiber coupling efficiency, and detector sensitivity may be determined for analog systems (Fig. 3) and digital systems (Fig. 4) based on end-to-end power margin constraints.

A p-i-n photodiode should be used for the detector wherever possible because it is generally less expensive than an avalanche photodiode (APD) and requires a lower operating voltage. Although it exhibits no gain, it also is not afflicted by avalanche noise problems.

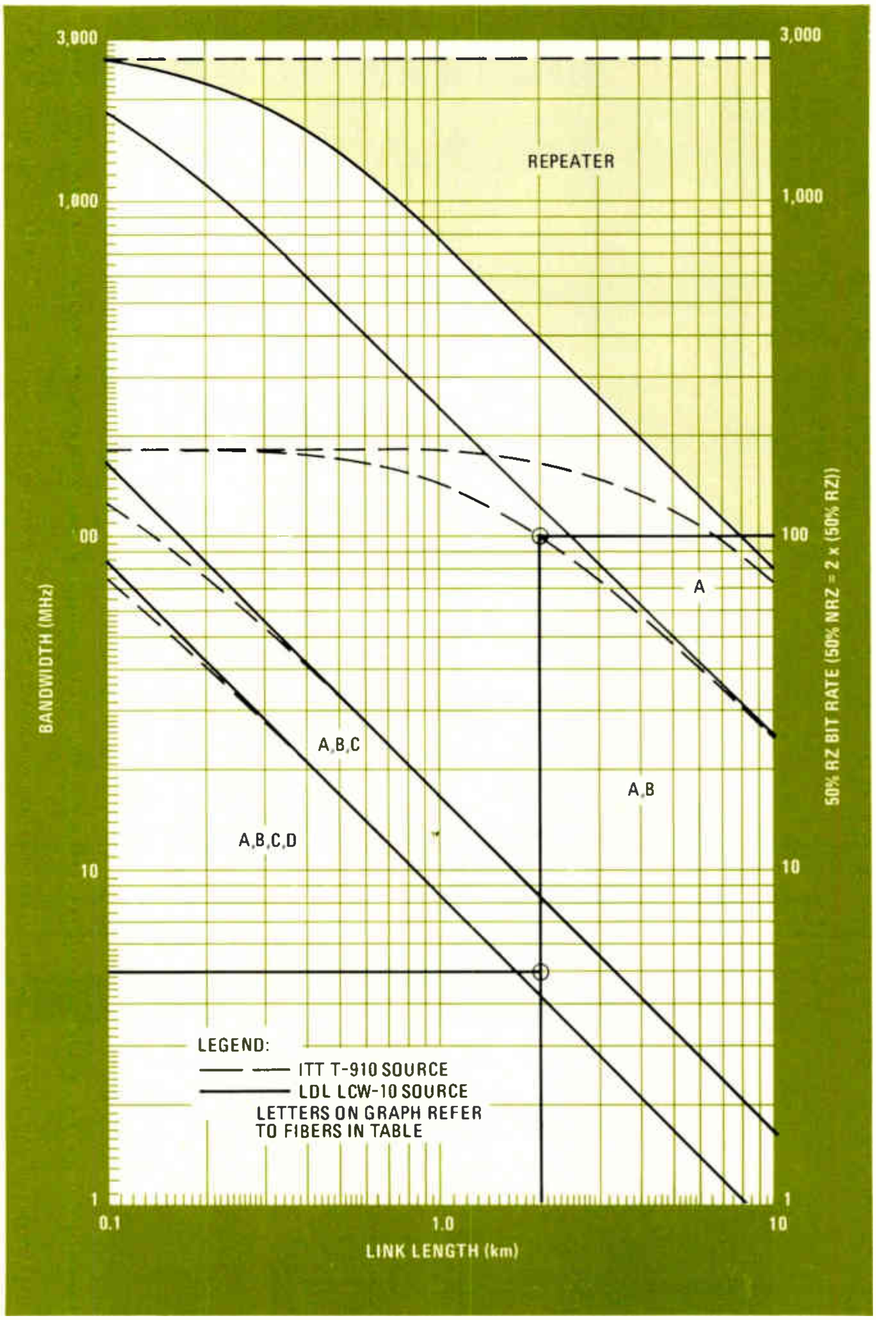
Total allowable system loss can also be determined directly from these curves as a function of source, fiber, and detector type; system bandwidth or bit rate; and system signal-to-noise ratio or bit error rate. The curves in the figures are based on assumptions of 3-decibel loss for connectors and splices (typical of two to three connectors), 5-dB loss for variations over time and temperature, 100% source modulation, and receiver bandwidth at twice the system bandwidth.

Figure 5 can be used to make quick preliminary tradeoffs between fiber type, line length, and allowed system power margin, and also to convert power margin to fiber attenuation per kilometer. The optimum optical fiber is then determined by extending a line from the required link length coordinate at left, through the appropriate allowable loss number, to intersect the fiber choice scale at right. All fibers listed above this intersection point will satisfy the system requirements; they are listed on the figure from the top down in order of decreasing cost.

Remember that the highest-loss fiber that meets system requirements (the one closest to the point of intersection) need not minimize the system cost. A premium fiber may relax source, detector, and electronics requirements, resulting in the least expensive combination of fiber, source, and detector. There is no way of choosing a fiber, source, and detector that optimizes the system cost under all conditions.

There are cost trends that can be discerned, however, and these have been incorporated into a form for system specification (Fig. 6a). This chart outlines all the system design steps and can be used to tabulate and trade off alternative system configurations. All allowable combinations of optical source, fiber type, detector type, and fiber attenuation can be accommodated. The optimum configuration based on cost is the combination of source and detector that yields the first realizable fiber grade, starting from the top of the chart.

One exception is that at present fiber cost dominates



2. Tradeoff. Where an LED cannot satisfy system requirements, it will be necessary to consider a laser source. This nomograph is used to select appropriate fibers for a premium- and a standard-grade laser. Again, the shaded portion at the top of the chart represents applications that require use of repeaters. Note that both this figure and Fig. 1 can be used for analog or digital designs.

total system cost for link lengths greater than 2 km. In such cases the system combination permitting the least expensive fiber should be chosen. For example, a more expensive avalanche photodetector should be preferred to the p-i-n for the 2-km case if a step-index fiber can be used instead of a graded-index fiber.

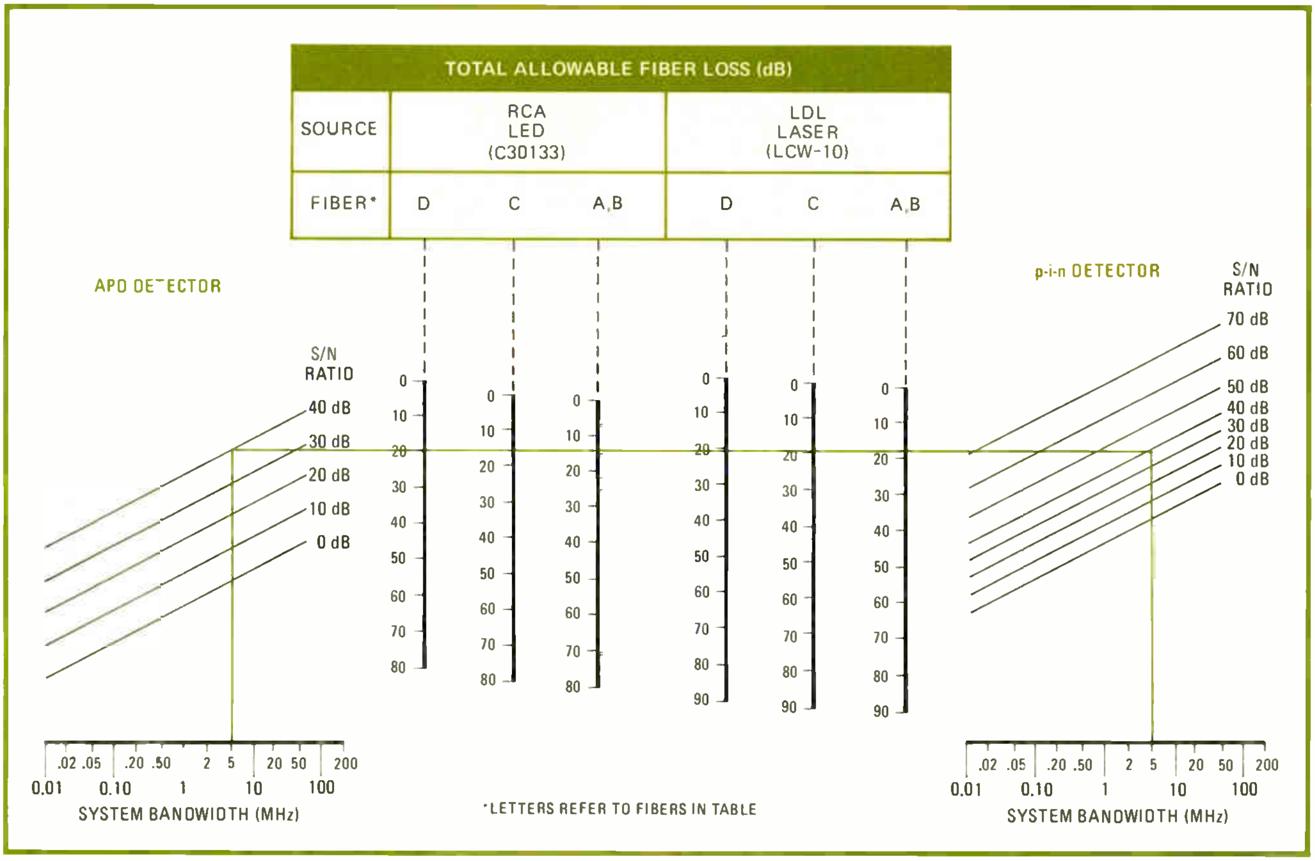
Design options

Although Fig. 6a represents a particular method of system design, Figs. 1, 2, 3, 4, and 5 can be entered from any point, working backward or forward to find, for example, the allowable line length, given a system bit rate and fiber type, or the allowable source and detector, given the system power margin and fiber type.

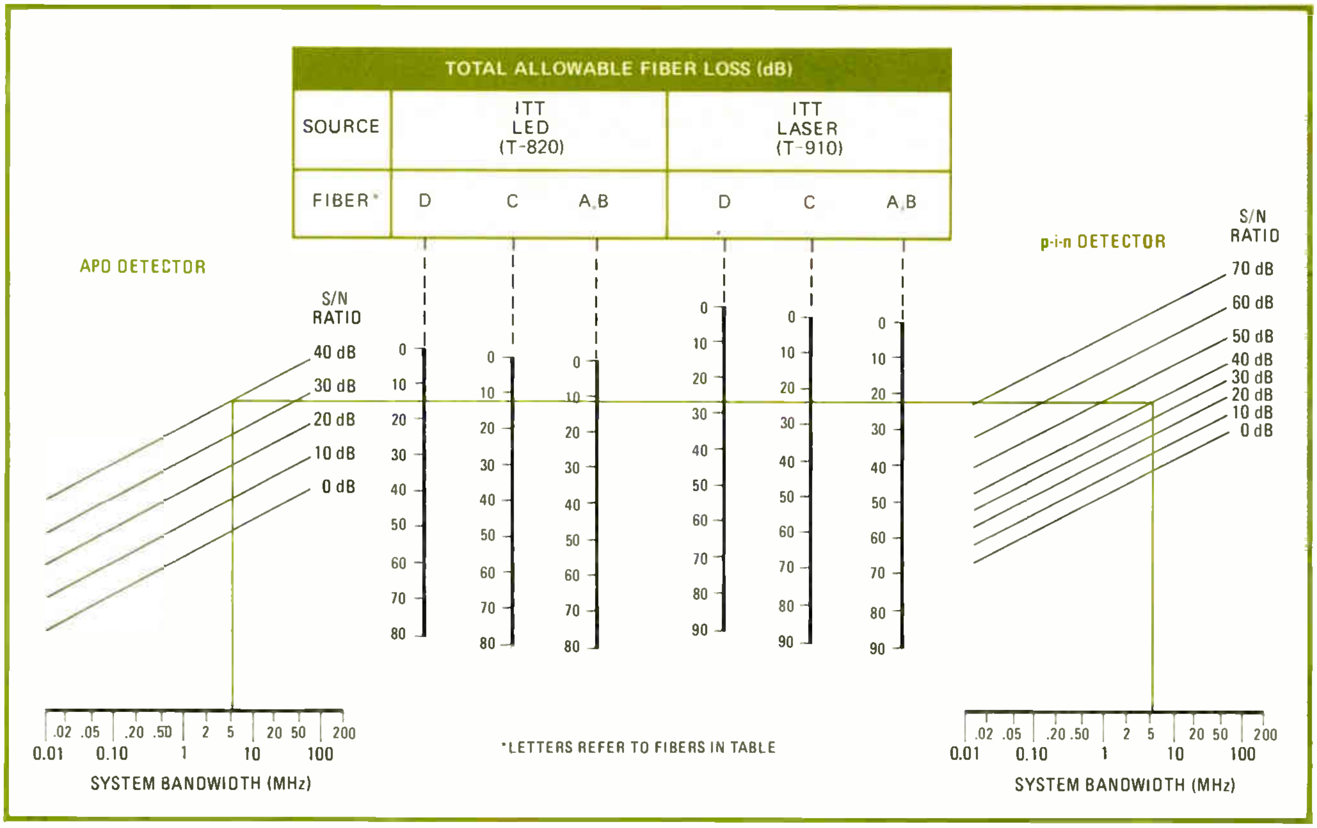
The charts are also useful in iterative system design. Different sets of system requirements and/or fiber-optic component specifications can be evaluated quickly and easily to arrive at an optimum fiber-optic system design.

To illustrate the overall use of the system design charts, consider a 2-km link configured with two 1-km fiber-optic cables (Fig. 8). This is a typical configuration for connecting satellite ground stations to support electronics. Other applications include telephone trunking, studio video transmission, computer interconnects, and remote sensing.

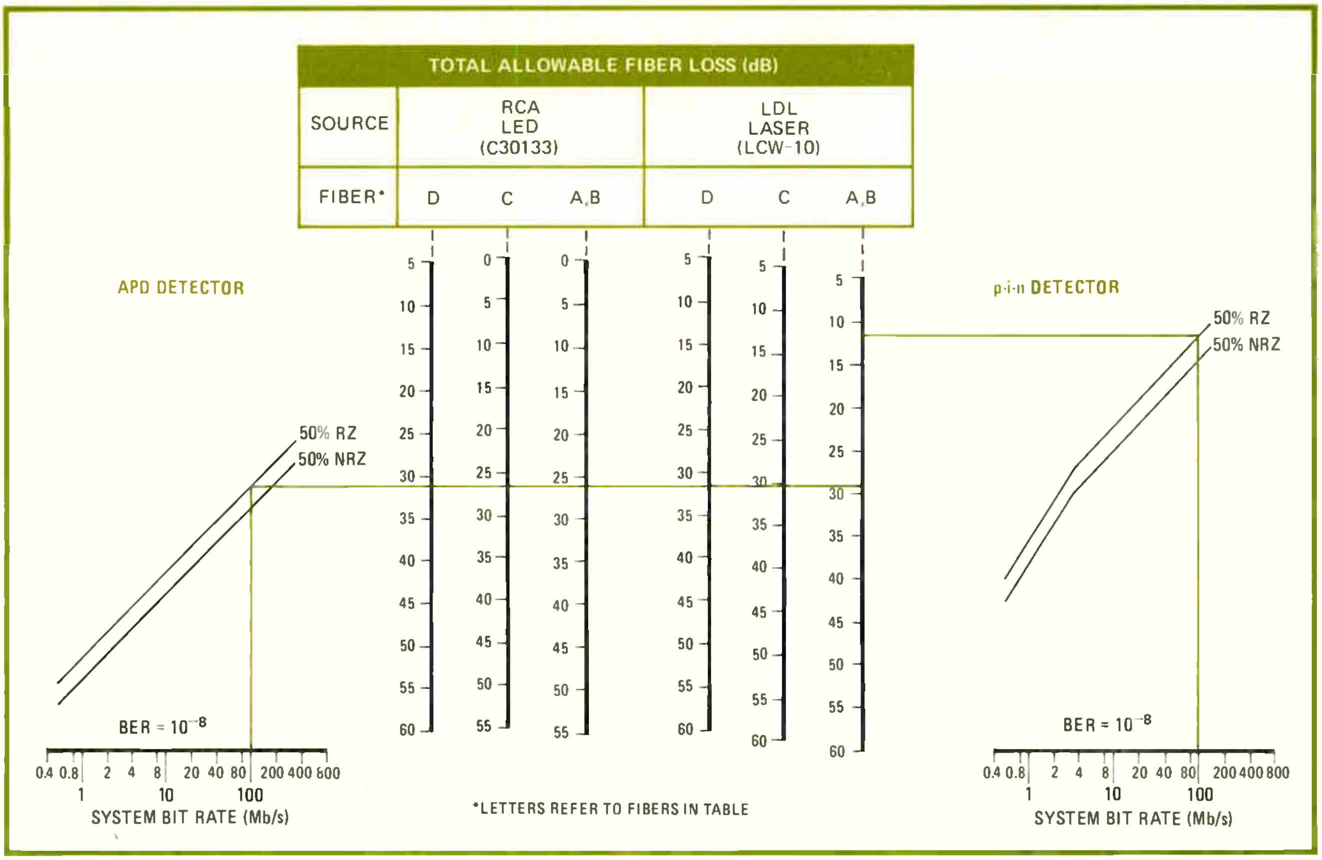
Tradeoffs between a 100-megabit-per-second digital video and a 5-MHz baseband analog video system are fairly straightforward. For the digital system, a 10^{-8} bit-error-rate is typical, while for the analog system a nominal peak-to-peak signal-to-noise ratio of 40 dB is called for. All other specifications, such as differential phase or gain, are assumed to be equal for both of the



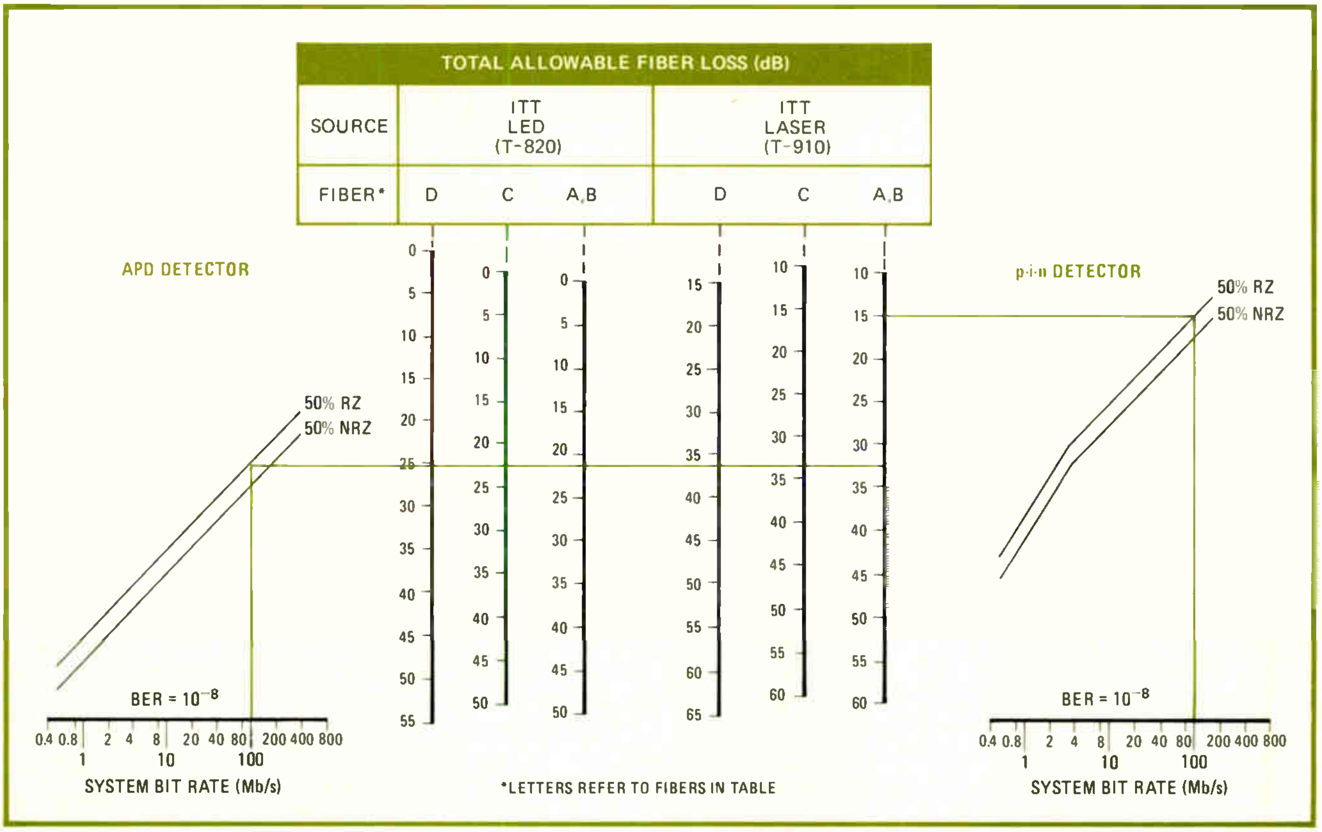
3a. Total fiber loss. The total allowable fiber loss for an analog system using a premium-grade light-emitting diode or laser source is calculated with relative ease using this nomograph. The left-hand scale is for an avalanche photodiode detector, the right-hand for p-i-n type.



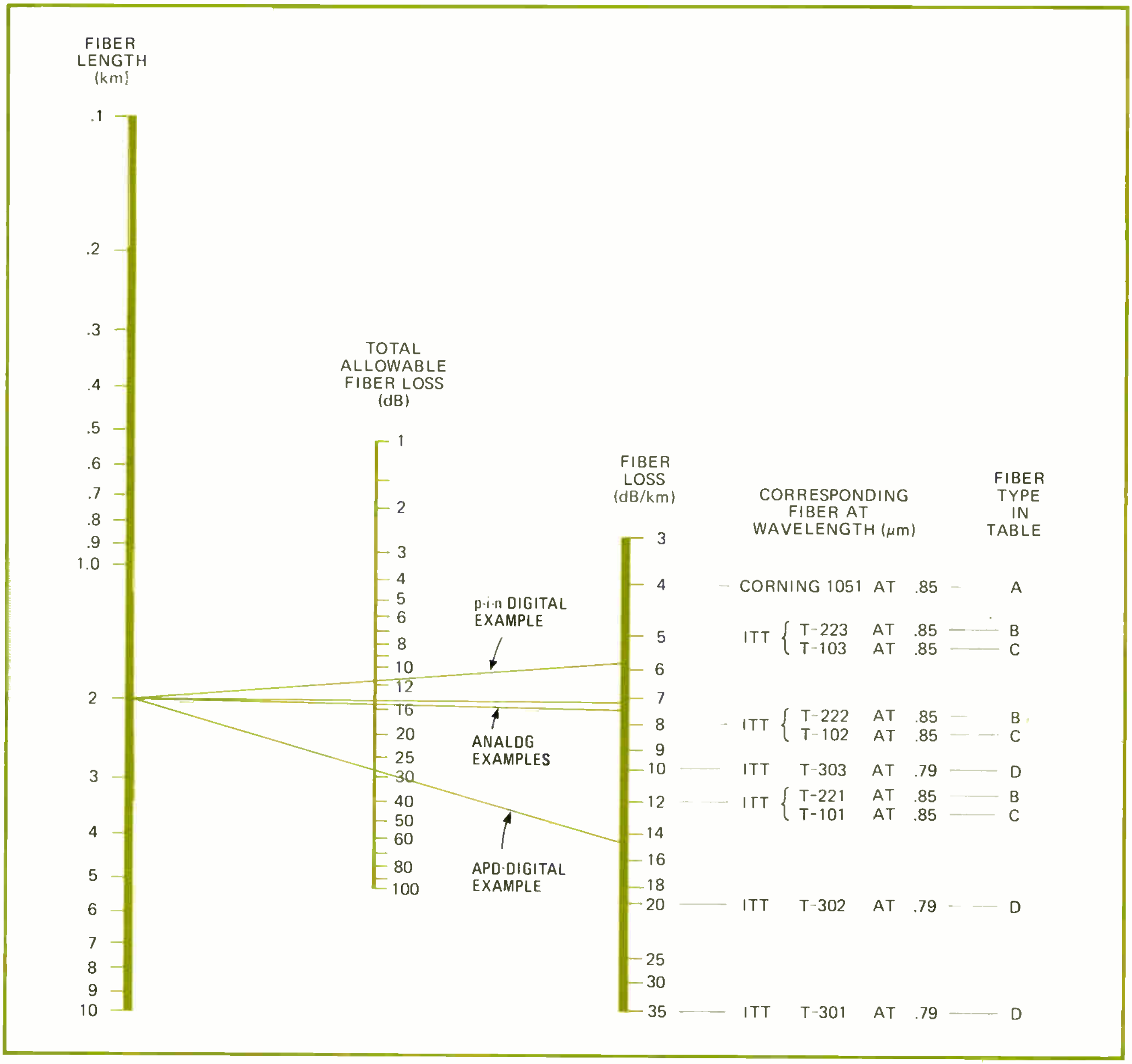
3b. Standard sources. Again, the nomograph allows simple calculation of total allowable fiber loss for an analog transmission system, but in this case the light-emitting diode and laser sources chosen from the table are lower-cost standard-grade devices.



4a. Digital loss. Using this nomograph, the total allowable fiber loss for a digital transmission system that employs a premium-grade light-emitting diode or laser source can be determined. Again the avalanche photodiode detector is at left, the p-i-n detector at right.



4b. Lower cost. Where a digital application allows less stringent component specifications, this nomograph will be useful. Standard-grade sources from the table are substituted for the premium devices used in the digital example of Fig. 4a.



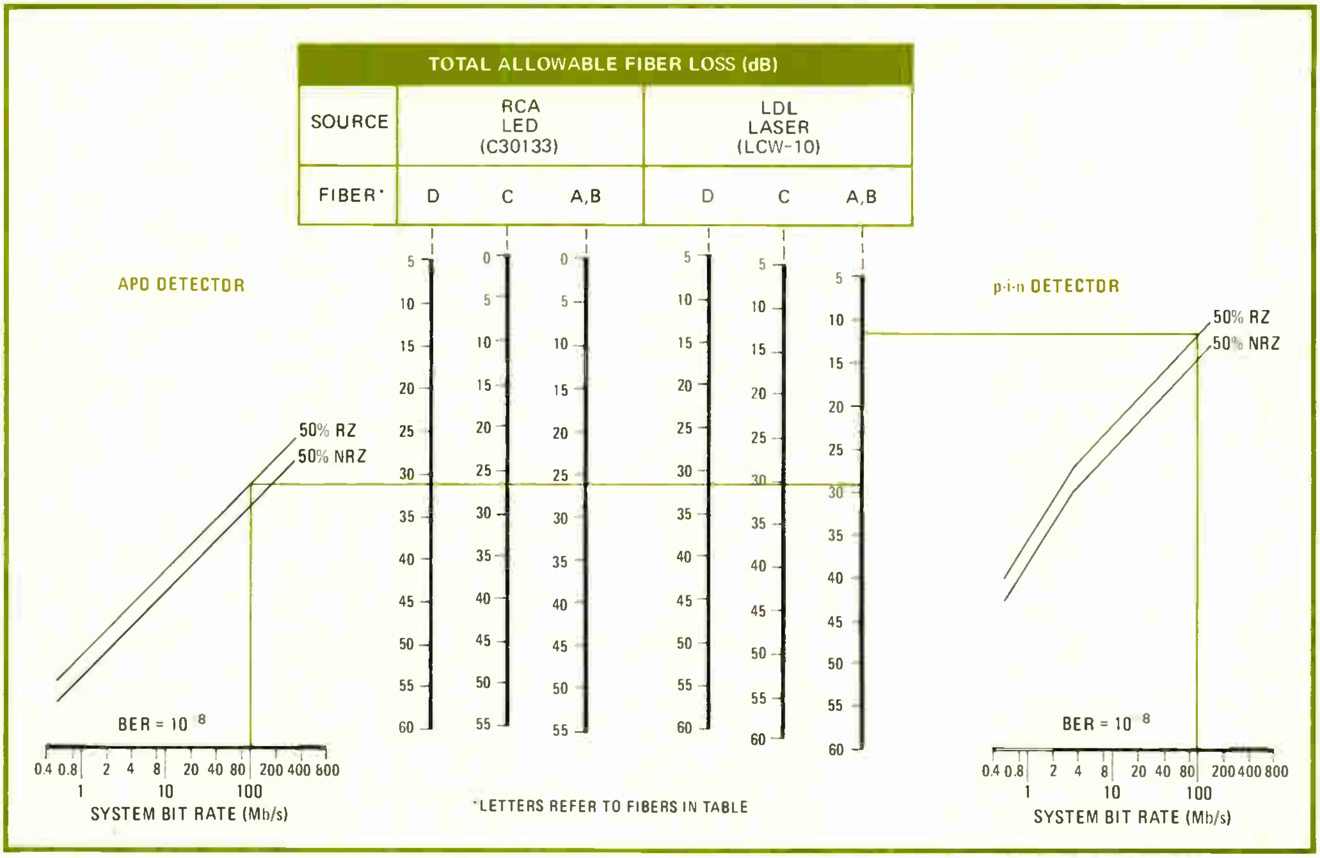
5. Attenuation. Quick preliminary tradeoffs between fiber type, line length, and allowed system power margin are made using this fiber attenuation nomograph. All fibers above the point of intersect on the fiber loss scale will satisfy system requirements.

systems. To begin the digital design, the point corresponding to 2 km on the X axis of Fig. 1 and 100-Mb/s, 50% return-to zero pulses on the right-hand Y axis is plotted on Fig. 1. This point lies beyond the region labeled repeater, indicating that this system cannot be realized with LED sources.

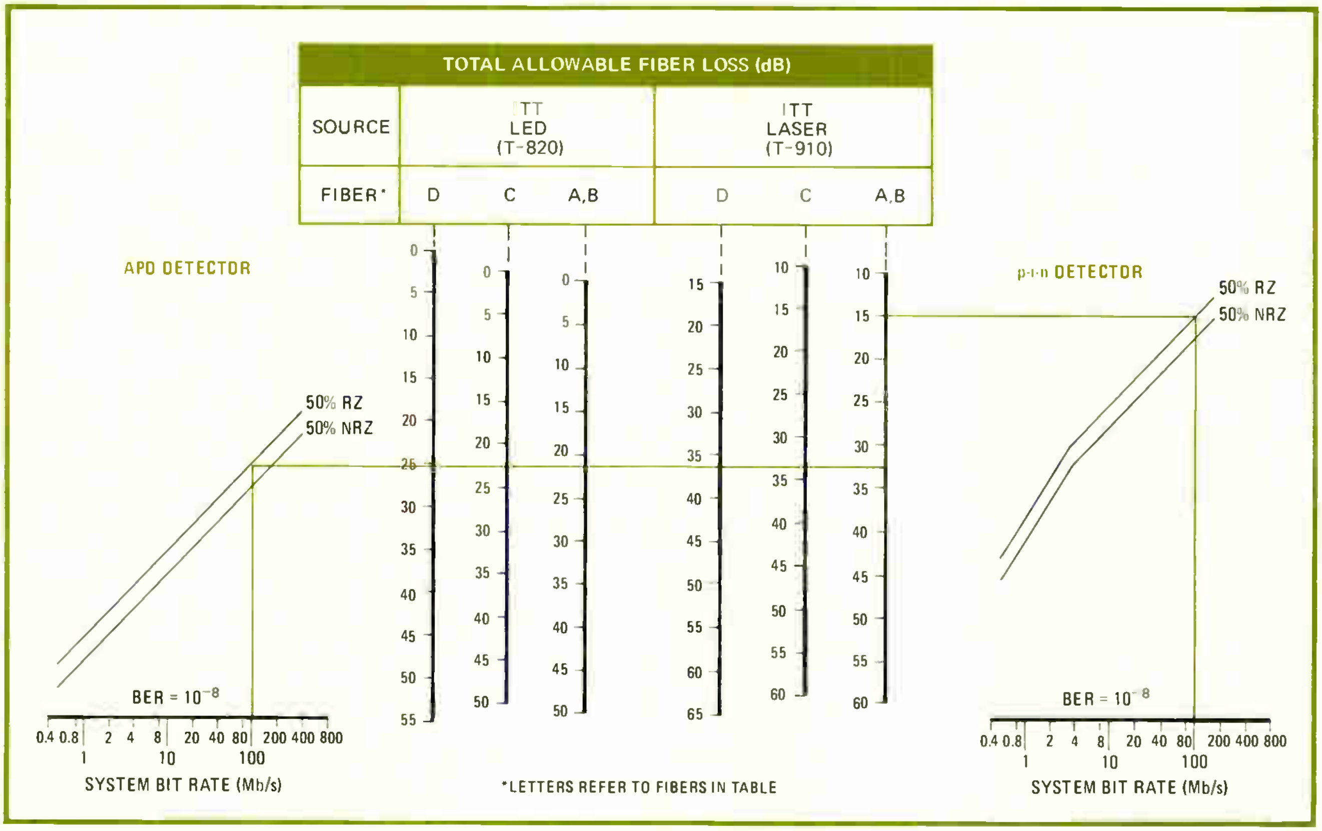
Continuing the design, the same point is plotted on Fig. 2. This point now lies in the fiber-type A-B region for the premium laser diode (defined by the solid lines) and in the fiber type A region for the standard-grade laser (defined by the dotted lines). For illustrative purposes, the premium laser alternatives will be carried through the rest of this analysis. Therefore, both fiber types A and B are written into the allowed-generic fiber block (Fig. 6b).

Next, total allowable system loss is determined from Fig. 4a. Lines are projected vertically from the 100-Mb/s points on the APD and p-i-n X axis to the 50% return-to-zero curve. Horizontal lines are then drawn from this intersection to the fiber-type A-B scale under the laser source heading. The indicated scale values are the total allowed fiber loss. These losses are then entered in the applicable fiber loss block of Fig. 6b.

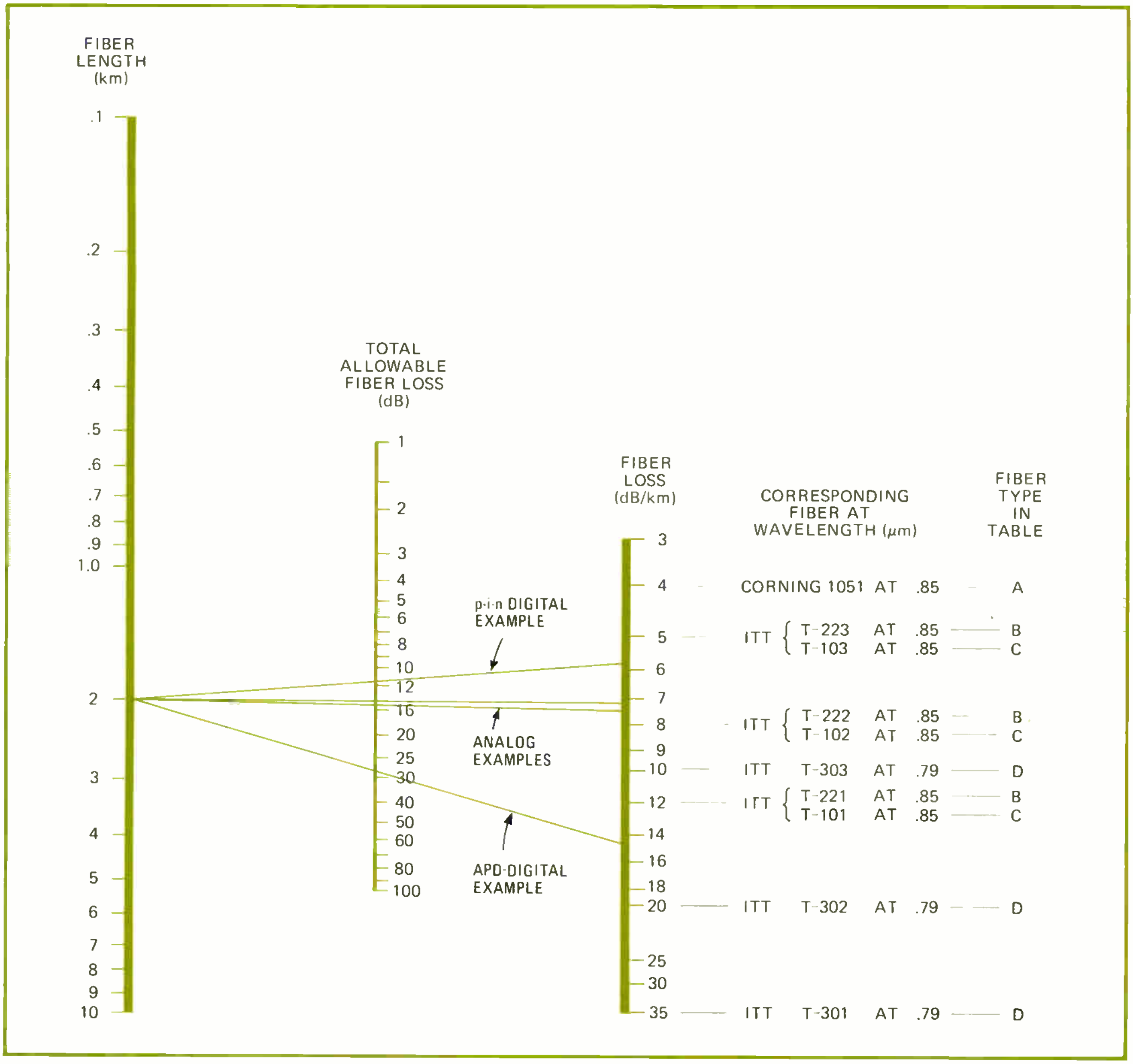
The design is completed by determining the fiber grade (Fig. 5). Lines are drawn from the 2-km-length point through the scale of total allowable fiber loss for the APD and the p-i-n detectors and extended to intersect the fiber loss and kilometer scale. The allowed fiber types closest to, but above, these intersections are entered in the fiber grade column (Fig. 6b). The final selection, based on approximate costs of the components listed in the table, is the premium Laser Diode Laboratories Inc. LCW-10 laser with ITT T-223 fiber and the Hewlett-Packard p-i-n detector. Remember that other



4a. Digital loss. Using this nomograph, the total allowable fiber loss for a digital transmission system that employs a premium-grade light-emitting diode or laser source can be determined. Again the avalanche photodiode detector is at left, the p-i-n detector at right.



4b. Lower cost. Where a digital application allows less stringent component specifications, this nomograph will be useful. Standard-grade sources from the table are substituted for the premium devices used in the digital example of Fig. 4a.



5. Attenuation. Quick preliminary tradeoffs between fiber type, line length, and allowed system power margin are made using this fiber attenuation nomograph. All fibers above the point of intersect on the fiber loss scale will satisfy system requirements.

systems. To begin the digital design, the point corresponding to 2 km on the X axis of Fig. 1 and 100-Mb/s, 50% return-to zero pulses on the right-hand Y axis is plotted on Fig. 1. This point lies beyond the region labeled repeater, indicating that this system cannot be realized with LED sources.

Continuing the design, the same point is plotted on Fig. 2. This point now lies in the fiber-type A-B region for the premium laser diode (defined by the solid lines) and in the fiber type A region for the standard-grade laser (defined by the dotted lines). For illustrative purposes, the premium laser alternatives will be carried through the rest of this analysis. Therefore, both fiber types A and B are written into the allowed-generic fiber block (Fig. 6b).

Next, total allowable system loss is determined from Fig. 4a. Lines are projected vertically from the 100-Mb/s points on the APD and p-i-n X axis to the 50% return-to-zero curve. Horizontal lines are then drawn from this intersection to the fiber-type A–B scale under the laser source heading. The indicated scale values are the total allowed fiber loss. These losses are then entered in the applicable fiber loss block of Fig. 6b.

The design is completed by determining the fiber grade (Fig. 5). Lines are drawn from the 2-km–length point through the scale of total allowable fiber loss for the APD and the p-i-n detectors and extended to intersect the fiber loss and kilometer scale. The allowed fiber types closest to, but above, these intersections are entered in the fiber grade column (Fig. 6b). The final selection, based on approximate costs of the components listed in the table, is the premium Laser Diode Laboratories Inc. LCW-10 laser with ITT T-223 fiber and the Hewlett-Packard p-i-n detector. Remember that other

SOURCE TYPE/ GRADE	ALLOWABLE GENERIC FIBER	DETECTOR	FIBER (TABLE 1)	FIBER LOSS (dB) (FIG. 3 or 4)	FIBER GRADE (FIG. 5)
LED	FIG. 1	p-i-n	D		
			C		
			B		
			A		
		APD	D		
			C		
			B		
			A		
LASER	FIG. 2	p-i-n	D		
			C		
			B		
			A		
		APD	D		
			C		
			B		
			A		

SYSTEM PARAMETERS	
ANALOG	BANDWIDTH
	LINK LENGTH
	SNR
DIGITAL	BIT RATE
	LINK LENGTH
	PULSE FORMAT

6. System specification. The form (a) outlines all system design steps and can be used to tabulate and tradeoff alternative system configurations. An example of how the chart is used in the design of a 2-km digital system is illustrated in the chart below (b).

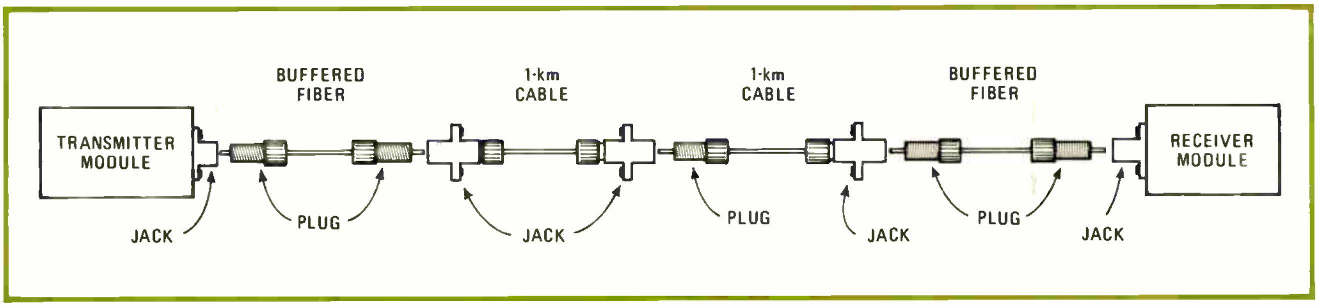
SOURCE TYPE/ GRADE	ALLOWABLE GENERIC FIBER	DETECTOR	FIBER (TABLE 1)	FIBER LOSS (dB) (FIG. 3 or 4)	FIBER GRADE (FIG. 5)
LED	FIG. 1 NONE	p-i-n	D		
			C		
			B		
			A		
		APD	D		
			C		
			B		
			A		
LASER LDL LCW-10	FIG. 2 A, B	p-i-n	D		
			C		
			B	11.5	ITT T-223
			A	11.5	CORNING 1051
		APD	D		
			C		
			B	29.5	ITT T-221
			A	29.5	CORNING 1051

SYSTEM PARAMETERS	
ANALOG	BANDWIDTH
	LINK LENGTH
	SNR
DIGITAL	BIT RATE 100 Mb/s
	LINK LENGTH 2 km
	PULSE FORMAT RZ, 50 %

SOURCE TYPE/ GRADE	ALLOWABLE GENERIC FIBER	DETECTOR	FIBER (TABLE 1)	FIBER LOSS (dB) (FIG. 3 or 4)	FIBER GRADE (FIG. 5)
LED RCA C30133	FIG. 1 A, B, C	p-i-n	D		
			C	15.5	ITT T-103
			B	15	ITT T-222
			A	15	CORNING 1051
		APD	D		
			C	15.5	ITT T-102
			B	15	ITT T-222
			A	15	CORNING 1051
LASER	FIG. 2	p-i-n	D		
			C		
			B		
			A		
		APD	D		
			C		
			B		
			A		

SYSTEM PARAMETERS		
ANALOG	BANDWIDTH	5 MHz
	LINK LENGTH	2 km
	SNR	40 dB
DIGITAL	BIT RATE	
	LINK LENGTH	
	PULSE FORMAT	

7. Analog example. The 2-km sample design illustrated in Fig. 6b is re-examined for a 5-MHz baseband analog system with a peak-to-peak signal-to-noise ratio of 40 dB. The premium light-emitting diode source, p-i-n detector, and fibers were selected from the table.



8. Design link. Used here to illustrate how to design and specify with the charts, this 2-km link could be employed for either an analog or digital transmission system. Typical applications are ground stations, telephone trunking, and studio video transmission.

components can easily be considered by adding them to or substituting them in the table.

The same systems-design procedure may be repeated for a 5-MHz analog baseband video system. Using Fig. 1 (2 km on the X axis, 5 MHz on the left Y axis), it is found that fiber types A, B, or C can be configured with either the standard or premium LED source.

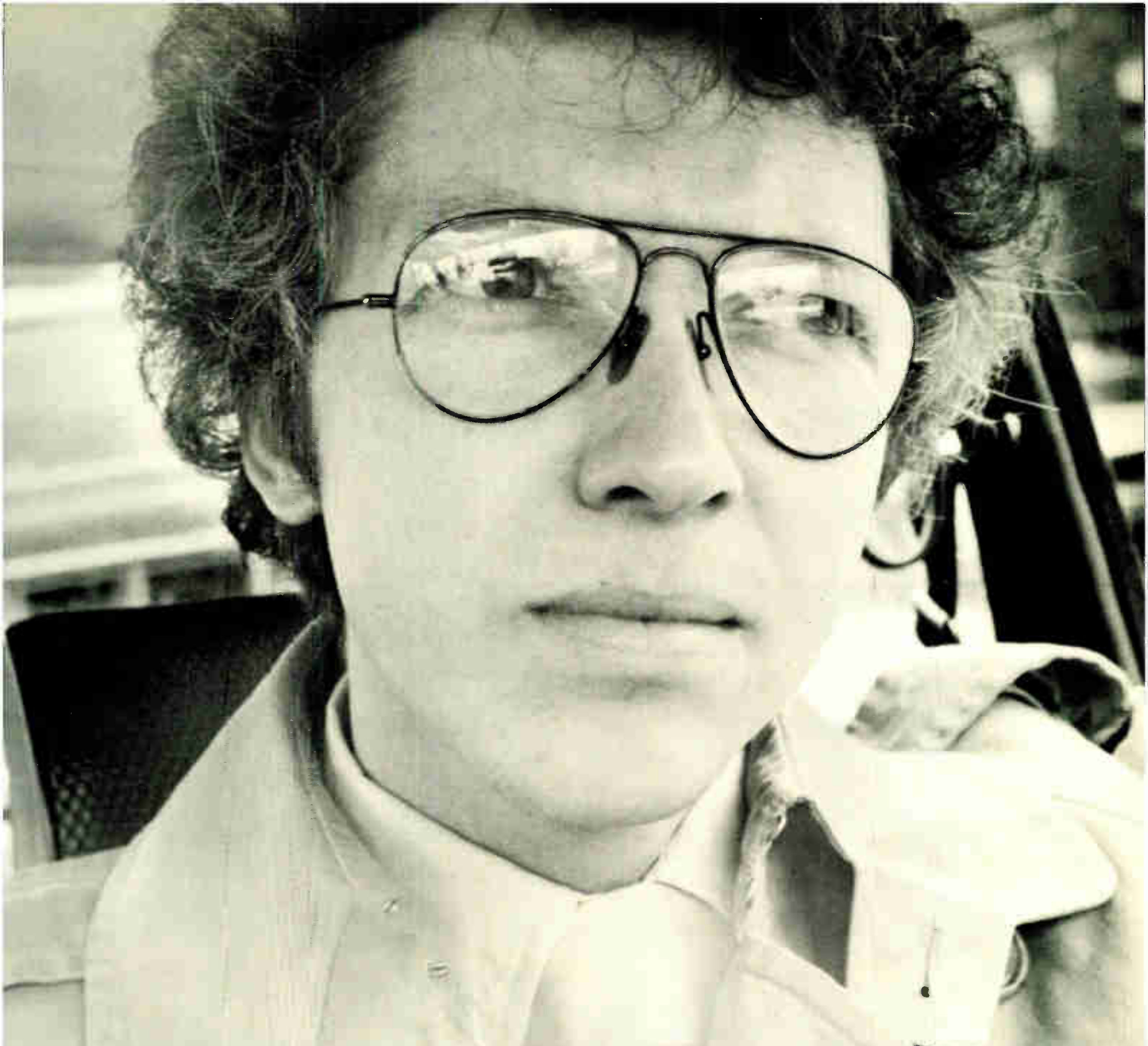
Analog design

Laser and fiber alternatives can be determined from Fig. 2. However, these will not be considered since, as previously mentioned, an LED source is usually preferred to the laser source where applicable. Figure 7 tabulates the fiber-source alternatives for the analog case. Again, only the premium source is considered.

From Fig. 3a, the total allowable loss is determined for both p-i-n and APD detectors. The loss numbers for LED source and fiber type A, B, and C combinations are entered in the fiber loss column of Fig. 7. Now the fiber grade for both types of detector (from Fig. 5) is entered in the fiber grade column (Fig. 7). Again based on cost trends, the RCA 30133 LED, HP p-i-n photodiode, and ITT T-103 fiber are selected although other options may be considered.

Finally, comparing the digital video and analog video systems, it is seen that either is feasible using a fiber-optic link. Which approach is taken will depend on other considerations—not the least of which is that digital systems will be considerably more expensive than analog systems because of electronics costs. ☐

Part 1 of this series on fiber-optic system design appeared in the Nov. 9 issue. In part 3 [*Electronics*, Dec. 21], commercially available fiber-optic data links will be discussed for both analog and digital applications. This special report will have a detailed chart of all pertinent electrical specifications.



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Optoisolators slash cost of three-phase detector

by G. Olivier and G. E. April
Concordia University and Montreal Polytechnic Institute, Canada

Optically coupled isolators replace transformers in a zero-voltage detector for synchronizing the firing of a thyristor in three-phase control applications, making this circuit cheaper, less bulky, and simpler than most competing designs. Moreover, the optoisolators eliminate the need for a low-pass filter, required in standard detectors for eliminating spurious zero-crossings caused by the thyristor's switching transients. They also provide high-voltage isolation and present much lower capacitive coupling to the circuit than a standard transformer, in fact presenting about as low a coupling as double-shielded types.

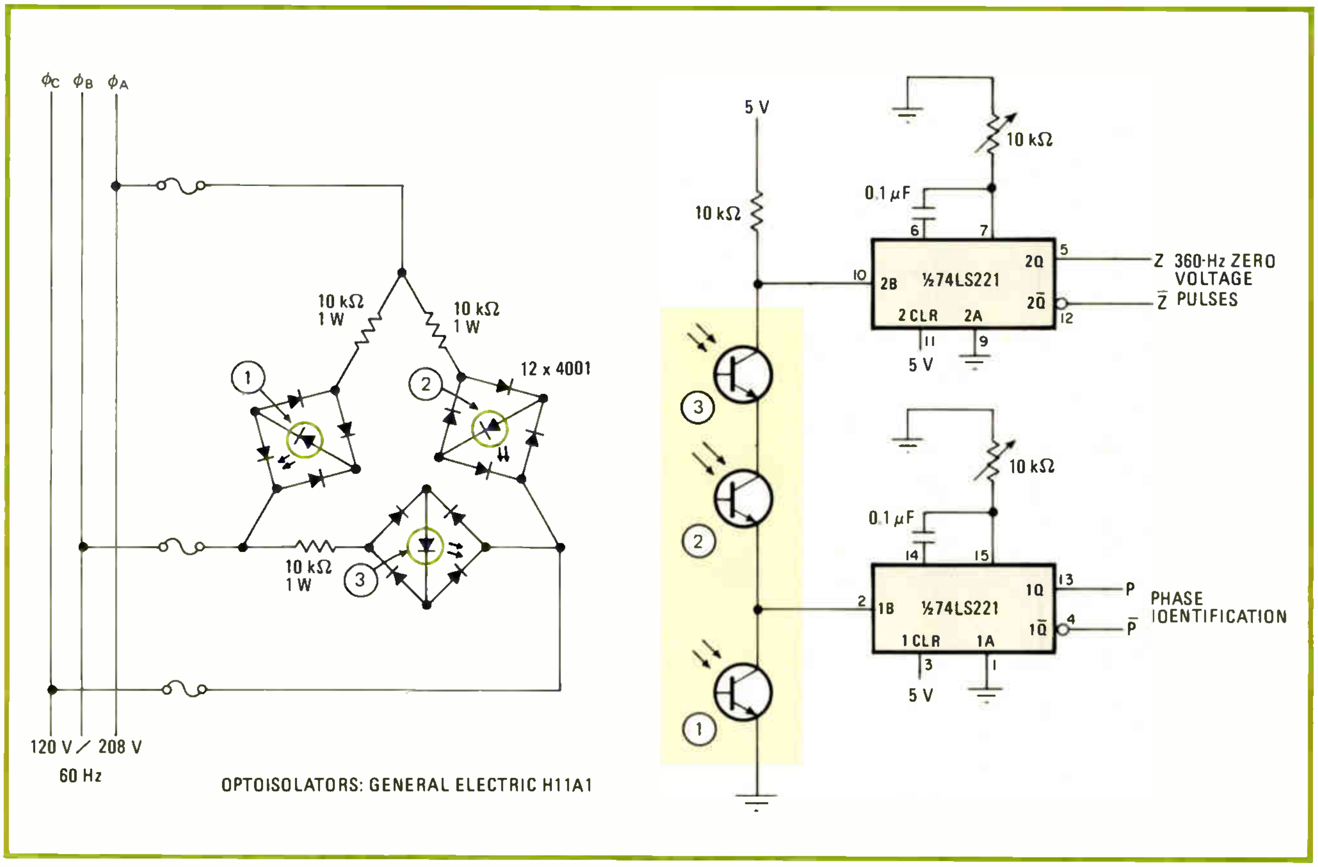
As shown in the figure, a light-emitting diode (contained in the GE H11A1 optoisolator) is inserted in each of three legs of a delta network. Each LED is wired to four standard diodes in a bridge arrangement, to enable it to respond to both polarities of the power-line input.

During most of the cycle, all phototransistors are on. At times when the voltage between any two lines is within 0.7 volt of zero, however, no current will flow through the LED connected across those lines. Therefore its corresponding phototransistor will be off, causing pin 2 of the 74LS221 one-shot to fire and a phase-identification pulse (P) to be generated twice every cycle.

In the case illustrated, the phototransistors are wired so that a pulse will be generated at the output each time the input voltage, as measured across ϕ_a and ϕ_b, passes through zero. Note that the one-shot should be adjusted so that the trailing edge of the output pulse corresponds to the actual zero-crossing point.

Identification pulses are also generated for all three phases collectively and these can be accessed, if required, at the zero-voltage pulse output, Z. These pulses occur three times as often as P.

Because at least one LED is conducting at any one time, no transient will normally be generated, so no low-pass filter is needed. Furthermore, the phototransistor's slow response of a few microseconds acts to suppress any transients that might occur near the zero-voltage points, thereby increasing the circuit's noise immunity. ☐



Economical. Three-phase, zero-voltage detector for synchronizing the firing of thyristors uses optoisolators in place of transformers to cut cost and bulk. Optocouplers provide circuit with high-voltage isolation and lower capacitive coupling than transformers.

One-chip oscillator generates in-quadrature waveforms

by Juan R. Pimentel
Department of Electrical Engineering, University of Virginia, Charlottesville

A quad operational amplifier, working as an oscillator, can generate in-quadrature signals for triangular or square waves, thus eliminating the need for phase-locked loops or other synchronous circuits in applications requiring either wave to be shifted by 90°. The low-cost circuit works over a wide range, thanks to a technique borrowed from Graeme[1] that uses op amps in an oscillator to generate in-quadrature sine waves.

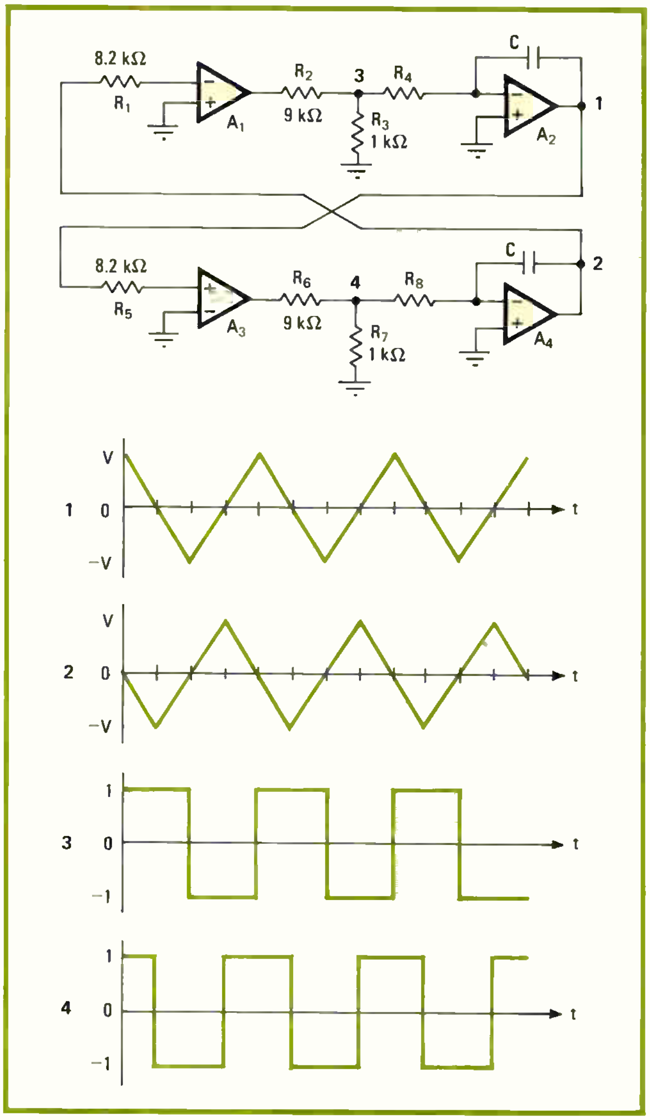
Op amps A_1 and A_3 function as comparators, and A_2 and A_4 as integrators, as shown in the figure. Resistors R_2, R_3, R_6, and R_7 are selected so that 1 volt appears across R_3 and R_7 when A_1 and A_3 are saturated (any other voltage could be chosen).

Circuit operation is simple. If A_3 is saturated at its negative power-supply value, the voltage across R_7 will be -1 v. The voltage at the output of integrator A_4 will then have a positive slope and increase linearly with time, because the input signal is introduced to A_4's inverting port.

When A_4's output passes through zero, the voltage across R_3 will reach -1 v, causing A_2's output to increase linearly (positive slope). Similarly, when the output of A_2 passes through zero, the voltage across R_7 will reach $+1$ v, causing A_4's output to decrease linearly in the negative direction. This operation will repeat, yielding the waveforms shown below the circuit diagram.

The time required to complete one cycle is $T = 4RCV$, and so the frequency of oscillation is $f = 1/4RCV$, where $R = R_4 = R_8$ and V is the power supply voltage. These equations assume a peak output of ±1 v at points 3 and 4. ☐

References
1. J. G. Graeme, G. E. Tobey, and L. P. Huelsman, "Operational Amplifiers—Design and Applications," McGraw-Hill, 1971.



Phasing. Quad op amp, working as oscillator, can generate two triangular- or square-wave outputs that are separated by 90°, thereby eliminating the need for phase-locked loops or other synchronous circuits. Frequency can be controlled by appropriate selection of resistors and capacitors associated with integrators A_2 and A_4.

One-button controller issues step, run, and halt commands

by Robert Dougherty
Dunedin, Fla.

The logic signals to step, run, and halt a computer or other appropriate digital device or system may be generated by this circuit, which is operated by just a single push button. The only active devices used are a dual one-shot and a dual flip-flop.

The step command is generated each time the push button is depressed momentarily. The run command occurs if the button is held down for a time exceeding about 180 milliseconds. This time represents an excellent compromise between circuit speed and accuracy. A much shorter duration means the circuit may fail to differentiate between the step and run commands and may generate the run command when the step command is desired, or vice versa. Also, repeatedly pressing the button rapidly to initiate step functions will generate the run command if the duration is set for much more than 180 ms. Finally, the computer will be halted if the push button is depressed momentarily when the circuit is in the run mode.

As shown in the figure, A_1 acts as an effective switch debouncer for the push button. For a step command,

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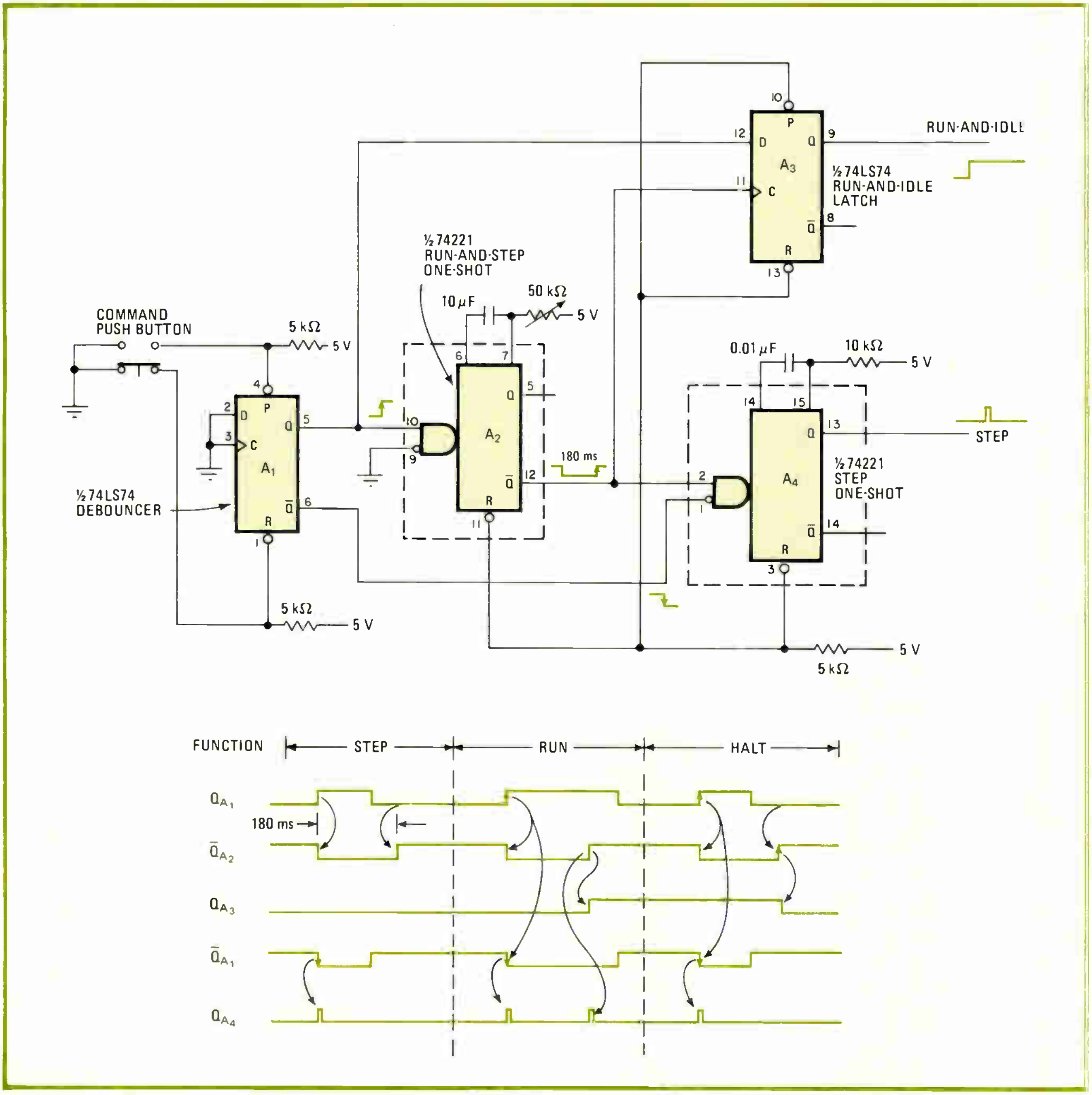
poking the button quickly will cause the Q output of A_1 to go high and fire A_2, the run-and-stop one-shot. A_1 is also fed to A_3, the D input of the run-and-idle latch. At the same time, the $\overline{Q}$ output of A_1, which moves low, will fire the step one-shot A_4, yielding the step function.

The sequence of events just discussed also describes the initial portion of the run command, whereby the step pulse is used to manually advance the computer's program counter by one. The run pulse then commands the computer to rapidly execute succeeding steps automatically. The $\overline{Q}$ output of A_2 moves high 180 ms after the push button is depressed. The positive-going, or trailing, edge of this pulse then clocks the state of the push button (as detected by A_1) into A_3.

If the button has been released before time-out, a zero appears at the Q output of A_3. But if the button is activated, A_3 moves high and the run command is executed by the computer.

A press of the button will cause the circuit to halt the machine if it is in the run mode, by clocking in a logic 0 to the run-and-idle latch. Note that the step pulse generated at the start of the halt sequence, as shown in the timing diagram, is of no consequence, since when the step is received, the machine is already in the run mode and will override that command. □

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



Touch control. One push button and two ICs single-step a computer's program counter or control run and halt operations. Button-depression time and present mode of controller determine the command generated. Timing diagram details circuit operation.

Single-loop process controller adapts gain to operating level

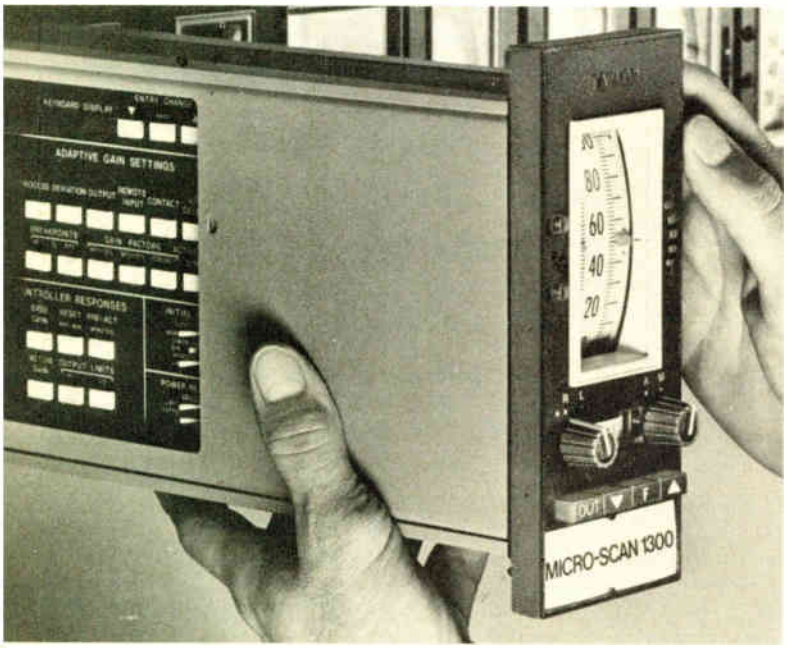
by Frank Hermance and David Farwell,
Taylor Instrument Co., Rochester, N. Y.

☐ There's a hobgoblin in some industrial processes that stymies standard process controllers, and that is a nonlinear variable. Standard units respond to changes in a process variable in three ways: integral, derivative, and fixed-gain responses. Most process variables change linearly, so these responses suffice for their control.

However, control of a nonlinear process requires a controller gain that changes as a function of one or more variables. A standard controller suffers woeful performance deficiencies in such a variable-gain process control loop. Tune it to the high-gain point in the process, and control will be sluggish at the low-gain point. Tune to the low-gain point, and the loop will oscillate at the high-gain point.

Attempts to synthesize an adaptive-gain process controller from discrete electronic components were cursed with undue complexity and high cost, so they met with limited success. But the arrival of the microprocessor chip has changed all that. Now, process engineers can implement such sophisticated control algorithms as adaptive gain by programming a microprocessor-based controller, like the Taylor Microscan 1300R.

This single-loop controller is packaged in a 3-by-6-by-24-inch enclosure (Fig. 1). Analog meters on the front show both the actual and desired values of the process variable to allow the operator to monitor and adjust the process. A keyboard and six-digit numeric readout on the side of the unit permit the process engineer to enter various algorithm parameters.



1. Adaptive-gain controller. The Taylor Microscan 1300R process controller—with operator's controls and indicators on the front panel, and process engineer's on the side—automatically adjusts its gain to variations in the operating level of a process variable.

What it is

For a cost-effective design, it makes sense to bring the microprocessor in on all five critical controller operations: analog-to-digital conversion of inputs, computation of the control algorithm, numeric-display multiplexing, keyboard scan, and backup-memory loading and unloading. Such a design requires minimal hardware but still allows the unit to sample the process loop four times each second, an acceptable rate in most cases.

A major design goal was limiting internal power dissipation to a level compatible with the controller's physical dimensions, so a complementary-metal-oxide-semiconductor microprocessor was a natural choice. The RCA 1802 processor was chosen since it satisfied the power-consumption requirements (only 6 milliwatts at 5 volts dc) at the lowest cost of any C-MOS chip available at the time. It has an 8-bit data word, direct addressing range of 65,536 words, 91 basic instructions, minimum instruction times that range between 2.5 and 3.75 microseconds, and 16 internal registers. It also features interrupt, direct-memory-access, and testable-flag capabilities.

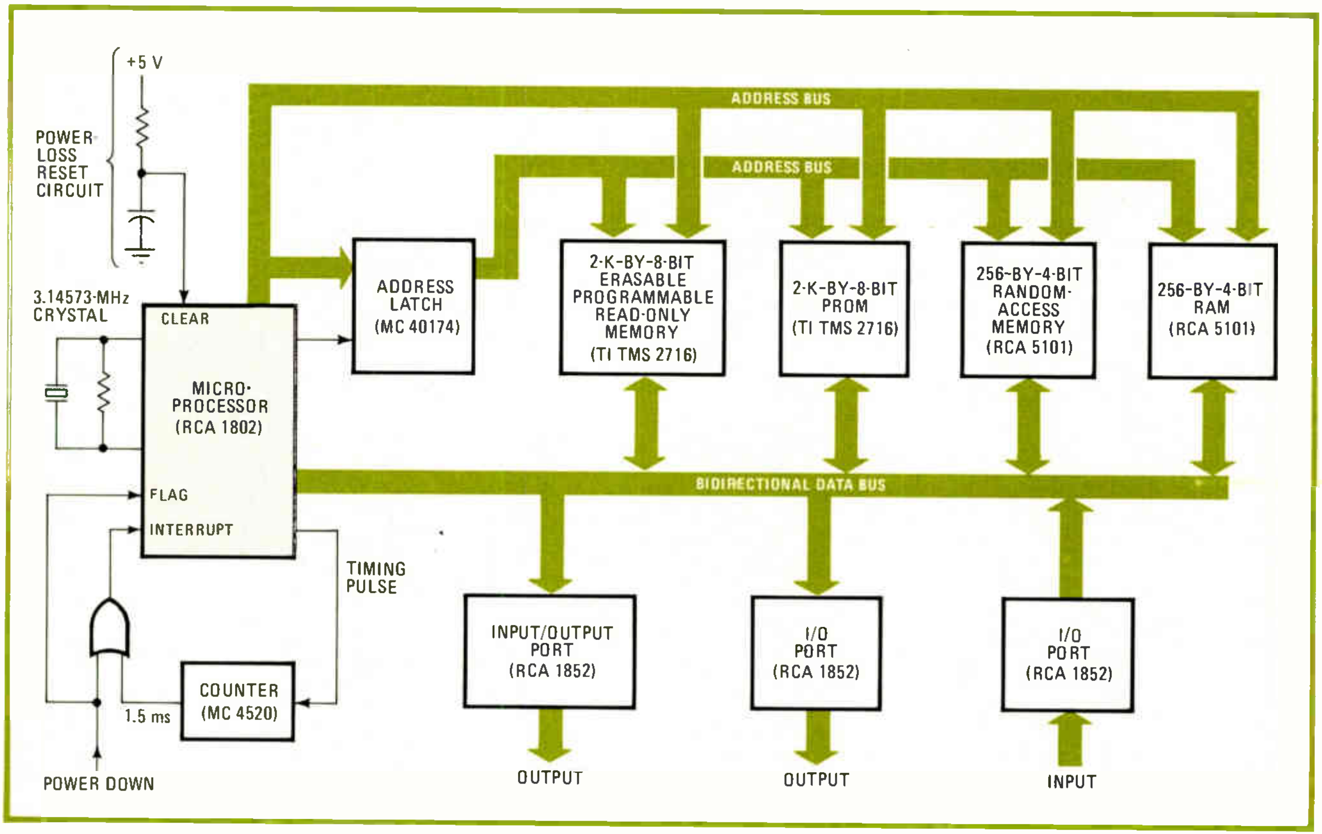
The instrument's central processor (Fig. 2) includes the 1802, 4 kilobytes of erasable programmable read-only memory for storing instructions, 256 bytes of working RAM, one input port, and two output ports. Also in the chip set are a 3.14573-megahertz crystal clock, an RC power-loss reset circuit, and a counter that sets the basic timing of the instrument.

How it works

The counter divides down the microprocessor timing pulse and feeds an interrupt signal back to the microprocessor every 1.5 milliseconds. The microprocessor then counts the interrupts internally, starting a new sample period every 160 counts, or 240 ms.

Specific events occur at specific values of the interrupt count. For instance, at the beginning of counts 9 through 14, 25 through 30, 41 through 56, etc., the numeric display is updated. The keyboard is scanned on interrupt counts 15 and 95, and analog data is put out on interrupt counts 47 and 159. When not performing these functions, the microprocessor is busy computing the adaptive-gain algorithm.

First step in the computation is data acquisition. As shown in Fig. 3, the controller receives three inputs:



2. Chip set. In addition to the RCA 1802 microprocessor, the processing section of the controller includes a working memory (RAM), a memory for storing instructions (E-PROM), a crystal clock, an interrupt-timing generator, an address latch, and three I/O ports.

- The process input—a 4-to-20-milliampere or 0.25-to-1.25-v signal, typically originating from a transducer. It is proportional to the value of the loop variable to be controlled such as flow, temperature, or pressure.
- The set-point input—a 0.25-to-1.25-v signal that represents the desired value of the process variable. This signal comes from a knob on the front panel of the controller.
- The remote input—a 0.25-to-1.25-v signal from some other variable in the process to which the microprocessor is programmed to respond. For example, it may be preferable to begin adapting the gain of a steam-flow controller in a heat-exchange application as soon as a change in fluid flow occurs, rather than wait to make a more drastic change in gain later when the fluid temperature itself begins to vary.

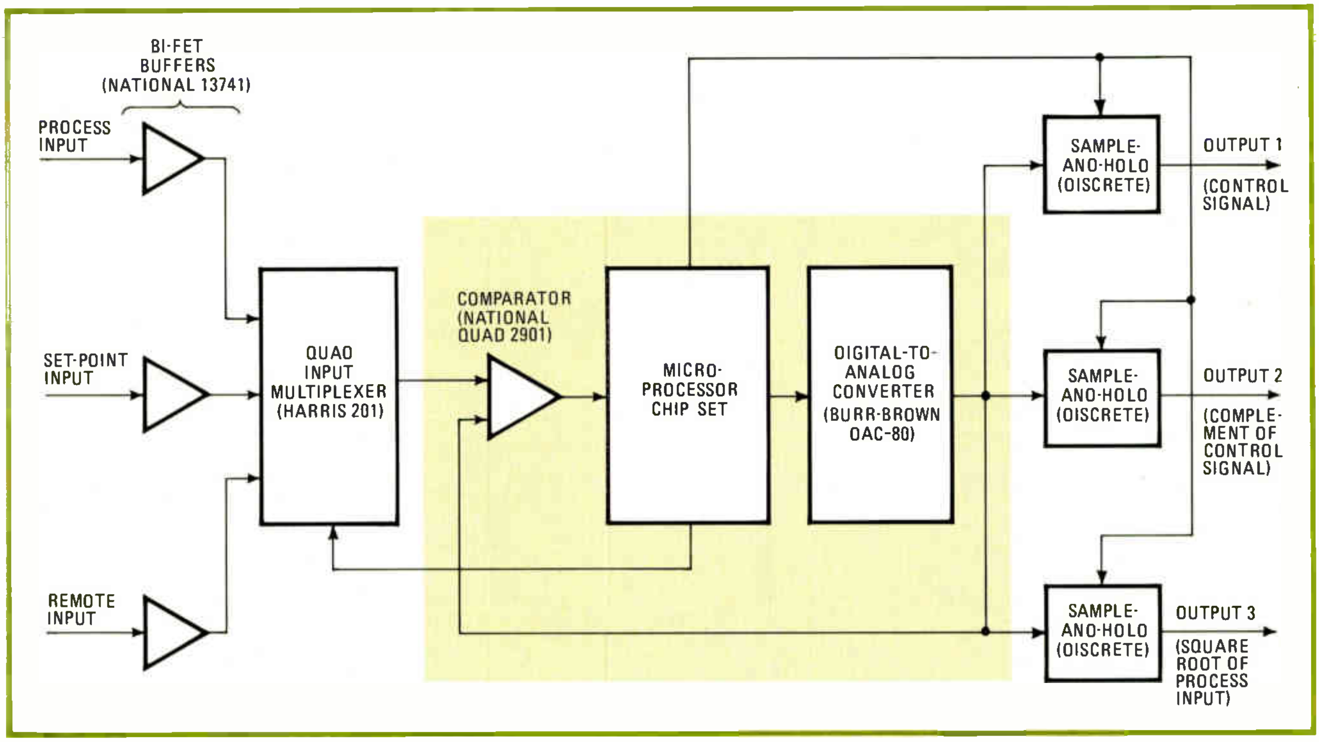
After buffering, all three analog signals are converted in turn into digital form, under microprocessor control, in a successive-approximation loop. This technique permits fast enough conversions for the same digital-to-analog converter to be used for a-d conversions of inputs and d-a conversions of outputs. Each conversion takes about 3 ms.

Once the microprocessor has digitized the analog inputs, it computes the control algorithm and puts out three analog signals: a control signal, its complement (needed to drive the front-panel meter correctly when controlling certain types of control valve), and, optionally, the square root of the process input (often used to drive a meter or to feed into a data-acquisition system). To sustain these three outputs, the microprocessor sequentially addresses three sample-and-hold circuits made of discrete components.

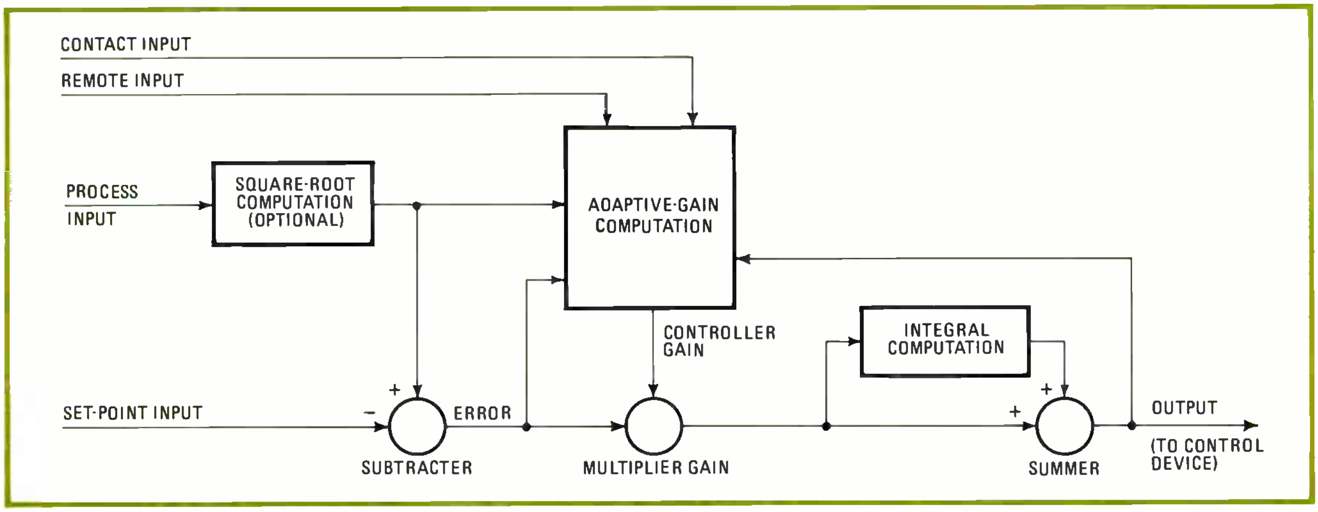
How it computes

The adaptive-gain algorithm (Fig. 4) basically works as follows: the set point is subtracted from the linearized process value to form an error value; the error value is then multiplied by the gain of the controller; and the result is integrated and summed with itself to form the controller output. The adaptive-gain computation is a function of five signals: the process, remote and contact inputs, the error, and the output. The contact input (used to make step changes in gain) and output signals multiply the gain of the controller by programmed values. The process-input, remote-input, and error signals each vary the gain according to linear relationships defined by keyboard entries.

To update the numeric display (Fig. 5), the controller puts out data for each digit in turn to a display-segment



3. Input/output conversions. Central to the computational process is the successive-approximation loop (tinted), which does both analog-to-digital and d-a conversions. Using the microprocessor in the loop saved one d-a chip, but at the expense of some conversion speed.



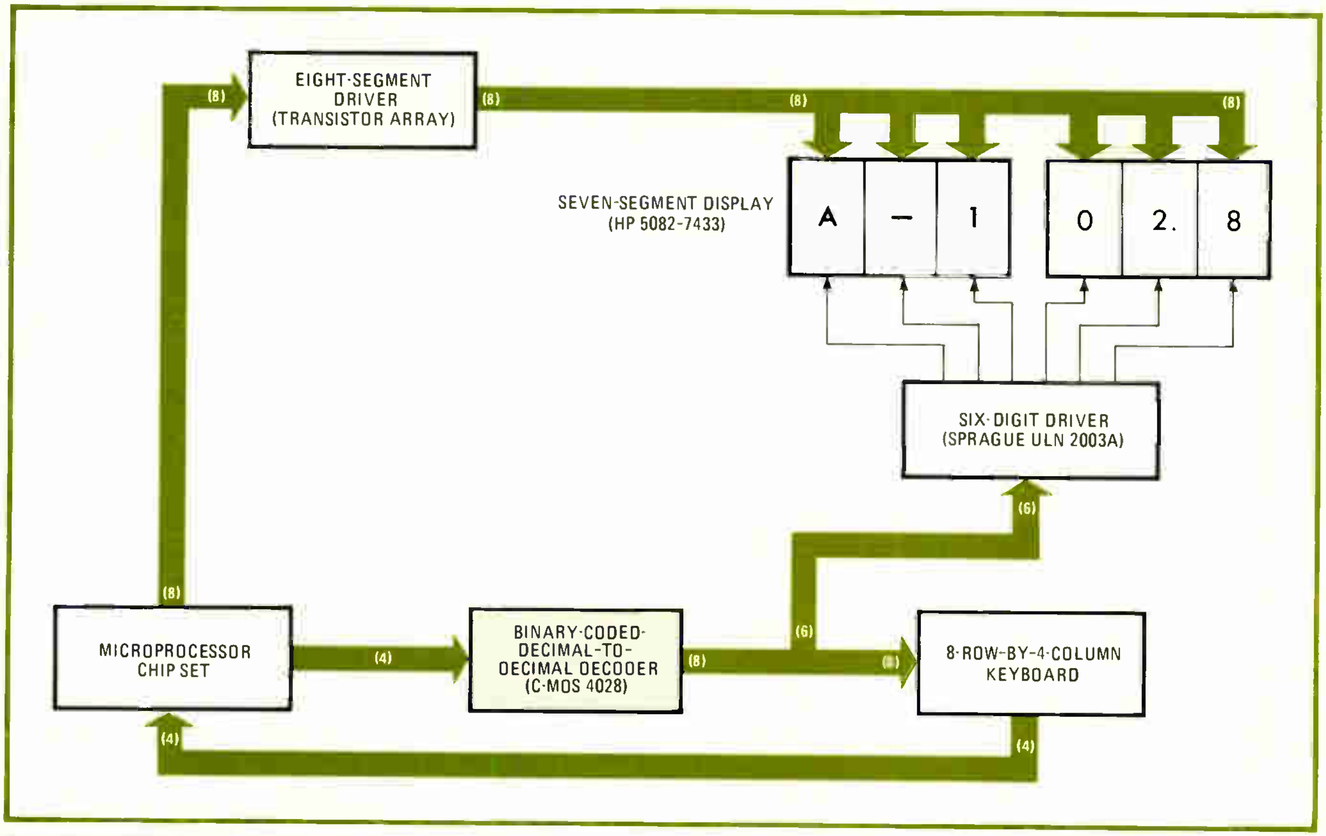
4. Adaptive-gain algorithm. Critical to the manipulation of the input signals to form the controller-gain output is the error signal, which represents the instantaneous deviation of the process variable from its desired value. In all, the computation is a function of five signals.

driver chip, then activates the appropriate digit through a binary-coded-decimal decoder (also used for keyboard scan) and digit-driver chip. Scanning the six digits at 40 hertz provides a flicker-free display.

Keyboard scan makes use of the same BCD decoder. The microprocessor sequentially interrogates each row in the eight-by-four keyboard matrix, identifies depressed keys, and takes appropriate action internally.

The keyboard facilitates entry of data into the instrument. However, since the entered data is stored in volatile RAM, it can be lost whenever instrument power is removed. Such a loss is unacceptable in many process control applications, so a backup nonvolatile semiconductor memory is included in the design.

The backup memory is a pair of Nitron NC7040L 64-by-4-bit metal-nitride-oxide-semiconductor chips.



5. Display update/keyboard scan. To update each digit in turn, the microprocessor first puts out data for each digit, then activates it through the decoder. For keyboard scan, the microprocessor sequentially looks at each row in the eight-by-four keyboard matrix.

They cannot be used as working memory, since they can be read only 10^9 times and written into only 10^5 times. However, they can be used during power outages to retain the keyboard-entered data base.

A few additional parts and some careful programming of the processor gives a foolproof backup operation. When power is lost to the 1300R controller, the internal power-supply capacitors start to discharge. The values of these capacitors were chosen to allow correct instrument performance for about 50 ms following a loss of power. During this period of time, the power loss is sensed and a microprocessor interrupt is generated. This initiates a routine that loads the keyboard-entered data base into the NC7040Ls through the chip set's I/O ports.

When power is reapplied, the microprocessor will reset or clear and load the contents of the nonvolatile memory back into the working RAM. The NC7040Ls are then erased, so they will be ready to accept new data upon a subsequent power outage. The erase procedure takes 1 second, during which no updating of the keyboard data base stored in RAM is allowed. Should a power failure occur during the 1-s erase, the data in working RAM (which is identical to the data being erased) will be rewritten into the nonvolatile memory.

To get the microprocessor to perform all these functions, extensive software development was necessary. The development package consisted of an RCA Cosmac development system with standard monitor, assembler and editor capabilities and floppy disk; a Hazeltine 2000 cathode-ray-tube terminal; and a line printer. The standard teletypewriter provided for hard copy proved to be too slow, so it was replaced by a high-speed line printer.

How software design went

Actual development of software began with computations of the error, gain, integral, and output, followed by the computations of adaptive-gain and square-root algorithms, the routines for keyboard scan/display update, and nonvolatile memory load/unload. It became apparent that the initial estimates of RAM and E-PROM sizes were too low, so each was doubled.

Most of the software development time was spent on the adaptive-gain algorithm. Initial work involved defining the algorithm, the constants used for programming it, and the range and resolution of the programmed constants. Subsequent programming of the algorithm in machine language progressed smoothly.

Overall, the software effort went quite well, because both the execution times and program-memory size were within the necessary limits. ☐

Self-balancing bridge standardizes thermistor mounts

by Richard P. Lanham
U. S. Army Calibration and Repair Support Center, Pirmasens, West Germany

Though Hewlett-Packard's HP-478A thermistor mount is often used with the HP-431 power meter to measure power in the microwave region, the matched thermistor elements it employs are sensitive to mechanical shock. These therefore need to be checked often and, if a number of mounts are to be tested, quickly as well.

A self-balancing bridge, with the aid of a digital voltmeter, can easily test for any thermistor mismatches. In this way the user can determine at once if the mount is fulfilling its primary job—minimizing the effect of environmental temperature changes on power measurements and thus providing a 50-ohm load for microwave generators over a wide band.

Just as important, this special bridge enables any thermistor mount to be quickly standardized, or made compatible, with any HP-431 meter. Other measurement techniques allow only one particular thermistor mount to be certified per HP-431 meter, mainly because it takes so long to perform the standard calibration procedure properly.

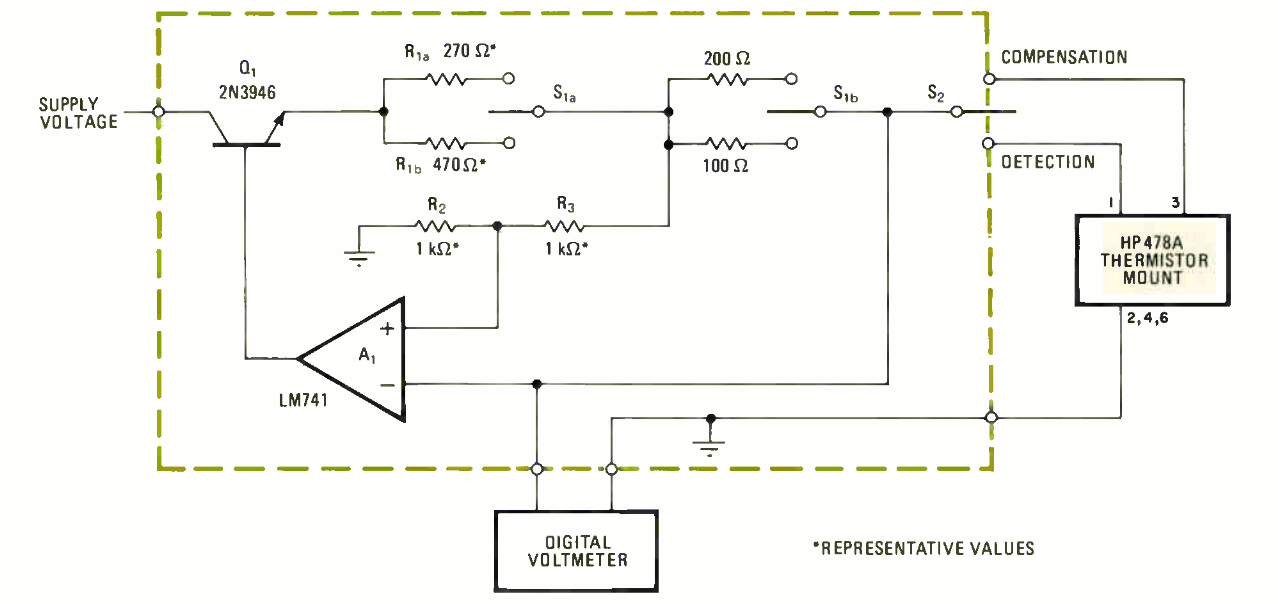
The system uses a resistance bridge to measure the difference in voltage between the detection and compensation thermistors in the mount. It also uses operational amplifier A_1 as a null detector and transistor Q_1 to control the bridge current.

S_1, a double-pole, double-throw switch in the measuring arm of the bridge, selects either a 100-Ω or a 200-Ω resistor, corresponding to the operating resistance (which can be specified for 100 or 200 Ω) of the thermistor mount to be measured. S_2 selects the thermistor elements in the mount to be tested.

The other leg of the resistance bridge contains two matched resistors, R_2 and R_3. R_{1a} and R_{1b} are current-limiting resistors whose values are determined by the supply voltage and the maximum current rating of the thermistor mount, which is 14 milliamperes. Q_1 can be any general-purpose transistor.

The bridge is self-balancing because the A_1–Q_1 loop automatically nulls the bridge independently of changes in temperature and so normalizes all readings. As the bridge current, which is controlled by Q_1, increases, heat is generated and changes the resistance of the thermistors monitored. A_1 detects any difference in voltage between its inverting and noninverting inputs and adjusts the base drive to Q_1 if needed, in order to reduce bridge current for a given supply voltage. In short order, the bridge becomes balanced as the voltages measured across the appropriate points in the bridge are equalized.

The absolute value of the voltage across the thermistor can then be measured between one end of the bridge and ground. In a standard bridge arrangement, in contrast, continued monitoring and adjustment for the null condition would be required for each mount being tested. In



Automatic null. Self-zeroing bridge enables fast check for mismatches of thermistors in HP-478A mount, independent of current through bridge and related temperature changes in thermistors. Circuit lets any mount be standardized to any HP-431 power meter.

Attention:

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Q. What are MicroSeries encoders?

A. They are ultra small, absolute, optical shaft angle encoders measuring only 1.6 inches diameter by 1.75 inches long for 13, 14 and 15 bit resolution (.8 to .4 millirad.) and 2.3 inches diameter by 1.75 inches long for 14, 15 and 16 bit resolution (.4 to .1 millirad.) with a small price to match their size.

Q. What do you mean by "small" price?

A. The price of Itek's MicroSeries encoders is less than ⅔ of the price of conventional optical encoders and significantly less than the price of resolvers and resolver-to-digital converters of comparable resolution.

Q. How do they compare with resolver systems on performance?

A. Itek's MicroSeries encoders are more than twice as accurate, have no slip rings or rotary transformers, use only DC power, and have less electronics because they are "inherently digital". This means better reliability and EMI performance even adjacent to torque motors.

Q. Why are they more accurate than resolver systems?

A. Resolver systems have a limited number of cycles per revolution (i.e. 1 for a single-speed resolver or 36 for 36:1 multi-speed resolver) and require substantial electronic interpolation to obtain 14 or 16 bit resolution.


μS___/23

μS___/16

MicroSeries encoders have many more cycles on the fine track (typically 1024 to 8192 cycles) which means higher accuracy with less electronics.

Q. What are the outputs?

A. The μS___/16 is available with natural binary and binary coded decimal mils (1 part in 6400) outputs. The μS___/23 is available with natural binary. Parallel outputs are standard on the natural binary units, but serial outputs can be provided. Serial output is standard on the BCD mils unit. Since the MicroSeries are absolute encoders, the outputs remain unchanged even with power interruptions.

Q. How is the electronics packaged?

A. The electronics is separate from the transducer and can be supplied as a module to be mounted on a printed circuit board or premounted on a board with or without a protective cover. The total volume is less than a pack of cigarettes.


Electronics

Q. What about pancake configurations?

A. Standard pancake units are not available at the present time. However, custom pancake designs can be developed for particular gimble assemblies. Contact Itek for details.

Q. Who needs them?

A. The MicroSeries encoders were specifically designed for military applications such as radars, optical sights, and guns on armored vehicles; laser designators/rangefinders on tripods or fixed pedestals; airborne turrets; and other military fire control applications. MicroSeries encoders are indicated where medium resolution, small size, and freedom from re-zeroing after power interruptions are required. They are designed (and priced) to be particularly attractive when the quantity required is 100 or more.

Q. What about commercial applications?

A. The MicroSeries encoders are probably over-designed in terms of small size, wide temperature performance, high shock environment etc. but the low price may still make them attractive for any applications requiring 13 to 16 bit resolution in an absolute encoder.

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Area Code (   ) Phone________________ actual operation, the system sends a dc output voltage across the compensation and detection thermistors of the mount under test. First the detection thermistors' output should be measured to within 0.001 volt of its true value. Then the voltage across the compensation thermistor should be measured. Readings should not differ by more than 0.030 v.

If readings are out of tolerance, two adjusting screws inside the thermistor mount permit compensation of the thermistors, within limits. ☐

Measuring picoamperes with extreme accuracy

by William D. Kraengel Jr.
Valley Stream, N. Y.

The accuracy of the simple measuring technique proposed by Battes ["Measuring small currents with an ordinary voltmeter," *Electronics*, Feb. 15, 1973, p. 118] can be greatly improved, to such an extent that nanoampere and even picoampere currents can be precisely determined. The basic technique remains unchanged: a voltmeter is still made to measure the potential developed across its own input resistor. But the results become more useful and precise when the original equation used to determine current is modified to compensate for the error caused by inserting the resistance in series with the circuit under test. Otherwise, the error in determining the actual current can be significant because the original equation is based on circuit assumptions that hold true only in certain cases.

As indicated in the figure, when the voltmeter's input resistance, R_{in}, is regarded as a calibrated current shunt, the test current, I_t, is calculated from:

$$I_t = V_m/R_{in} \qquad (1)$$

where V_m is the voltmeter's displayed reading. This is the equation for the approximate current as derived in the original article.

This current value approximates the true load current:

$$I_L = E_s/R_L \qquad (2)$$

where E_s is the source voltage and R_L is the sum of the source and circuit-load resistances. This equation holds true only if R_{in} is very low, since:

$$I_t = E_s/(R_L + R_{in}) \qquad (3)$$

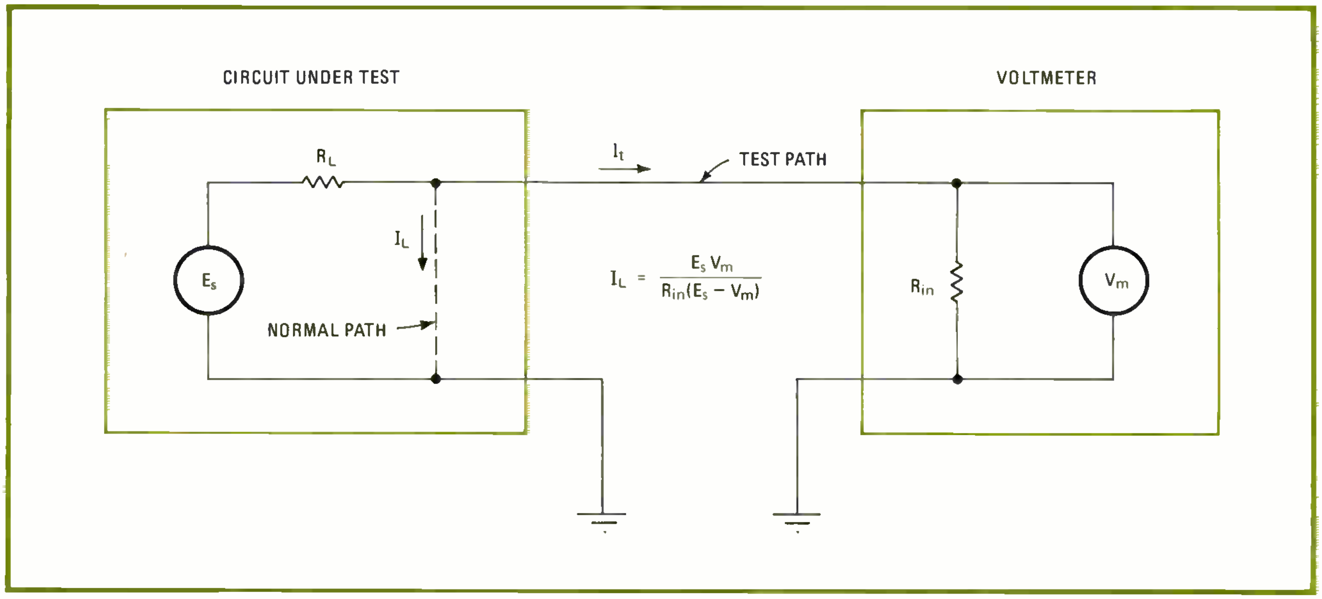
Thus the general equation for determining the true load current may be had by setting Eq. 1 equal to Eq. 2, solving for R_L, and substituting for R_L in Eq. 2 to yield:

$$I_L = E_sV_m/R_{in}(E_s - V_m) \qquad (4)$$

Consider the case where a digital multimeter with an R_{in} of 10 megohms measures V_m = 181.8 millivolts for an E_s = 2 volts and R_L = 100 MΩ. The test current calculated from Eq. 1 is 18.2 nanoamperes, whereas the value of I_L from Eq. 4 is 20 nA, the actual value. Thus a measurement error of about 10% is avoided.

Ac test current can be determined as well by simply replacing R_{in} with the voltmeter's input impedance, Z_{in}, in Eq. 4. The impedance must of course be known for every frequency of interest.

Though it is true that even currents in the picoampere range can be calculated, it must be noted that modern digital multimeters have input-bias currents on the order of 10 to 100 pA. This consideration alone invalidates the technique for measuring currents in that range. ☐



Accurate. Nanoampere currents can be precisely determined by measuring the potential developed across a voltmeter's own input resistance for a given test configuration and substituting the value into the redeveloped equation [*Electronics*, Feb. 15, 1973, p. 118]. Currents in the picoampere range can be found, too, provided they are well above the 10–100-pA input-bias value of the digital voltmeter.

Phase-noise nomograph eases power/bandwidth tradeoff

by R. S. Baggett
Rockwell International Corp., Collins Satellite Group, Richardson, Texas

The residual noise generated by a frequency- or phase-modulated system limits the amount of information that can be passed through a satellite communications network. But determining what tradeoffs to make in noise power versus bandwidth versus frequency can be tedious for those who must solve the defining equations repetitively. The nomograph shown is a quick way to relate the residual noise, also known as phase noise, to its equivalent noise power for a specified system bandwidth and frequency offset from the carrier.

More exactly, this nomograph converts phase noise in a 1-hertz bandwidth, which is measured in decibels below the carrier power (dBc/hertz), to decibels below a carrier that is undergoing a deviation of 200 kilohertz in a channel having a bandwidth of 3.1 kHz. The carrier deviation and channel bandwidth are industry standards.

The noise bandwidth, the frequency at which the measurement is taken (offset from the carrier), and the phase noise are related by:

$$\text{dBc/Hz} = 20\log(\Delta f_1/2^{1/2} f_m) \qquad (1)$$

where f_1 is the root-mean-square deviation of noise in hertz and f_m is the measurement frequency in hertz. Noise power in a bandwidth other than 1 hertz can be found with the aid of:

$$\Delta f_2 = (BW_2)^{1/2}\Delta f_1 \qquad (2)$$

where BW_2 is the actual bandwidth and Δf_2 is the new bandwidth of the noise.

When Equations 1 and 2 are combined, the result is:

$$\Delta f_2 = (2BW_2)^{1/2} f_m 10^{(\text{dBc/Hz})/20} \qquad (3)$$

When Δf_2 is related to the 200-kHz reference deviation by:

$$\text{dBm0} = 20\log(\Delta f_2/200{,}000) \qquad (4)$$

where dBm0 is defined as the equivalent noise power, and when BW_2 is made equal to 1.3 kHz and Eq. 3 is combined with Eq. 4:

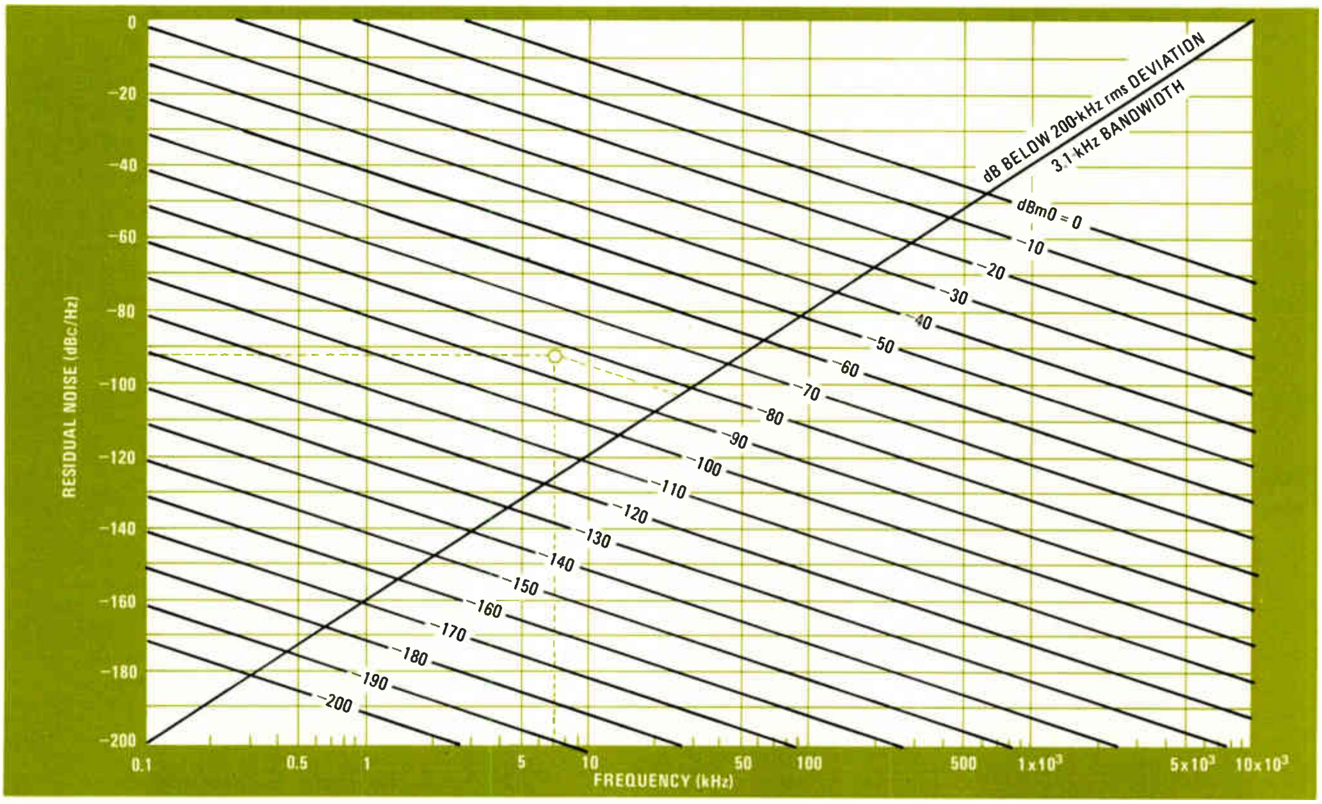
$$\text{dBm0} = -68.10 + 20\log f_m + \text{dBc/Hz} \qquad (5)$$

Equation 5 is plotted on the nomograph using lines of constant dBm0.

Use of the nomograph aids the designer in converting from a given dB_c/Hz value to its dBm0. For example, a noise at 15 Hz in a standard 3.1-kHz-bandwidth system has a measured (and calculated) $\text{dB}_{c/H}$z of −91.3 when f_m = 7 kHz. As shown on the sample plot on the nomograph, −91.3 is equivalent to a dBm0 of −82.5. As a check, Eq. 3 is used:

$$20\log(15/200{,}000) = -82.5\ \text{dBm0}$$ ☐

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.



Signal to noise. Nomograph relates phase noise to demodulated power for channel bandwidth of 3.1 kilohertz. In example, noise at 15 Hz produces phase noise of −91.3 dBc/Hz 7 kHz from carrier, generating an equivalent noise power of −82.5 dBm0.

Engineer's newsletter

Zn and Cd can give you more field than you bargained for

When working close to absolute zero, watch out for superconducting activity in the silver brazing alloy (silver solder) Easy Flo 3. It's commonly used for joining dissimilar metals, forming large fillets, and bridging gaps too large for the more fluid silver solders. But at milli-Kelvin temperatures, according to James R. Thompson and John O. Thomson of the physics department of the University of Tennessee in Knoxville, the material **can foul up sensitive magnetic devices like magnetometers by generating perturbing fields.**

The main ingredients of the alloy are zinc and cadmium, both of which are superconductors in their elemental form. Nonsuperconducting alloys like Silvalloy 355 are preferable for very low-temperature applications.

Comsat slide rule aids design of satellite links

"It makes a decibel artist out of every satellite user," says Neil R. Helm of his company's Satellite Service Calculator. Available free from Communications Satellite Corp., the 6-by-10-in. slide rule makes it a snap to calculate the major rf parameters for up- or down-link performance of both the earth station and the satellite.

About a dozen parameters, including **system noise, carrier-to-noise ratio, effective isotropic-radiated power, and various figures of merit,** can be estimated. Write to Neil Helm, manager of development applications, Comsat Corp., 22300 Comsat Drive, Clarksburg, Md. 20734, or phone him at (301) 428-4531.

Kit shows how to mount power semiconductors

A common cause of failure in power semiconductors is improper mounting—using too much or too little thermal compound or applying too much torque. To assist both manufacturers and repair personnel with this problem, Westinghouse Electric Corp.'s Semiconductor division has put together a portable mounting kit. Along with **three different thermal compounds and a Never-Seez compound that prevents nut and thread binding,** the kit contains two rubber squeegees for applying the compounds, plus cleaning solvents and tissues. Also included are a laminated instruction card, a mounting guide template, a user's manual, and a data book. The kit costs $39.95 from the Westinghouse Technical Information Center, Semiconductor division, Youngwood, Pa. 15697.

Where to find data-communications standards

If you need to determine which data-communications standards apply to your network requirements and don't know where to start, take a look at "McGraw-Hill's Compilation of Data Communications Standards." This 1,133-page reference work contains verbatim reprints of 87 relevant standards promulgated by the Consultative Committee for International Telephony and Telegraphy (CCITT), the International Organization for Standardization (ISO), the American National Standards Institute (ANSI), the Electronic Industries Association (EIA), and the Federal Telecommunications Standards Committee (FTSC). **Also included are the as-yet unpublished Federal Standard 1003 and CCITT's just published May 1977 provisional amendments.**

The book sells for $165. To order, write to Data Communications Standards, P. O. Box 669, Hightstown, N. J. 08520, or phone (609) 448-1700, ext. 5494.

Harvey J. Hindin

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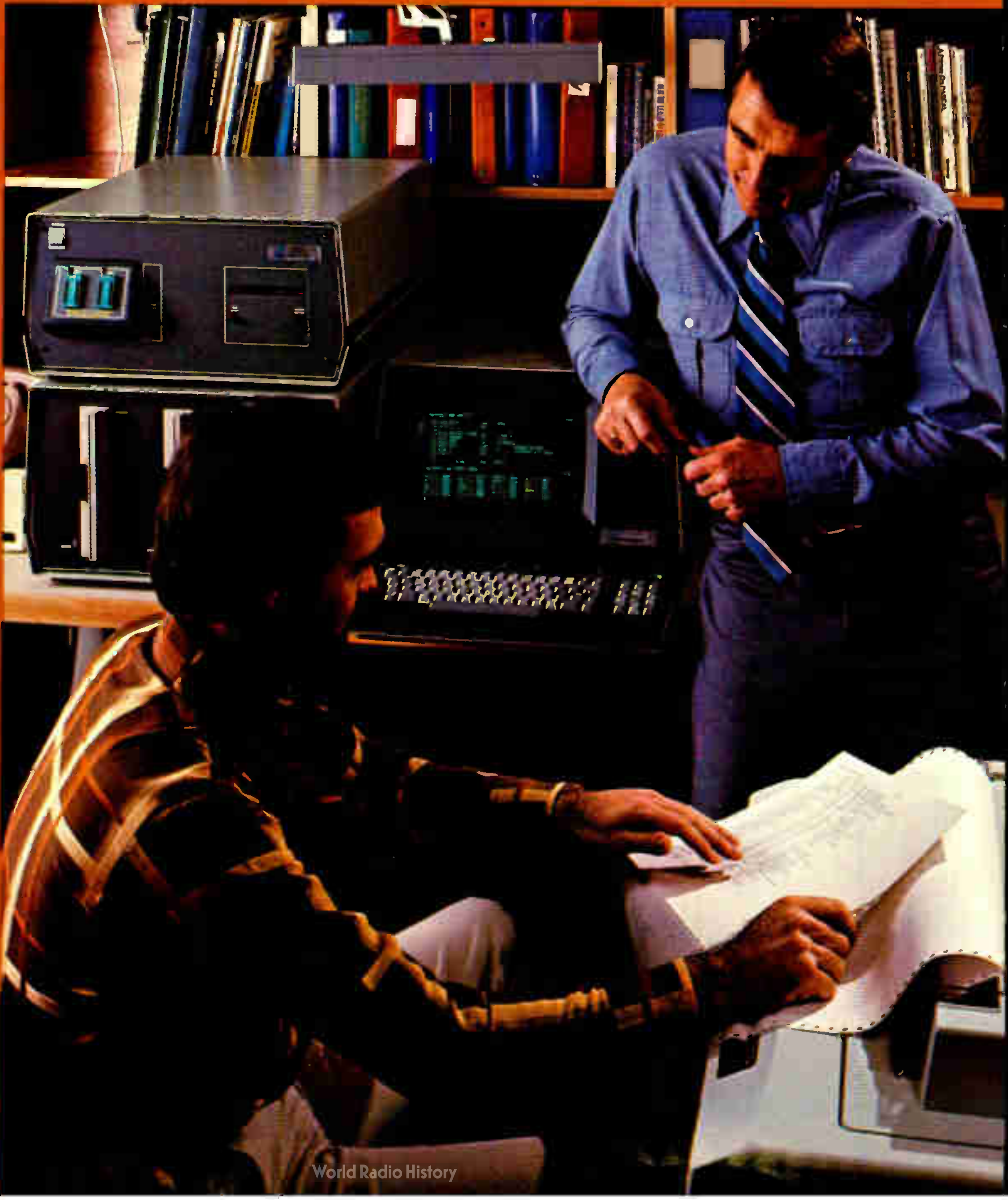

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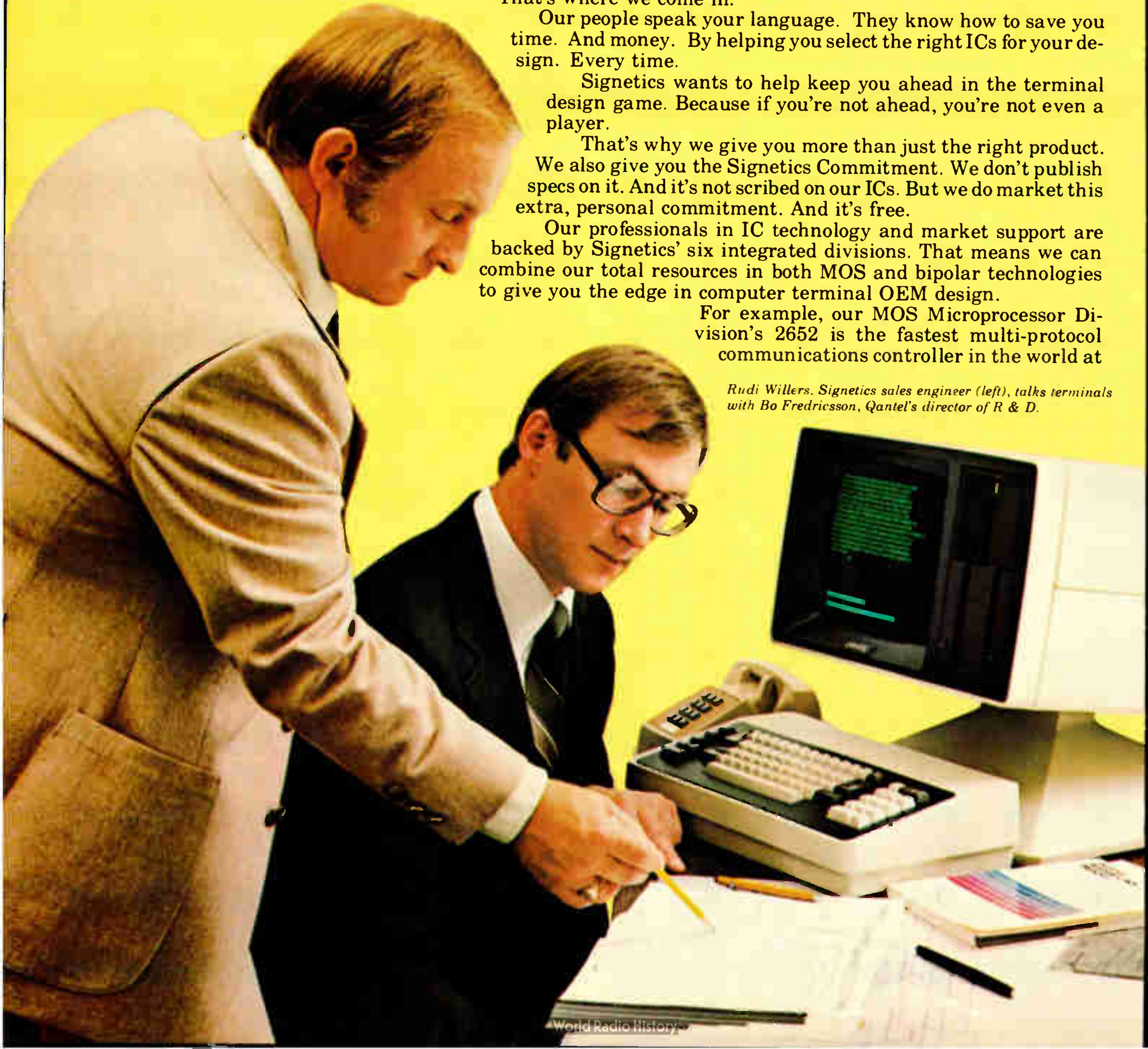

Rudi Willers, Signetics sales engineer (left), talks terminals with Bo Fredricsson, Qantel's director of R & D.

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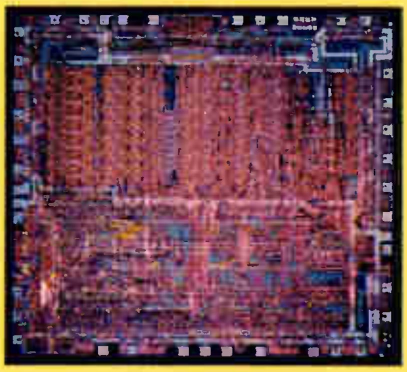

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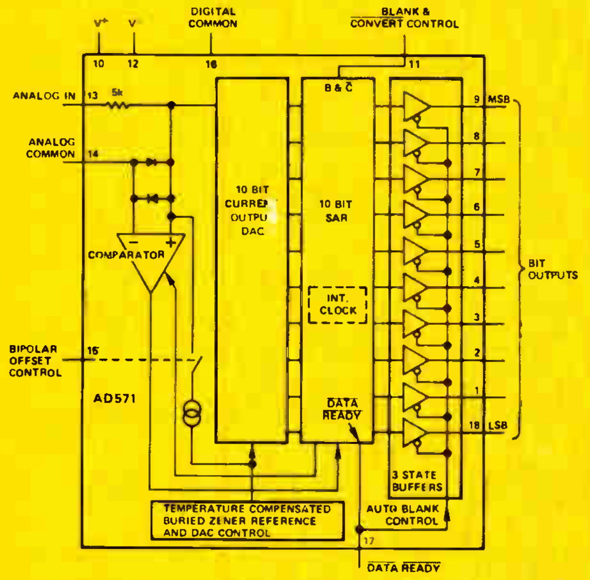

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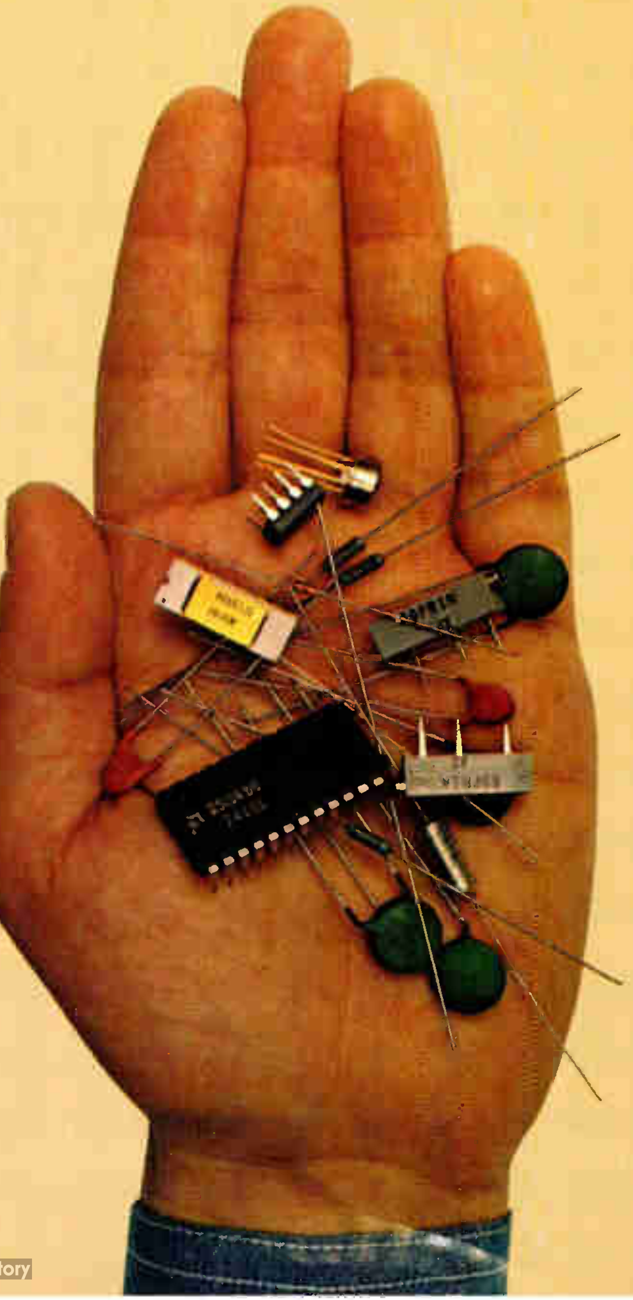

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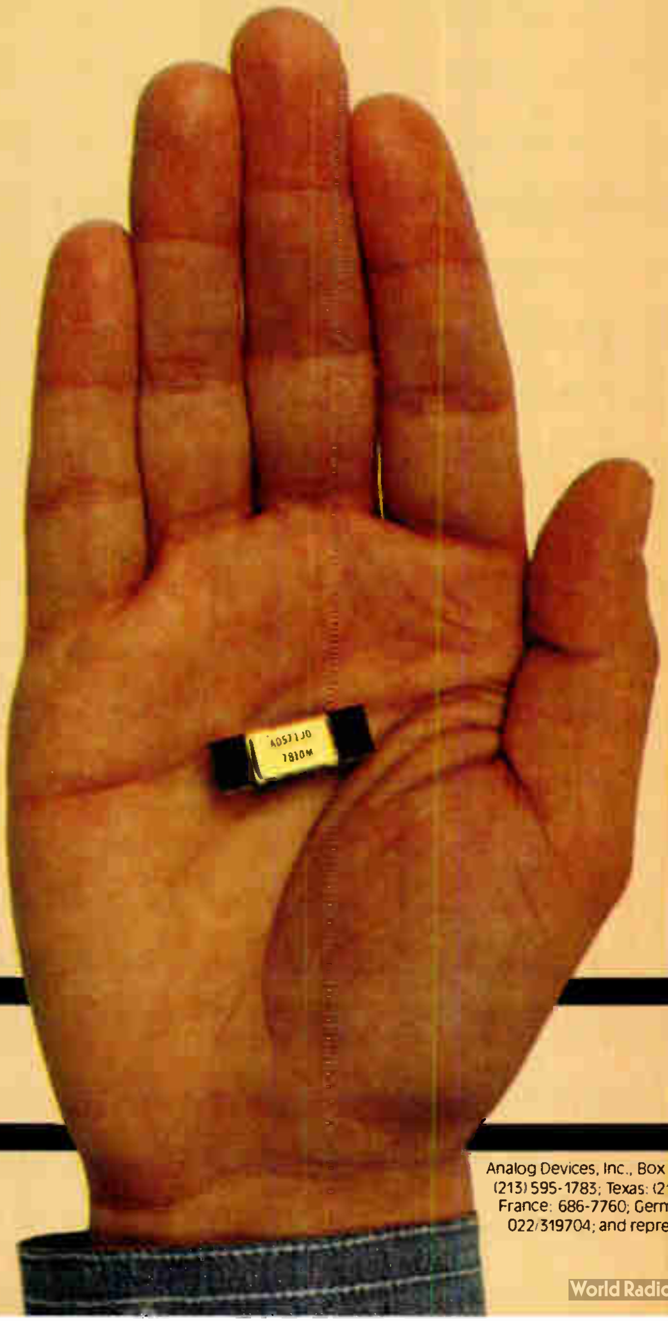

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World Radio History

Beam-penetration displays get cheaper

High-resolution three-color cathode-ray-tube unit sells for $4,750, writes at 25.4 centimeters/second, and consumes ony 100 watts

by Robert Brownstein, San Francisco regional bureau

Color graphics displays are catching on because they make it so much easier to sort out densely packed information. Designers of equipment for airport surveillance radars, computer-aided design, and flight simulation, among others, are finding that their added value outweighs their added cost.

Two basic techniques have emerged for making color cathode-ray-tube displays—shadow masking and beam penetration. The former lacks the speed and resolution of the latter, whereas the latter lacks the full-color capability and economy of the former. The economic distinction between the two, though, is blurred by Hewlett-Packard's new model 1338A three-color display, a beam-penetration unit that sells for less than $5,000.

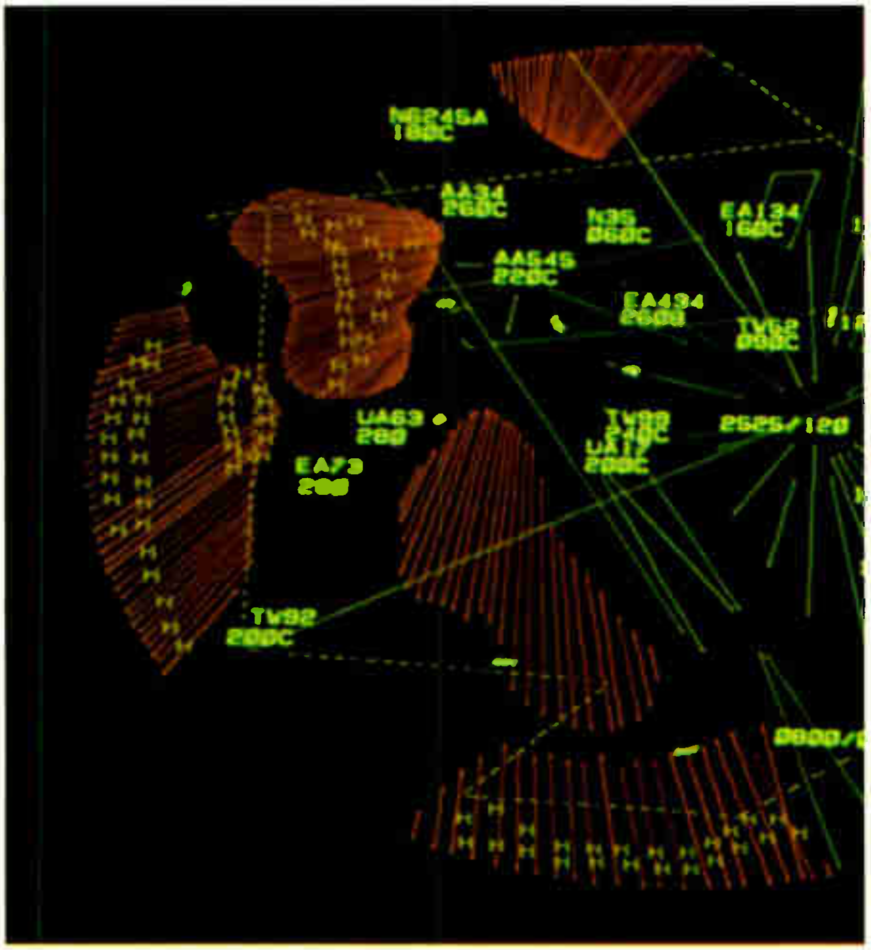
In defining its goals for the product, HP chose to tackle the power consumption and price limitations of the beam-penetration concept while accepting its sparse color repertoire, according to product manager David Wilson. The designers aimed at a display that would sell for less than $5,000 and use less than 100 w of power, thereby becoming a competitive entry into the beam-penetration system market.

The upshot of the designers' work is a unit with a 7-inch-diagonal CRT of the electrostatic-deflection type. Using electrostatic, rather than magnetic, deflection results in a full-screen deflection time of only 100 ns and also helps the system to meet the overall power consumption goal. It also allows the price to come in on target at $4,750.

"Where resolution and updating speed are not critical, as in displays for process-control or business, the shadow-masking systems offer capabilities that beam penetration cannot match," concedes Wilson. However, where there is a need for nearly calligraphic quality of presentation and rapid screen updating, the user has no choice but to go with the limited color capability and higher power requirements of a beam-penetration system, he asserts.

In a radar traffic control example, the graphics data—aircraft position, alphanumerics, and cloud patterns—can be displayed simultaneously and updated quickly. Further, because there are three colors, important details can be discerned even where they overlap with other information (see photo).

To generate the three colors, the display's cathode-ray tube uses a two-layer phosphor screen. When excited by the electron beam, the inner layer (closer to the electron gun) produces red light; the outer



layer produces green. To generate red light, a total beam-accelerating voltage of 6 kV is used, sufficient to excite the red but not high enough to penetrate through to the green layer. At 8.5 kV, both red and green light are produced, resulting in a yellow image. At 12 kV, the green light completely overpowers the red.

An important design feature of the CRT is its low-gain lens, which allows constant deflection sensitivity despite the large changes in post-accelerator voltage needed to produce the various colors. This greatly simplifies the required deflection-drive circuitry and helps to keep down both cost and switching time.

As important in the CRT circuitry is a monitor that limits the number of color changes per fixed frame period. This keeps color changes from slowing down the display and increasing power consumption. By writing all of the data of a given color before switching to the next one, little writing time is lost, Wilson says. With efficient programming, the loss can be held to 2%. In any event, the monitoring circuit will limit it to at most 12%.

In addition to speed, beam-penetration displays are known for their high resolution. The 1338A is no exception: it has a spot size of less than 0.3 mm (12 mils). The spot can write across the screen at linear rates in excess of 25.4 cm/s with a full-screen deflection typically requiring only 1 V. The exact voltage can be internally adjusted from 0.9 to 2.5 V. For added flexibility, the user can switch in a 5:1 or a 10:1 attenuator whenever it is necessary.

The 1338A interfaces directly with HP's 1350A graphics translator, but can be used independently with other systems, too. Colors are specified by a 2-bit binary code on the unit's color bus. Once the code is latched by a validation pulse, the color is generated on the screen and a handshake signal is produced by the 1338A in order to indicate that the request for the color change has been received.

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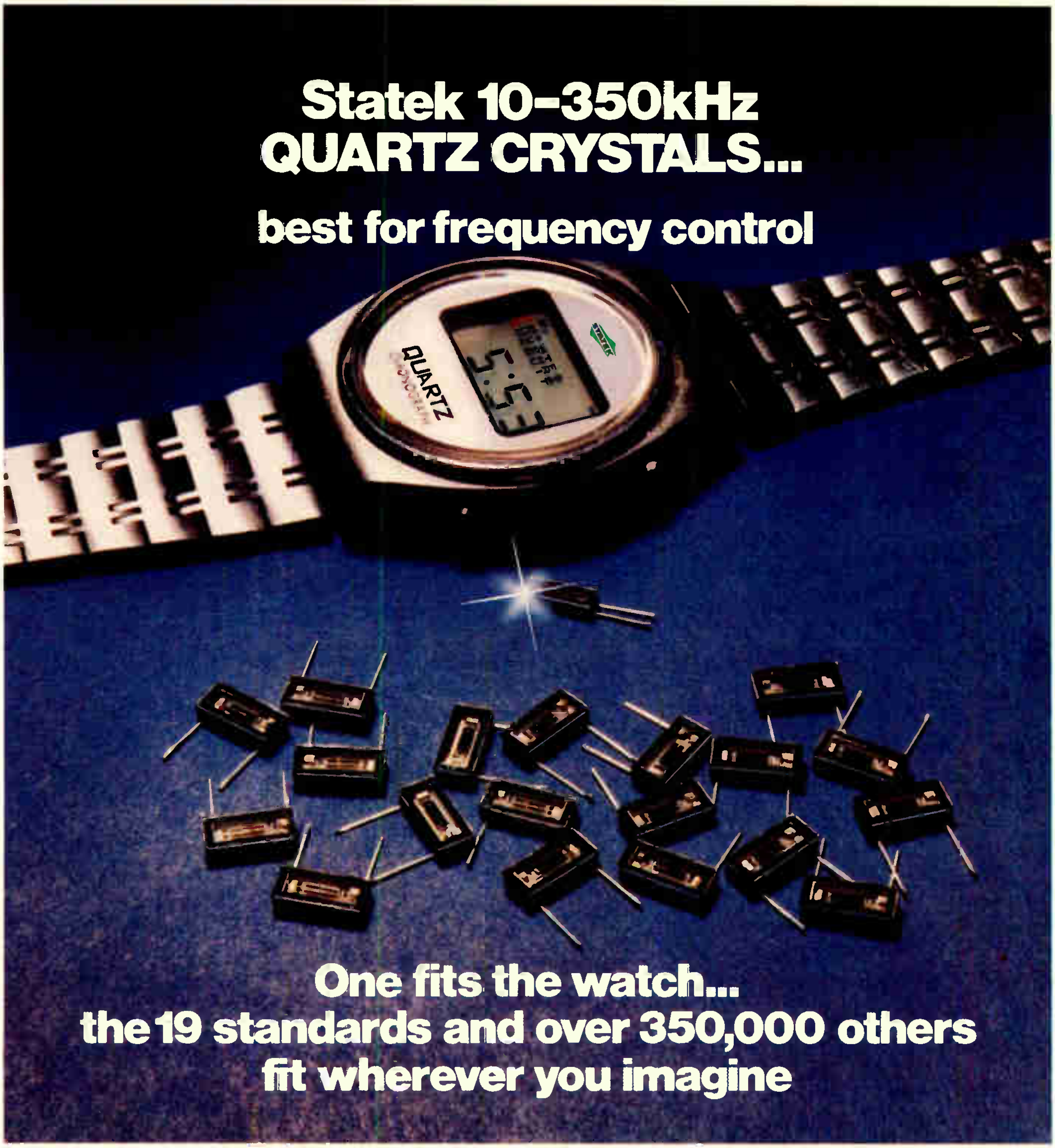

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MC6801 Expanded Non-Multiplexed Mode

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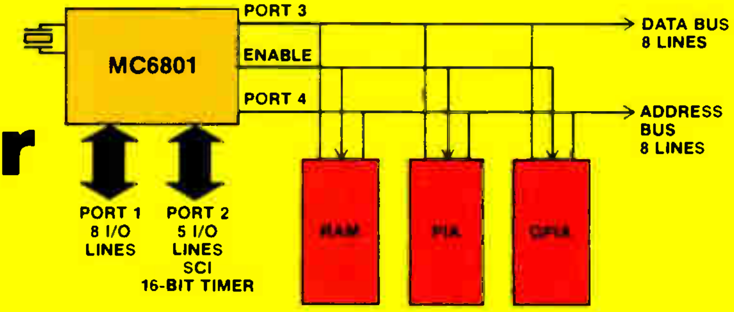
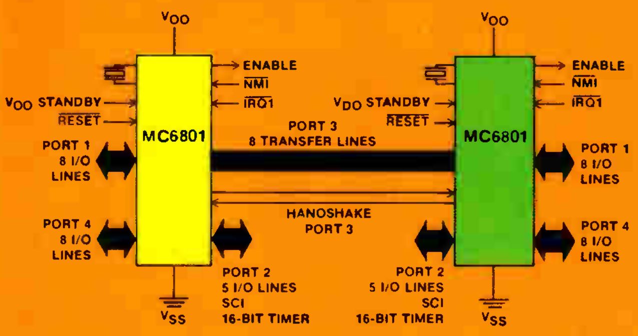


MC6801 Single-Chip Mode

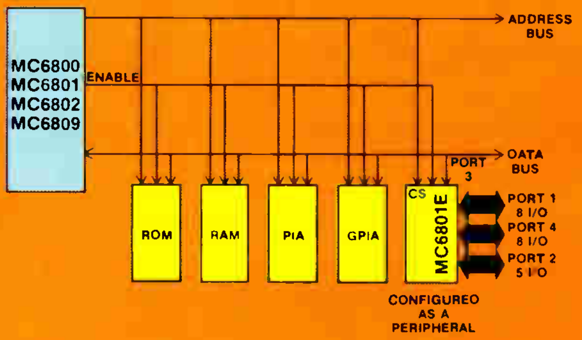
Two MC6801s tied together, both in single-chip mode, for dual processor configuration.



Parallel I/O Interface

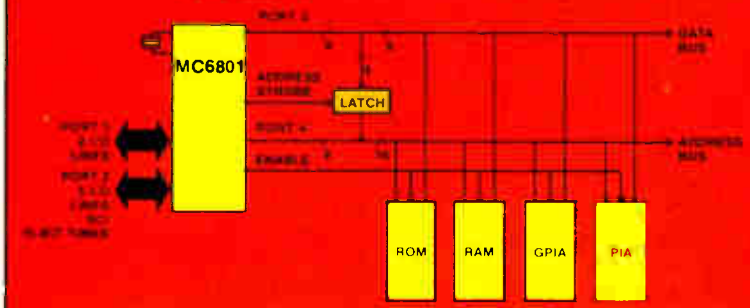
MC6801E Single-Chip Mode

Peripheral controller configuration as an alternative to custom chip or MSI design.



MC6801 Expanded Multiplexed Mode

Full 65-byte configuration for higher-end communication/EDP applications.



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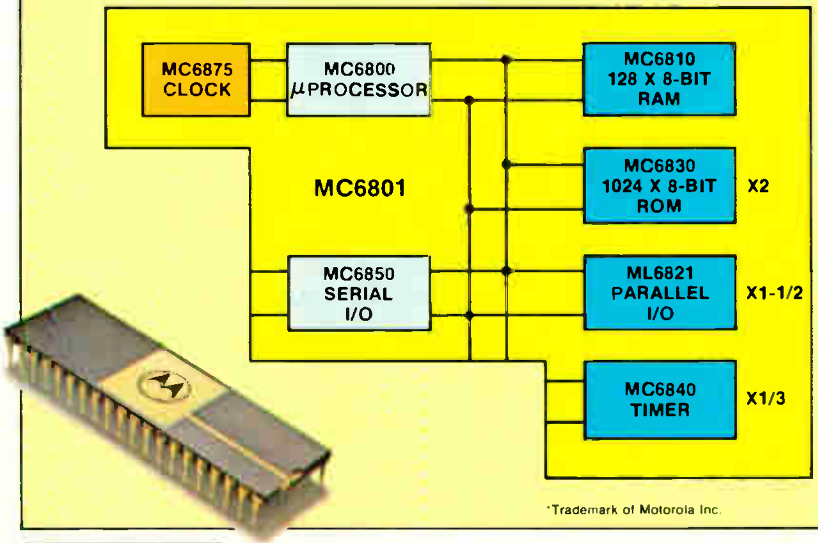

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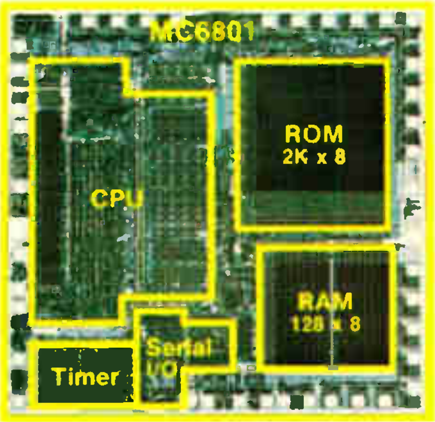

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The MC6801 microcomputer is available now, in limited sample quantities. Production quantities will be available in December. Same for a no-ROM version of the '6801, the MC6803. An EPROM version—the MC68701—will also be out in the fourth quarter, while the MC6801E—which is the '6801 wired for external clock operation—will bow first quarter '79.

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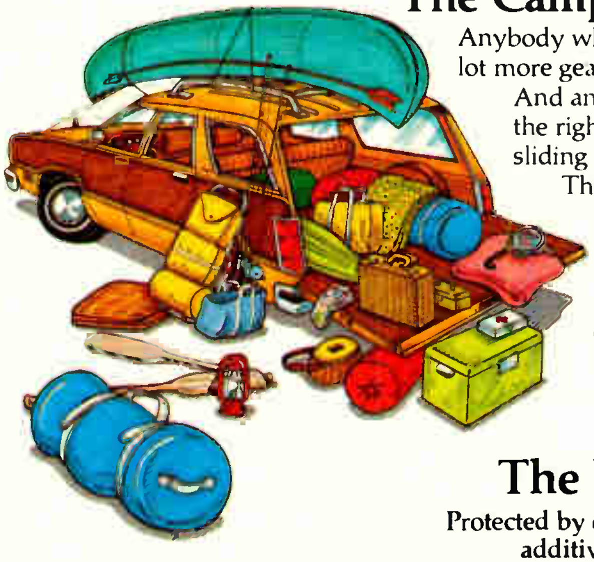

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Chip formats hard-sectored floppies

N-MOS device fits between host processor and disk controller, allows read and write operations simultaneously on two drives

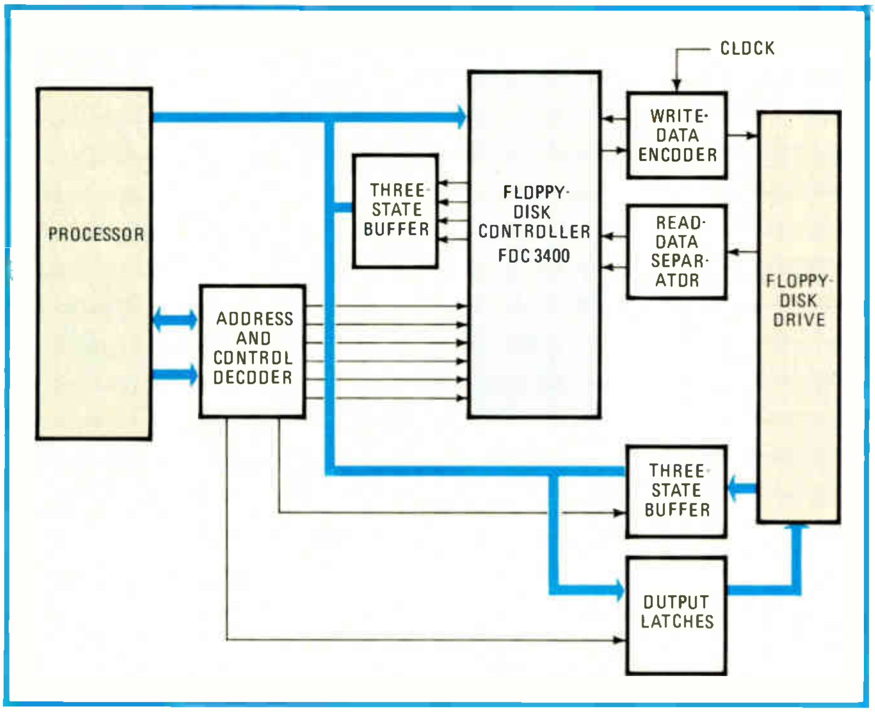
by Ray Capece, Solid State Editor

Several manufacturers are making floppy-disk controller chips that use the soft-sectored data format, an approach established as a *de facto* standard for floppies by IBM Corp. that devotes disk data to sectoring information. But Standard Microsystems Corp. is gambling that there are still plenty of people using hard-sectored floppies, which have holes punched for sectoring information. That's why the Hauppauge, N. Y., semiconductor manufacturer has built a chip that takes care of the data handling for hard-sectored floppy drives.

"It will test the hard-sector market," says Gerry Gollub, senior vice president at SMC. "We think lots of people in the word-processing and hobbyist markets will stick with hard sectoring." The approach stores 23% more data on each disk than soft sectoring: 315 kilobytes versus 256 kilobytes of formatted data on a single-sided, single-density-encoded 8-inch disk, for example.

The FDC3400 chip, built with an n-channel metal-oxide-semiconductor process, fits between a host processor and the drive control circuits, as shown in the figure. It works with both 5¼-inch minifloppy and 8-inch standard floppy drives.

During a write operation, the FDC3400 receives parallel data from the processor and shifts it out serially to the data-encoding logic; conversely, during a read operation it receives a serial data stream from the data separator, establishes byte synchronization, and transfers data in bytes to the processor.



The 40-pin chip, which uses +5- and −12-volt supplies, is thus only a data handler, not a full-fledged controller. It is not involved with lifting of the read/write head or the operation of the track-following servo. SMC explains that while it could have built a full-blown controller, there are too many unknowns in the design. "There are no standards, not even *de facto* ones, in hard-sectored drives," says Gollub. He explains that each manufacturer devises his own sectoring format. "We detect the sync bytes with our chip, for example," explains John Tweedy, manager of product planning at SMC, "and external circuits do the counting according to the number of sync bytes. But if the standard was, say, two bytes, we would be doing the counting on chip."

The company did, however, put as much on the chip as it thought would be readily acceptable. The FDC3400 detects data overrun and underrun, which occur when either too little or too much data is being written into a sector, and it indicates these conditions on its status lines. Also, since the chip has separate storage registers for read and write data, the operations can be performed simultaneously on two different drives with a single chip. A byte-search feature is even included that permits the processor to search for the occurrence of a specific byte while reading a sector simply by loading a different byte into the byte-sync register. The chip is available from stock for $7.00 each in 1,000-piece quantities.

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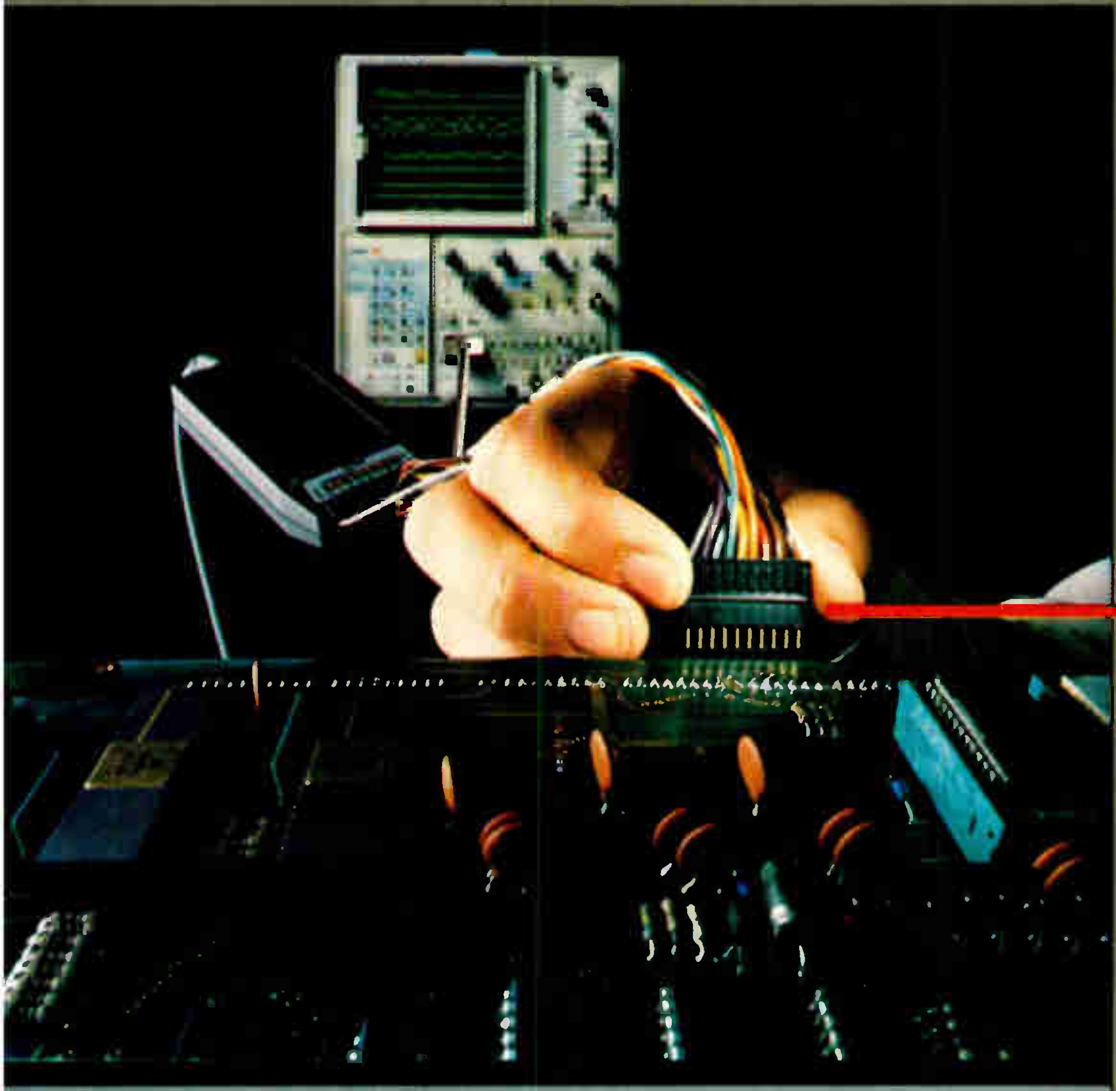

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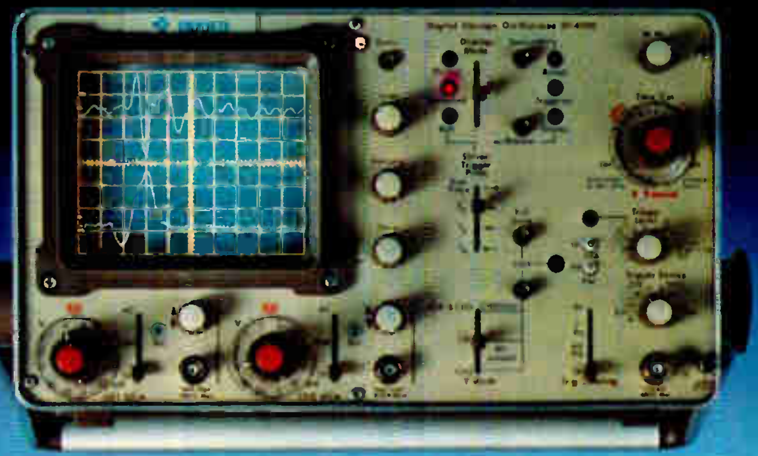
Circle 177 on reader service card



Extend your storage capabilities beyond the conventional.

Now Gould offers a range of digital storage oscilloscopes that offer a world of advantages over conventional tube storage technology, beginning with being able to capture transient or "one-time" events and store them indefinitely for display or hardcopy printout. This makes them ideal for electronic, electromechanical, educational, and biophysical applications.

Both the OS4000 and the new OS4100 combine the capabilities of semi-conductor memory with a bright, stable, flicker-free display. This technique allows analysis of signal build-up and decay characteristics through pre- and post-trigger viewing. Expansion of the display after storage permits detailed study of specific areas of the trace.

The new model–OS4100–also offers you stored X-Y displays, channel sum or difference and a maximum of 100μV per cm sensitivity with noise suppression. A unique trigger window circuit assures capture of transients of unknown polarity.

Other outstanding features include automatic operation, display of stored and real time traces simultaneously and hard copy memory output in digital or analog form. And IEEE488 is available for compatible interfacing.

If features like these aren't enough to lure you away from less sophisticated instruments, remember that Gould scopes are backed by a two-year warranty of parts and labor, exclusive of fuses, minor maintenance and calibration. And application assistance, customer training and worldwide service centers are part of Gould's customer support program.

GOULD

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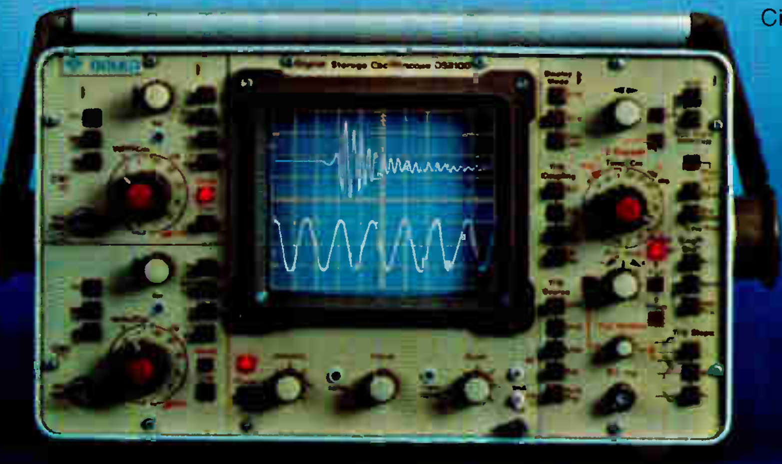


Microcomputers & systems

Video boards end access conflicts

Transparent memory allows full-speed computing with glitch-free displays

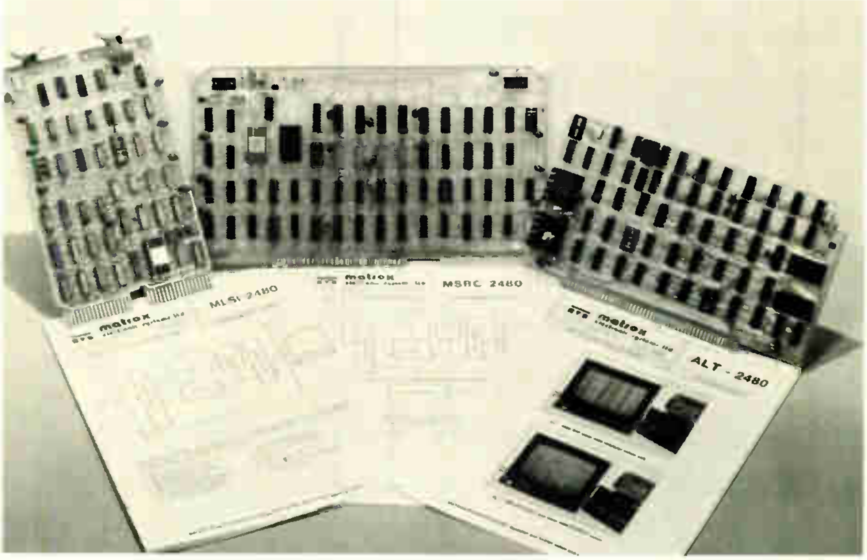
A classic shortcoming of video controllers stems from the fact that only one device at a time can access the memory holding the information to be displayed. But two devices need access to the refresh memory—the cathode-ray-tube controller and the central processing unit that updates the memory's contents. Since both devices may want to control the memory at one time, a quarrel ensues over whose turn it is to get at the data.

This memory-contention problem has been cleared up with a concept called transparent memory, developed by Matrox Electronic Systems. The feature has been incorporated into a series of video-display boards that provide a 24-line-by-80-character display. So far, the series includes cards compatible with the Intel iSBC-80 Multibus (National BLC), the Digital Equipment Corp. LSI-11/2 bus, and the S-100 bus. This list will soon be expanded to include Motorola's Exorcisor bus and others.

Before transparent memory, the memory-contention problem had been circumvented with two approaches. The first scheme, commonly known as the video–random-access-memory approach, allows the refresh memory to be switched between the CRT controller and the CPU via address multiplexers and three-state buffers. The flaw in this method is that CPU accesses disconnect the refresh memory from the controller, creating annoying streaks on the screen. The interference can be eliminated by limiting CPU accesses to the horizontal- or vertical-retrace intervals, but this severely restricts the speed of screen updates.

Another solution uses a direct-memory-access approach. The refresh memory is part of the CPU's main memory and the CRT controller forces the central processor to halt whenever the controller requires access to the data. Since the display memory needs to be refreshed frequently, this method adversely affects system timing and bogs down the CPU.

Transparent memory, however, offers the best of both schemes: the CPU is never interrupted; it has access to the refresh memory at any time; and there is never an unsightly glitch on the screen. This method does not rely on the peculiar timing



characteristics of a particular CPU, and it can be applied to a variety of microcomputers and minicomputers. A unique multiplexing technique allows nonconflicting accesses by both CPU and CRT controller.

All cards in the series feature memory-mapped addressing. This allows the full power of the processor's instruction set to manipulate the display data. On board is a 128-location character generator that incorporates the full ASCII repertoire with upper- and lower-case letters, as well as limited graphics. The characters are formed with a 5-by-7-dot matrix in a 6-by-10 field, which results in a non-interlaced display that is completely flicker-free.

All models suit both American and European television standards and operate from a single +5-v supply. The MSBC-2480, MLSI-2480, and ALTR-2480 products mate with the Intel, DEC, and S-100 buses, respectively. The cost of a single board is $495; for a quantity of 100, the price drops to $350. Delivery time is two to four weeks.

Matrox International Corp., Trimex Building, Mooers, N. Y. 12958. [371]

Software lets many terminals access single microcomputer

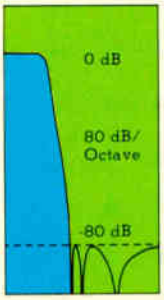
Those who would like to provide simultaneous access to their Z80-, 8080-, or 8085-based systems from a number of different terminals can now do so with Pana/Basic. The software package consists of a multiterminal operating system, an extended-Basic processor, and a comprehensive file-management system.

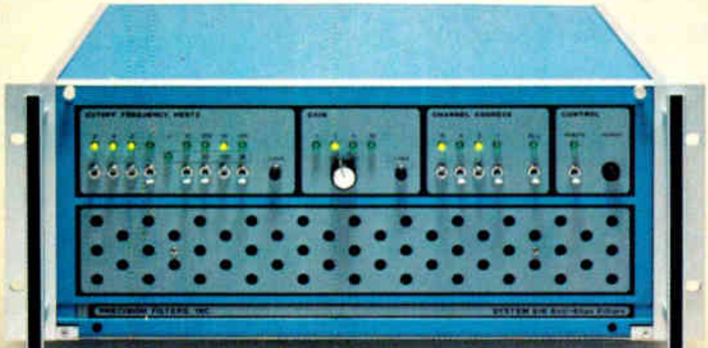
The software system uses queued inputs and outputs to permit overlapping of computation and I/O operations. A background processor that handles long-running programs frees the system for independent enquiries and data entry from multiple terminals, and an immediate mode lets operators conversationally control the operating system.

Data file capabilities include most of those specified by ANSI Cobol 1974, level 2. File organizations include sequential, relative, and indexed sequential; available file access modes are sequential, indexed, and consecutive, and files can be accessed dynamically—that is, the same file may be accessed by multiple users in different modes, unless it is being updated.

Files are identified by coding which prevents unauthorized access. Most data records can be retrieved within two or three disk-access periods because of a proprietary indexed-search design.

Pana/Basic can manipulate data in any one of four formats: decimal, extended precision decimal, binary integer, and string. In the extended precision decimal mode, accuracy is





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For information, contact a Boschert representative. Or write Boschert Incorporated, 384 Santa Trinita Ave., Sunnyvale, CA 94086. Phone (408) 732-2440. TWX 910-339-9241. The finest microprocessor-based systems are powered by Boschert. What about yours?

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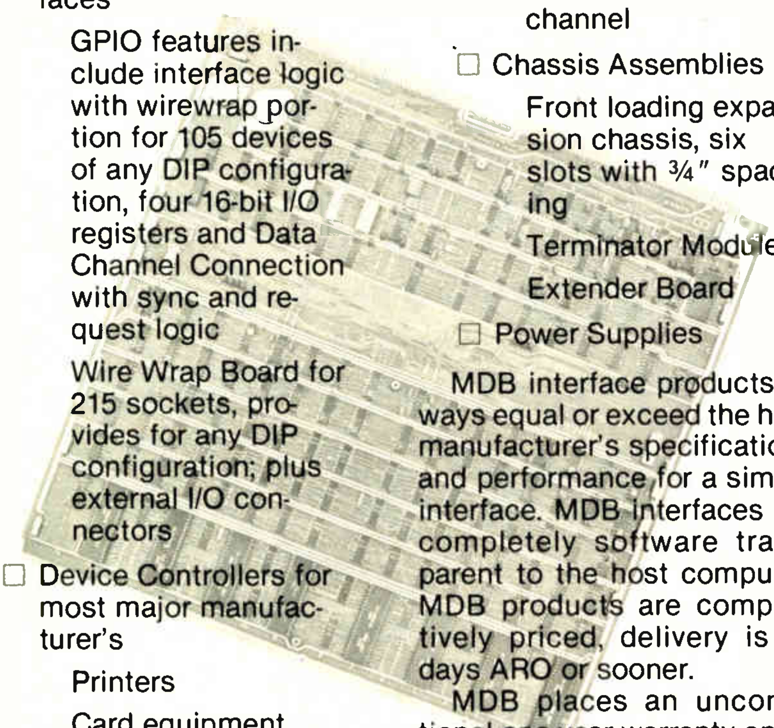

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15 decibel digits at a maximum.

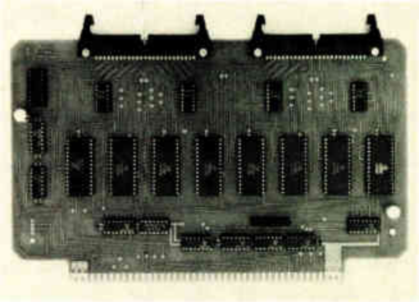
The software package is available on a nonexclusive permanent licensing basis to original-equipment manufacturers for a one-time fee of about $150,000.

Panatec Inc., 1527 Orangewood Ave., Orange, Calif. 92668. Phone (714) 633-8961 [373]

M6800-compatible module times with 24 clocks

One of a family of support modules designed for compatibility with the M6800 microprocessor, the model 9640 is an array of eight MC6840 programmable timers. Each timer can be programmed to perform three different timing functions, giving the module a total of 24 different timers.

Individual MC6840s occupy 8 bytes of memory and the module can be strapped to any 64-byte memory location. Buffered timer input/output lines are user-accessible by means of two flat-cable connectors at the top of the card, and system bus lines are also buffered. In single quantities, the completely populated version is priced at $350 and is available from stock.



Creative Micro Systems, 6773 Westminster Ave., Westminster, Calif. 92683. Phone (714) 892-2859 [374]

Tape-drive interface keeps data moving on Multibus

The QIM-1/MX is a tape-drive interface that connects the Intel SBC 80/10, 80/20, MDS, or any Multibus computer to as many as

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Circle 185 on reader service card

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Speed isn't the only reason our LSI testers are moving so fast.

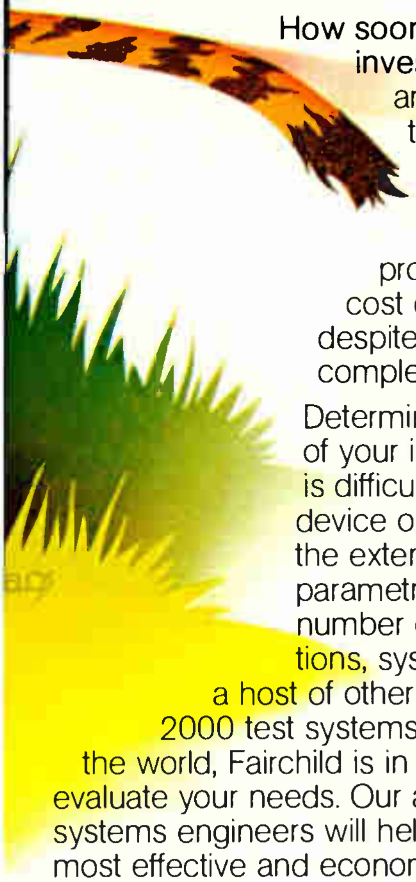
Sure, speed is important when you're testing complex LSI and VLSI devices, but there are a lot of other factors to consider before you spend a hundred, two hundred or three hundred thousand dollars for a semiconductor test system. Things such as: How soon do I recoup my investment? Is the system powerful enough to meet my testing needs as they become more complex? What and how much software support can I expect? How about training, application support, installation and service?

These are all valid questions that you should ask of any test system manufacturer before you make a decision to buy. We'd like to give you some of Fairchild's answers.

Is the system powerful enough to meet my testing needs as they become more complex? With the fast moving pace of semiconductor technology, you have to be careful that today's effective tester doesn't become tomorrow's white elephant. This won't happen with Sentry.®

Today, Sentry systems will routinely handle microprocessors, peripheral chips, bit slices, phase lock loops, RAMs, ROMs, shift registers, universal asynchronous receiver/transmitters (UARTS) and digital hybrids in technologies such as NMOS, PMOS, CMOS, SOS, ECL, DTL, TTL and I^2L.

And your Sentry system will keep pace with the technical requirements of tomorrow's most complex devices as well. Devices such as high performance, extended function microprocessors, large memory circuits and the most versatile special purpose devices are well within the testing capability of the Sentry.



How soon do I recoup my investment? Testing costs are rising fast. But today, thanks to Sentry's throughput, 196K computer memory and real-time multiprocessing capability, this cost can be reduced, despite the increased complexity of your devices.

Determining the effectiveness of your investment, however, is difficult. It depends upon the device or devices to be tested, the extent of testing (functional, parametric, dynamic, etc.), number of multiplexed stations, system architecture and a host of other factors. With over 2000 test systems installed throughout the world, Fairchild is in a unique position to evaluate your needs. Our application and systems engineers will help you determine the most effective and economical solution to your present and future requirements. Just give us a call.

What and how much software support can I expect? As the undisputed leader in semiconductor testing, Fairchild offers the broadest range of software. It includes problem solving software such as general-purpose utility programs, debugging aids, analysis/characterization programs, FACTOR enhancements and peripheral control routines for delivering management information; Device test programs for virtually every type, class and family of semiconductor; and Systems operating software to control all the internal system functions, housekeeping, test data exchange between peripherals, processors and memory and the self diagnosis routines to verify its own operating integrity. And all Sentry systems feature a high level of source program compatibility to minimize programming costs as you increase or expand your Sentry test facility.

How about training, application support, installation and service? Our products made us number one in the semiconductor test industry. Our service keeps us there. Training centers in the U.S., Europe and Asia have taught over 5000 engineers and technicians the latest in LSI and VLSI testing techniques. Our worldwide application staff will help you develop test programs to suit your requirements so your Fairchild system is productive from the moment it's installed. And our field service group will be close by to keep your system running.

What if I have a dedicated memory testing application? Fairchild's Xincom III can handle your most exacting memory testing requirements: static and dynamic MOS, bipolar and CCD devices. It can be used in production and incoming inspection for qualification testing or in the QA department and engineering labs for complete circuit characterization.

The Xincom III features Fairchild's unique distributed architecture that controls up to eight test satellites, each with two heads. This means that you can do real time foreground testing of up to 16 different devices simultaneously; a capability unmatched by any other memory tester.

And, while this testing is going on in the foreground, you can utilize Xincom III's background capability for program development, data analysis and logging and for printer/CRT interaction.

Here's where speed is really important. The unprecedented demand for Sentry and Xincom systems has us working three shifts already. To assure the 1978 delilvery of your system, you'd better hurry. Just mail the coupon today or better still, give us a call. **Fairchild Test Systems Group**, Fairchild Camera and Instrument Corp., 1725 Technology Drive, San Jose, California 95110 (408) 998-0123

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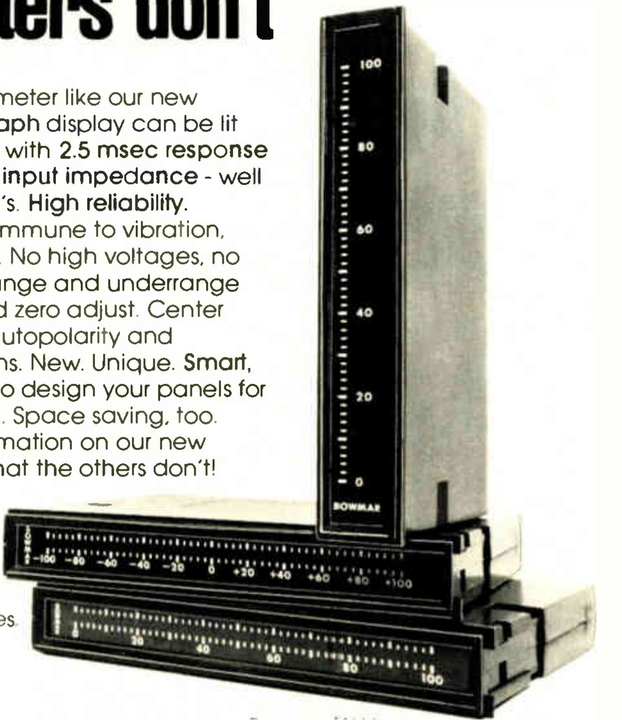

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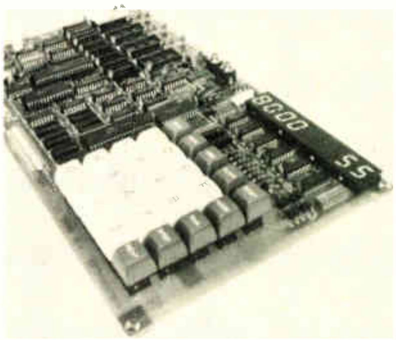

once through with school, can easily find work in the process control, distributed processing, or environmental monitoring and control fields.

The TK-80A is priced at $299 in single quantities and is available immediately.

NEC Microcomputers Inc., 173 Worcester St., Wellesley, Mass. 02181. Phone (617) 237-1910 [376]

LSI-compatible card doubles memory by halving height

The NS11/2P condenses quad-height card features into a double-height card, so that two 5.187-by-8.43-by-0.50-in. cards can provide 128 kilobytes of address space in a single card slot. The card is plug-compatible with LSI-11, LSI-11/2, and PDP-11/03 microcomputers.

Each 32-K-by-18-bit card, fabricated using n-channel metal-oxide-semiconductor random-access memory, offers on-board parity generation and checking circuits, external or internal refreshing capability, and provision for backup batteries. Read-access time for memory is 250 ns and read cycle time is 500 ns; write time and write cycle time are 130 and 545 ns, respectively.

The card is priced at $1,565, and a depopulated version with half the memory capacity is available for $965. Delivery is 30 days after receipt of order.

National Semiconductor Corp., Computer Products Group, 2900 Semiconductor Dr., Santa Clara, Calif. 95051 [377]

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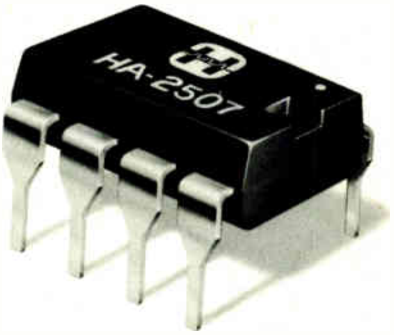

With operating temperatures from 0°C to +75°C, the new Harris op amps cover a wide range of industrial and commercial applications including: Laboratory-grade test equipment. Automatic electronic test systems. Medical patient monitoring systems. CRT displays. Process control systems...and many more.

Harris epoxy op amps provide the highest level of ac performance that is commercially available in a monolithic form. They give the designer a new degree of freedom without cost concern; give the customer a new measure of economy without forfeiting performance. And that should satisfy both you and your boss. Get the happy story today by calling the Harris Hot Line, or write: **Harris Semiconductor Products Division, Box 883, Melbourne, Florida 32901.**

HIGH SLEW RATE

	PRECISION				COMPENSATED				UNCOMPENSATED				
	−55 to 125°C	−55 to 125°C	0 to 70°C	EPOXY 0 to 75°C	−55 to 125°C	−55 to 125°C	0 to 70°C	EPOXY 0 to 75°C	−55 to 125°C	−55 to 125°C	0 to 70°C	EPOXY 0 to 75°C	
PARAMETER*	HA-2500	HA-2502	HA-2505	HA-2507	HA-2510	HA-2512	HA-2515	HA-2517	HA-2520	HA-2522	HA-2525	HA-2527	UNITS
OFFSET VOLTAGE	2	4	4	5	4	5	5	5	4	5	5	5	mV
BIAS CURRENT	100	125	125	125	100	125	125	125	100	125	125	125	nA
VOLTAGE GAIN	30K	25K	25K	25K	15K	15K	15K	15K	15K	15K	15K	15K	V/V
UNITY GAIN BANDWIDTH	12	12	12	12	12	12	12	12	20	20	20	20	MH
SLEW RATE	±30	±30	±30	±30	±65	±60	±60	±60	±120	±120	±120	±120	V/μs
RISE TIME	25	25	25	25	25	25	25	25	25	25	25	25	ns
	APPLICATIONS DATA ACQUISITION SYSTEMS SIGNAL GENERATORS				**APPLICATIONS** R.F. AMPLIFIERS PULSE AMPLIFIERS				**APPLICATIONS** VIDEO AMPLIFIERS SIGNAL CONDITIONING				

*VALUES GIVEN ARE TYPICAL AT 25°C

WIDE BAND WIDTH

	COMPENSATED				UNCOMPENSATED				
	−55 to +125°C	−55 to +125°C	0 to 75°C	EPOXY 0 to 75°C	−55 to 125°C	−55 to +125°C	0 to 70°C	EPOXY 0 to 75°C	
PARAMETER*	HA-2600	HA-2602	HA-2605	HA-2607	HA-2620	HA-2622	HA-2625	HA-2627	UNITS
OFFSET VALVE	0.5	3	3	4	0.5	3	3	4	mV
BIAS CURRENT	1	15	5	5	1	5	5	5	nA
VOLTAGE GAIN	150k	150k	150k	150k	150k	150k	150k	150k	V/V
UNITY GAIN BANDWIDTH	12	12	12	12	100	100	100	100	MHz
SLEW RATE	±7	±7	±7	±7	±35	±35	±35	±35	V/μs
RISE TIME	30	30	30	30	17	17	17	17	ns
	APPLICATIONS HIGH Q ACTIVE FILTERS HIGH SPEED COMPARATORS				**APPLICATIONS** VIDEO AMPLIFIERS PULSE AMPLIFIERS				

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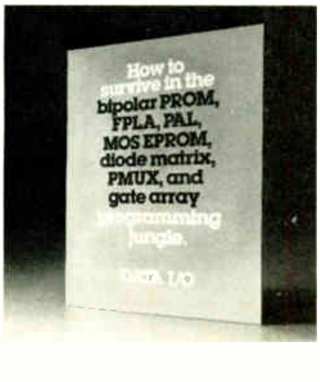

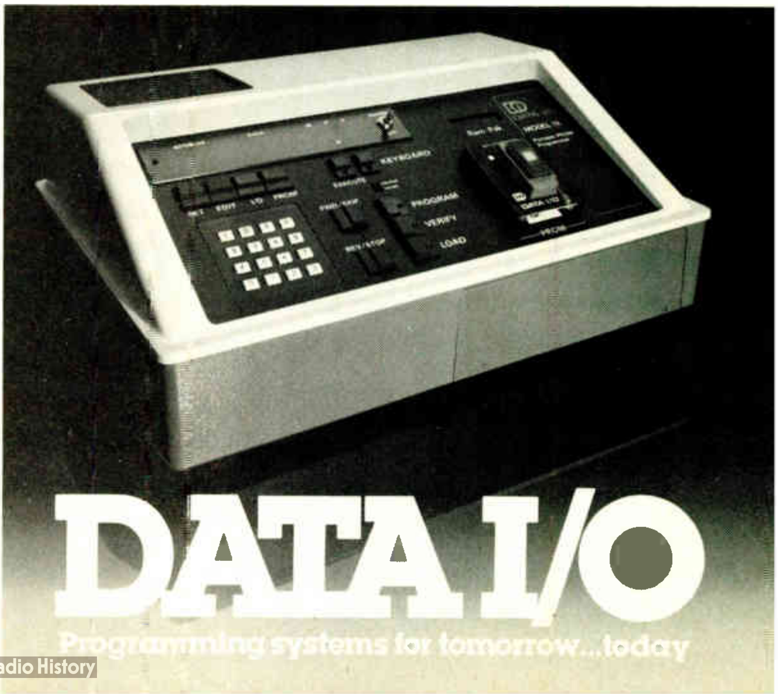

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Hybrid designer sells for $16,460

Computer-aided system can create up to 1,300 user-defined layers

In creating complex multilayer hybrid circuits, design engineers often need the help of computers to keep track of the layers and compute their dimensions. Unfortunately, a typical computer-aided-design system costs well over $100,000, which means a designer often must do without it. Now I-Corp. is bringing out a CAD system based on an intelligent terminal and is selling it for only $16,460. For that price, the system not only offers design aid but also can drive an X-Y plotter, a photo plotter, or a Rubylith cutter for making the required masks.

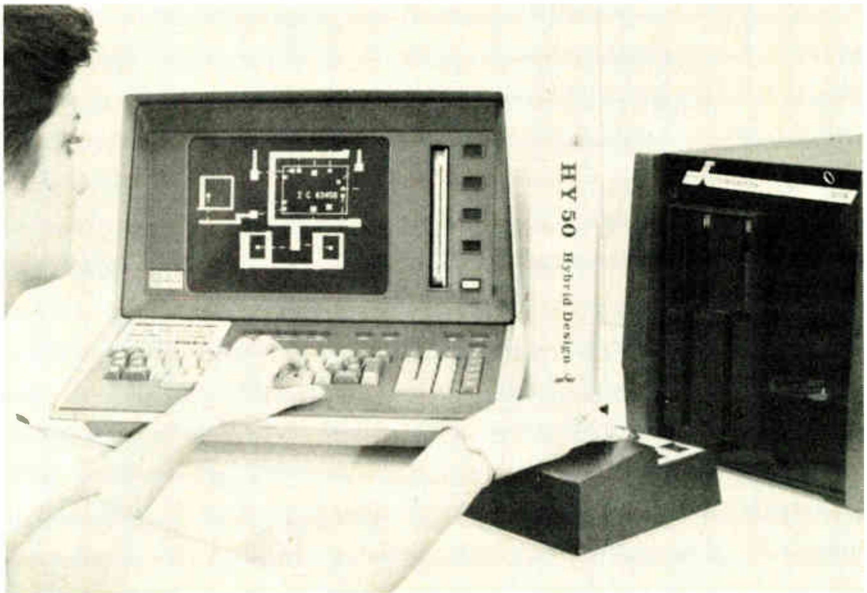
"A simple circuit involves at least four to five layers, not including the resistors, and a more sophisticated one has many more conductive layers," explains Victor Kley, the system designer. "Even a color graphics system barely offers the discrimination you need to separate out those layers." I-Corp.'s HY-50 computes, plots, and catalogs resistive, insulating, and conductive elements on up to 1,300 user-defined layers, allowing each layer to be displayed or drawn independently.

The company's goal with the HY-50 is to provide design aid for hybrids as large as 10 inches square. "That should satisfy the needs of hybrid manufacturers for the next 10 years," Kley believes.

The hardware portions of the system are a Tektronix 4051 intelligent terminal and a Persci 3200A dual flexible-disk drive. "The 4051 provides the graphics resolution we need and the 3200A gives us the fastest read-write performance available in floppy drives because of its voice-coil activation," says Kley.

One side of the dual drive houses the disk on which the layout data is stored; the other disk stores a library of up to 8,000 elements defined by the user. These elements the user draws on the screen with a combination of keystrokes and a cursor-directing joystick control while the HY-50's operating system controls the display and the storage and retrieval of data.

Retrieval of object library data is speeded by a special algorithm in the operating system. "Instead of a file-searching routine, we use a direct map technique," Kley explains. This speeds up the display of objects previously stored in the second flex-



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ible disk. Besides speed, the disk storage scheme has plenty of capacity—on the order of 40,000 line elements per single side.

The goal of a computer-aided graphics system, as defined by Kley, is to free the engineer from paper, pencil, or adhesive tape and let him expand, shrink, twist, and turn the design elements on a screen until satisfied, then produce a piece of artwork or a mask from them. The HY-50, he feels, is a big step in that direction.

"Ultimately, I would like to make a system with closer to real-time response and a 4,000-by-4,000-point color display screen [the 4051 is 1,000-by-1,000]—that would be the real can opener," Kley concludes.

I-Corp., 735 Addison St., Berkeley, Calif. 94710. Phone (415) 848-6623 [391]

TLC rids connectors of paddleboard blues

In computer applications, the connectors most widely used with flat, transmission-line cables contain printed-circuit boards. Usually referred to as paddleboards, these elements add cost to the connector, increase its size, and are a source of cable mismatch. For flat cables with signal leads spaced on 0.050-in. centers, the TLC connector does away with the need for traditional paddleboards, since its design allows flexible termination of ground lines to a single bus bar.

To make a termination, a prepared cable is inserted in the lower part of the three-piece unit, where it is held in place by inserting a grounding bus bar. In place, the signal leads are cut, the ground wires are folded over the bus and cut, and both leads and wires are simultaneously reflow-soldered. The process is automated by the use of an applicator that cuts the leads and wires and completes the connection by inserting a strain relief.

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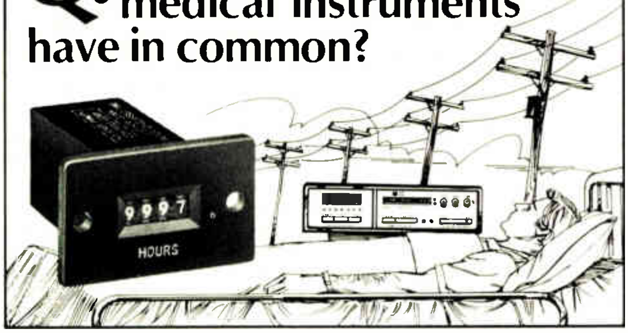

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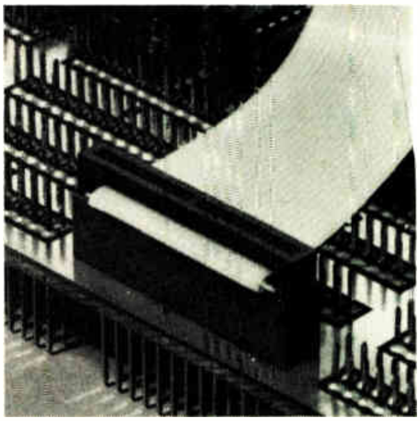

TLC connector mates with standard 0.025-in.-square pins on 0.100-in. centers.

In large quantities, the connectors are priced at 8¢ per line; the applicator costs $7,500. Delivery is 8 to 10 weeks after receipt of order.

Berg Electronics Division, Du Pont Co., Route 83, New Cumberland, Pa. 17070. Phone Frank Morris Jr. at (717) 938-6711 [393]

Heat-dissipation system comes from off-the-shelf parts

The PE series heat-dissipation system places no restriction on the spacing between printed-circuit-board rows or on the number of dual-in-line-packaged devices in a row. Consisting of conduction bars and side rails, the system can be used to make custom cooling systems from off-the-shelf components.

The system components are made of solder-plated, high-thermal-conductivity copper. Conduction bars are offered in lengths up to 14 in. for use with 16-pin DIPS and in lengths up to 13.2 in. to accommodate 8-, 10-, 12-, or 24-pin DIPS. Stand-off spacers raise the bars 0.020 in. above the pc board.

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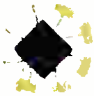

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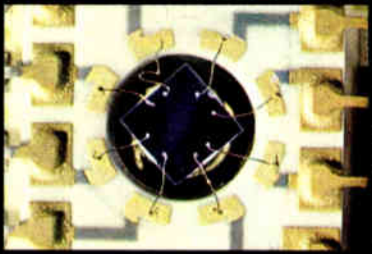

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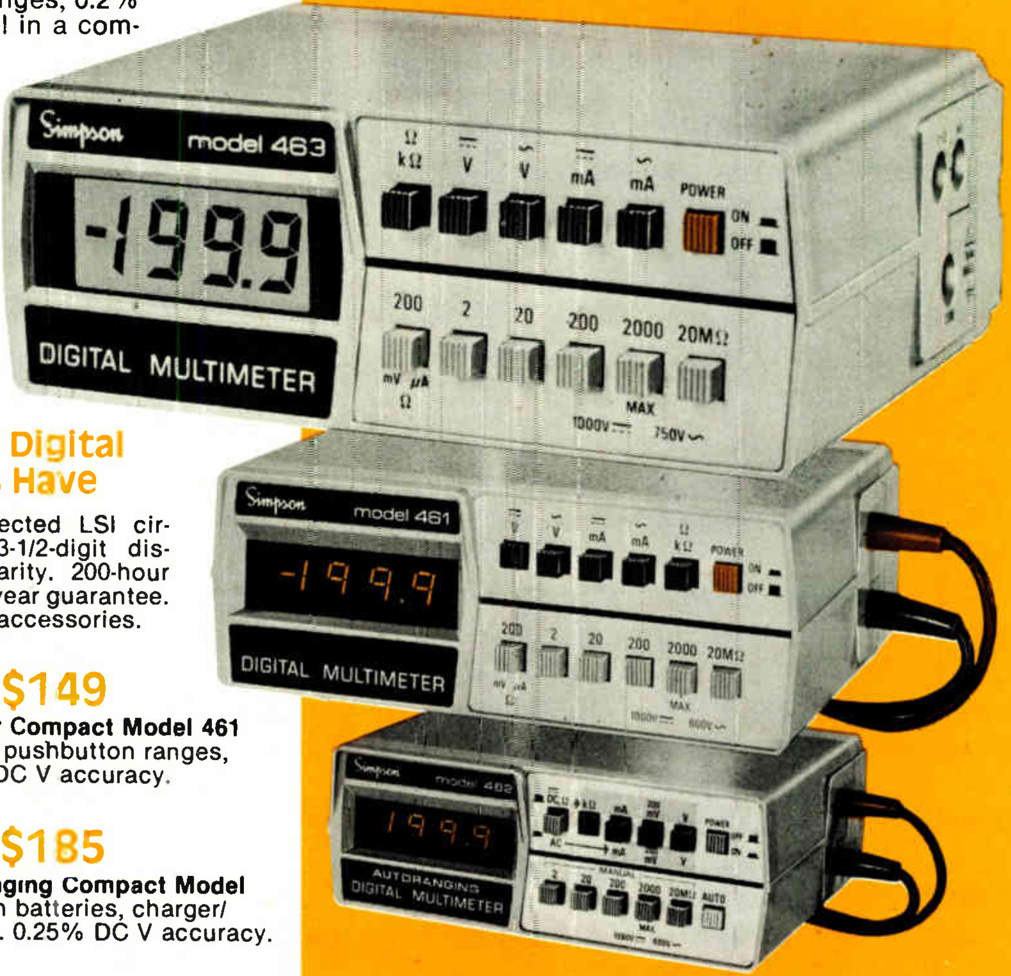

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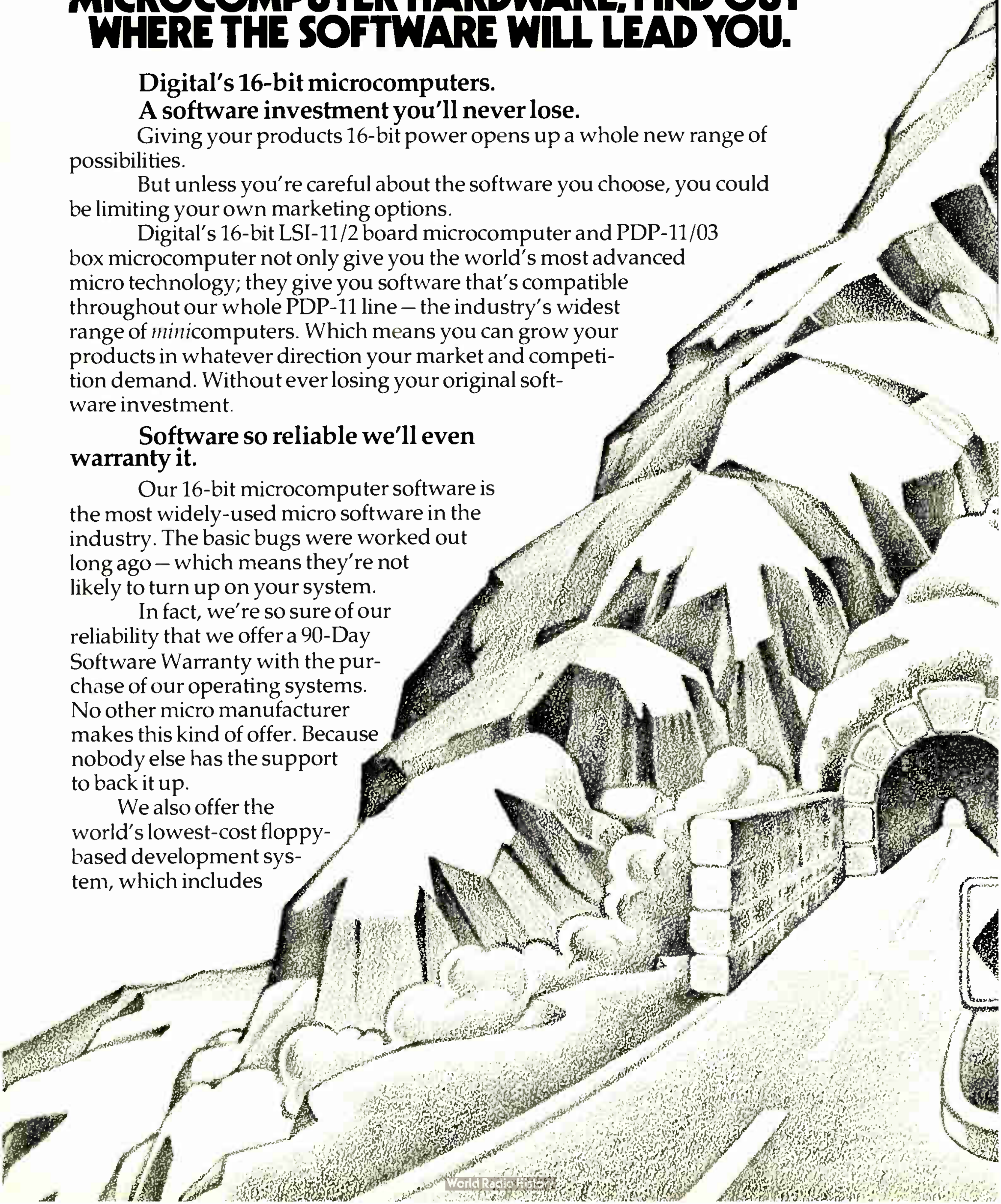

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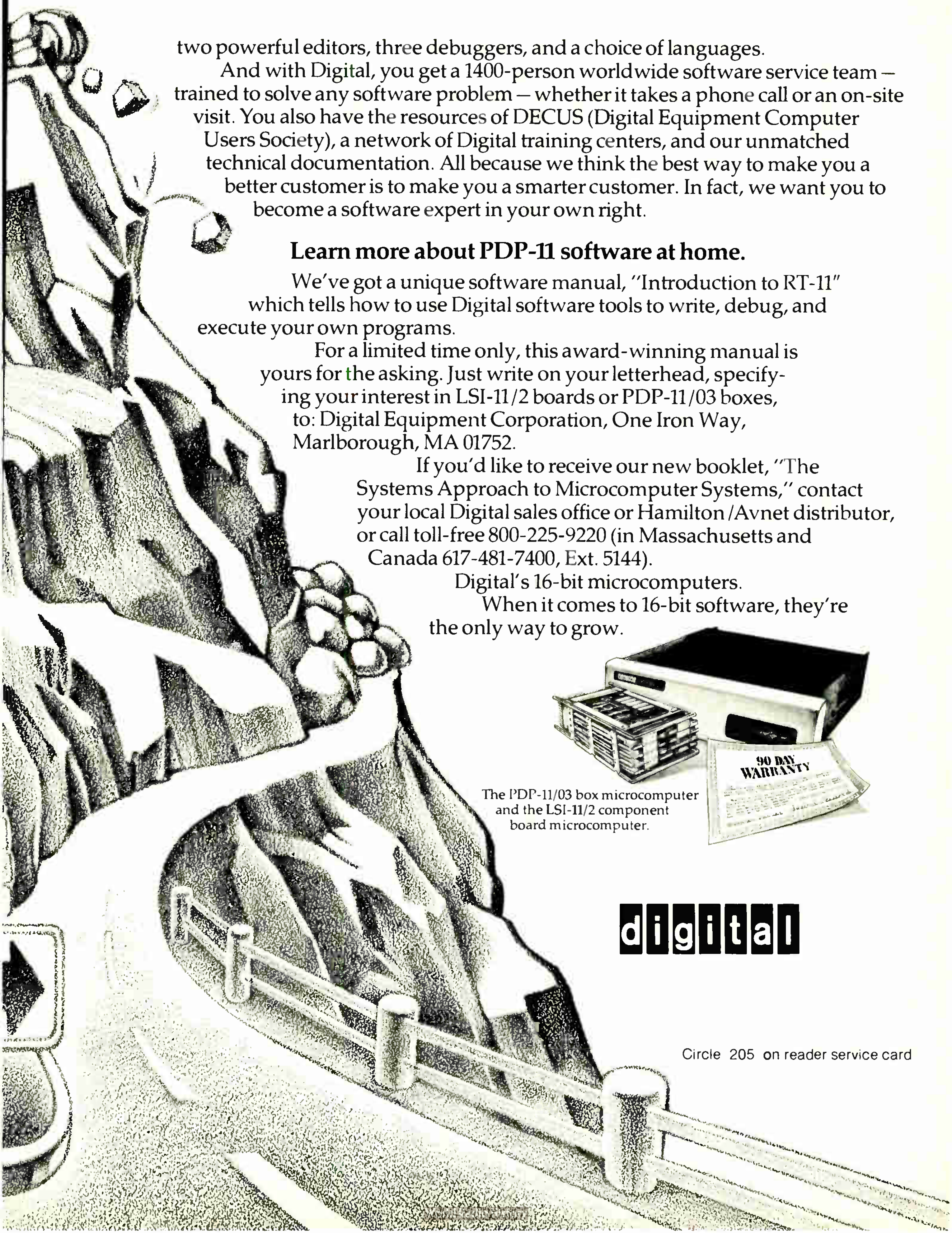

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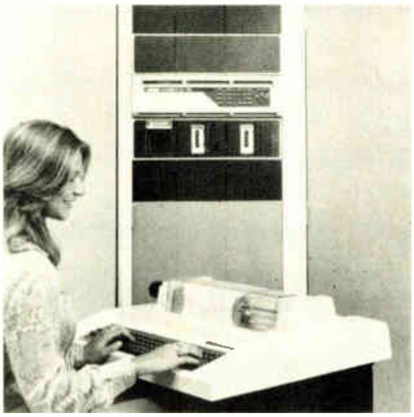

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- Jumper selectable in 2K blocks anywhere in 64K
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MM803 16K STATIC RAM

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- 120HZ real time programmable IRQ
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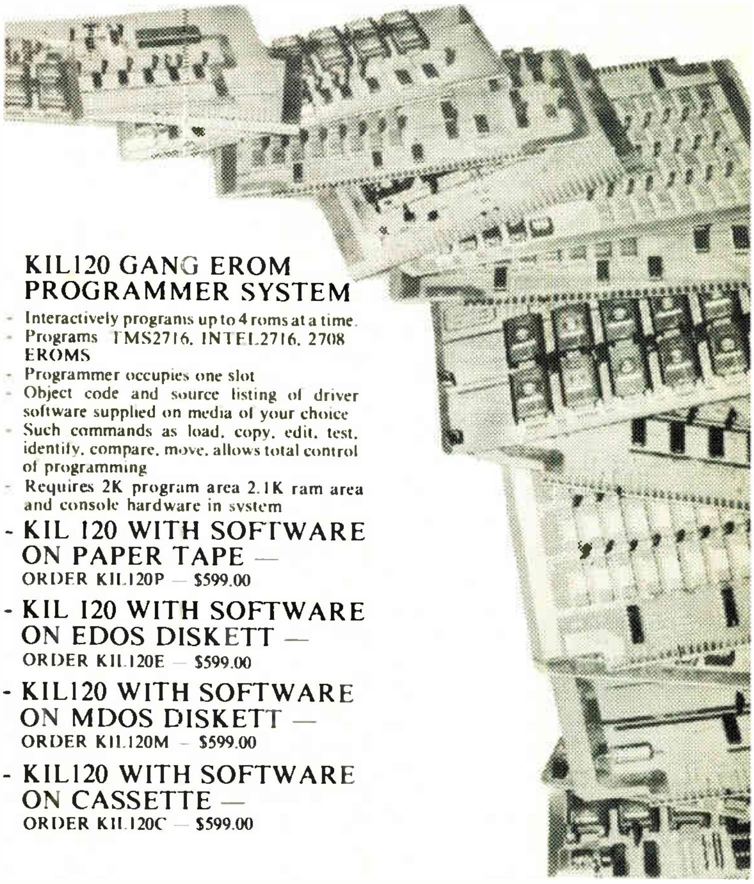

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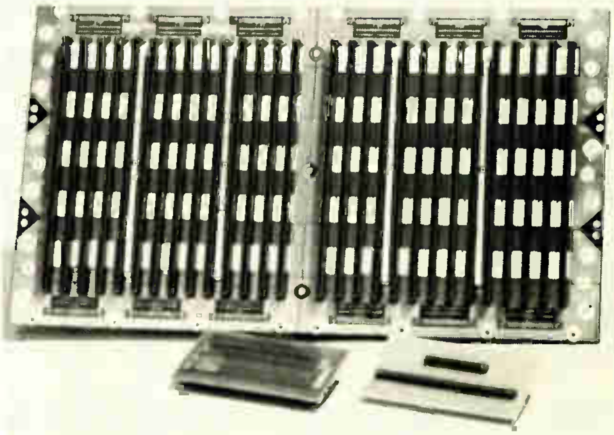

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Guaranteed to pass muster.

FAST AC characteristics are guaranteed over the full military voltage and temperature ranges.

Part #	t_{PHL} (ns)	t_{PLH} (ns)	Available
54F00DM	6.5	7.0	Now
54F02DM	6.5	8.0	Now
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54F08DM	7.0	8.0	Now
54F10DM	6.5	7.0	Now
54F11DM	7.0	8.0	Now
54F20DM	6.5	7.0	Now
54F32DM	7.0	8.0	Now
54F64DM	6.5	8.0	Now

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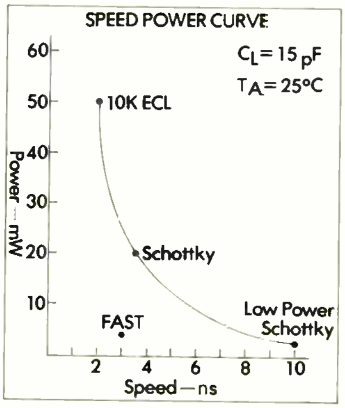

Inspect our specs.

FAST gives you external gate delays of 4-4.5 ns over the full military temperature and voltage ranges. Internal gate delays are 1.5 ns and power consumption is typically 4 mW per gate function. Input thresholds are 1.5 V and output drive is identical to 20 mA Schottky.

To find out how to cost-effectively rejuvenate your TTL systems and drastically cut design time in the bargain, just call toll-free (800) 227-8158 or (800) 982-5805 in California. Or, contact your Fairchild sales office, distributor or representative. Fairchild Camera and Instrument Corporation, P.O. Box 880A, Mountain View, California 94042. TWX: 910-379-6435.

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Circle 209 on reader service card

New products

Data acquisition

Controller makes system smart

Microcomputer-based unit lets data-acquisition and -control system stand alone

Not every data-acquisition system can claim to be intelligent, but with the ANDS7000 microcomputer-based controller, Analogic Corp.'s AN5400 can be called just that. The company's data-acquisition and -distribution system can act as a stand-alone general-purpose acquisition and control system, a data-logger, or as part of a larger network, operating with a host computer.

"The AN5400/ANDS7000 system is synergistic," says Martin S. Gordon, product group manager, data systems. "It has more than ample intelligence and is a totally stand-alone system."

The ANDS7000 uses Digital Equipment Corp.'s LSI-11/2 microcomputer and can interface directly with DEC's memories and display terminals. It has a data-word format of 15 bits signed or 16 bits unsigned and a maximum memory capacity of 32,768 words. Software support includes the PDP-11 instruction set, RTX and RSX operating systems, and utility, diagnostic, exerciser, and driver programs developed in house by Analogic.

Rack-mounted, the 7000 is housed in a standard 19-in. chassis containing power supplies, front-panel status indicators and process controls, and a bus-configured back plane for additional bus-compatible modules.

The AN5400, introduced in 1976 [*Electronics*, March 18, 1976, p. 150], has a capacity of 4,096 single-ended input channels or 2,048 differential, using up to seven expansion chassis. Each is configured for users' needs; currently Analogic has 500 systems in the field.

The table-driven, high-speed direct-memory-access interface between the AN5400 and the ANDS7000 is transparent, flexible, and powerful, according to Robert W. Havener, chief engineer for minicomputer-based systems. "With a general-purpose interface, you can't provide specialized software support, nor the most sophisticated interface," he says.

Unusual software for the 7000 includes a self-test plug-in card and an associated program, which allow the user to verify within 2 minutes the analog-input common-mode rejection ratio, the settling time, or the analog-to-digital conversion linearity. In addition to these, there are 13 other tests on the program.

The interface can act as a programmed input/output interface in a-d transfers or in handling digital I/O with sequential commands; as a DMA interface for up to 100,000 conversions per second in a 12-bit system; or as a memory-mapped I/O interface, where, according to Havener, "card slots appear as memory locations to the 7000. For example, the digital output card in the 5400 can be directly accessed as if it were memory."

Typical applications for the AN5400/ANDS7000 system will include: temperature monitoring and strain-gage measuring in process control systems and distributed processing of data. Prices for the combined system will start at about $6,500 ($3,500 for the 7000 and $3,000 for the 5400) and can go as high as $30,000 or $40,000, depending on user configuration and application. Delivery is within 8 to 10 weeks of receipt of order.

Analogic Corp., Audubon Road, Wakefield, Mass. 01880. Phone Donald Chase at (617) 246-0300 [381]

Data-acquisition system offers choice of system controller

Since the amount of data-handling capability varies from application to application, the model 3052 data-acquisition system is offered with a choice of three system controllers. For less data-intense applications, the system's 9825S controller offers a 23-kilobyte memory, an alphanumeric display, and a 16-character-wide thermal strip printer. It uses HPL language, which is similar to both Basic and Fortran but has such features as multiple-statement lines and multidimensional arrays.

A more complex controller, the 9835, has a 50-kilobyte memory that can be expanded to 246 kilobytes. It comes with a thermal line printer, too, but offers instead a cathode-ray-tube display for writing and simple plotting. The 9845S controller's CRT display, on the other hand, has a full graphics capability and is

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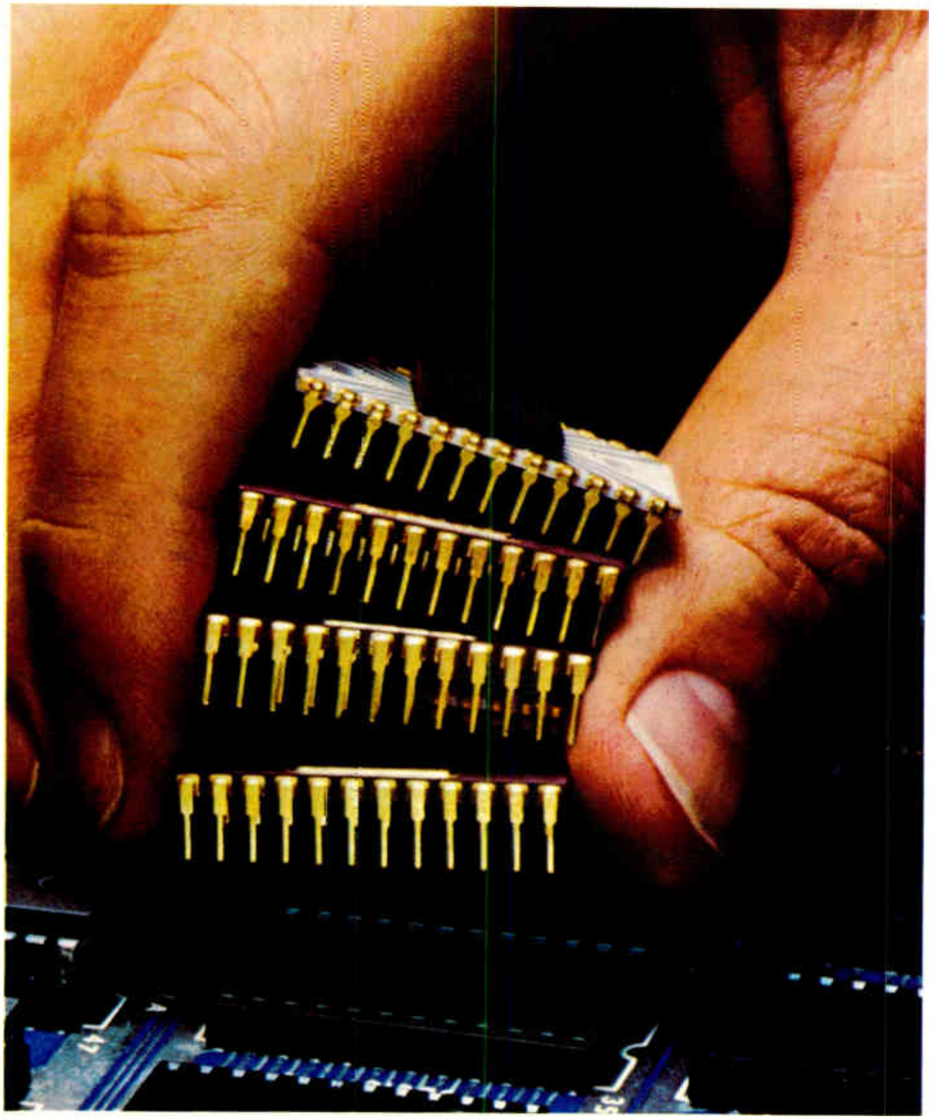
The S4216B Static VMOS ROM. This 16K (2048 X 8) device has an access time of just 250 ns. Its three chip selects are mask programmable, the active level for each being specified by the user.

The S4264 Static VMOS ROM. This 64K (8192 X 8) memory has a 350 ns access time, operates from a single + 5V power supply and features three-state outputs which aid memory expansion by allowing the outputs to be OR-tied to other devices.

The S6831A/B Static NMOS ROMs. One version of this 16K (2048 X 8) memory, the S6831A, is pin compatible with Intel's 2316A ROM. The second version, the S6831B, is compatible with Intel's 2316E ROM and 2716 EPROM. Access time is 450 ns maximum.

The S68332 Static NMOS ROM. This 32K (4096 X 8) memory also has an access time of 450 ns. It's both fully TTL *and* pin compatible with our 16K and 64K ROMs.

For a refreshing change from slow memories that won't even share the same sockets, contact your local AMI sales office. Or write to AMI Marketing, 3800 Homestead Road, Santa Clara CA 95051. Phone (408) 246-0330. We'll do our all four you.



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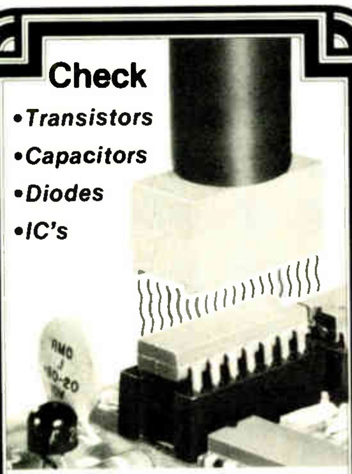
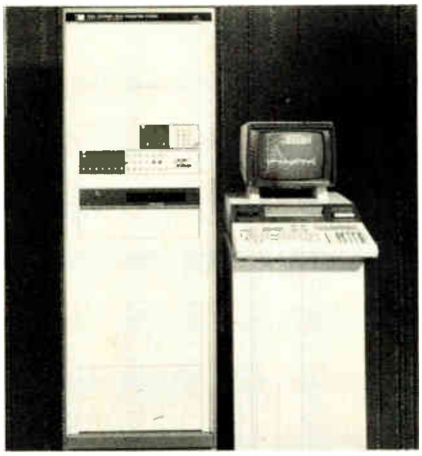
Circle 211 on reader service card





augmented with an 80-character thermal printer. This controller has a 62-kilobyte memory and comes with a dual tape-cartridge drive.

Aside from the controller, the system consists of a digital multimeter, a sampling digital voltmeter, and a scanner. With the scanner, the DMM can make dc measurements at rates up to 19 channels/s. In the 100-mv range, it resolves 1 μV.

Measurements can be taken to 1 MHz using the system's ac true-rms converter. A programmable fast measurement mode permits measurement rates up to 10 channels/s above 300 Hz. Repetitive waveforms above 1 MHz (or transients of less than 1 Hz) can be displayed on the sampling DVM and, by multiplexing inputs to it with the scanner, up to 1,000 channels/s can be measured.

The relay actuator cards in the scanner allow the system to perform control, alarm, and multiple switching functions. Prices for the 3052 are dependent on the number of channels required and the controller chosen; they start at $17,950. Delivery time is from 12 to 16 weeks.

Hewlett-Packard Co., 1507 Page Mill Rd., Palo Alto, Calif. 94304 [384]

Serial-output a-d converter offers 7 bits for a mere 65¢

Although conversion speeds have been getting faster and faster, such consumer applications as microwave ovens and electronic games really have no need for greater speed. So in designing the TL507 serial-output a-d converter, engineers worked on improving a parameter particularly critical for those uses—price.

Because it is fabricated in integrated injection logic, the dual in-line packaged eight-pin device sells for a low 65¢ in 100-piece lots. Ramesh L. Gidwani, linear marketing manager for Texas Instruments' Integrated Circuits division, points out that the 507 can replace several discretes that would cost up to $3.

The converter contains a 7-bit synchronous counter, a binary-weighted resistor ladder network, an operational amplifier, an internal regulator, and required logic. Pins are provided for reset and enable, and all that is needed for operation with a microprocessor is either a regulated 3.5-to-5.5-v or unregulated 8-to-18-v supply and an external clock.

Typically, the device's conversion time is 1 ms and it consumes about 25 mw. The commercial-temperature version is currently in production and samples are immediately available.

Texas Instruments Inc., Inquiry Answering Service, P. O. Box 225012, M/S 308, Dallas, Texas 75265. Phone Mary Perkins at (214) 238-5908 [382]

Voltage output settles in 750 ns for d-a converter

Intended for use in servo or video systems, as well as in other applications that really do demand high speed devices, the DAC392 digital-to-analog converter settles to within ±½ least significant bit for a full-scale digital input change in only 750 ns, typically, and 800 ns, maximally. This rapid voltage-output settling time is achieved by using a thin-film resistor network with very low capacitance between it and the substrate.

The converter can be used either as a dc unit with internal reference or as a two-quadrant multiplier. Of note in the latter case is the fact that output for a 6.2-v change in analog reference input settles to within

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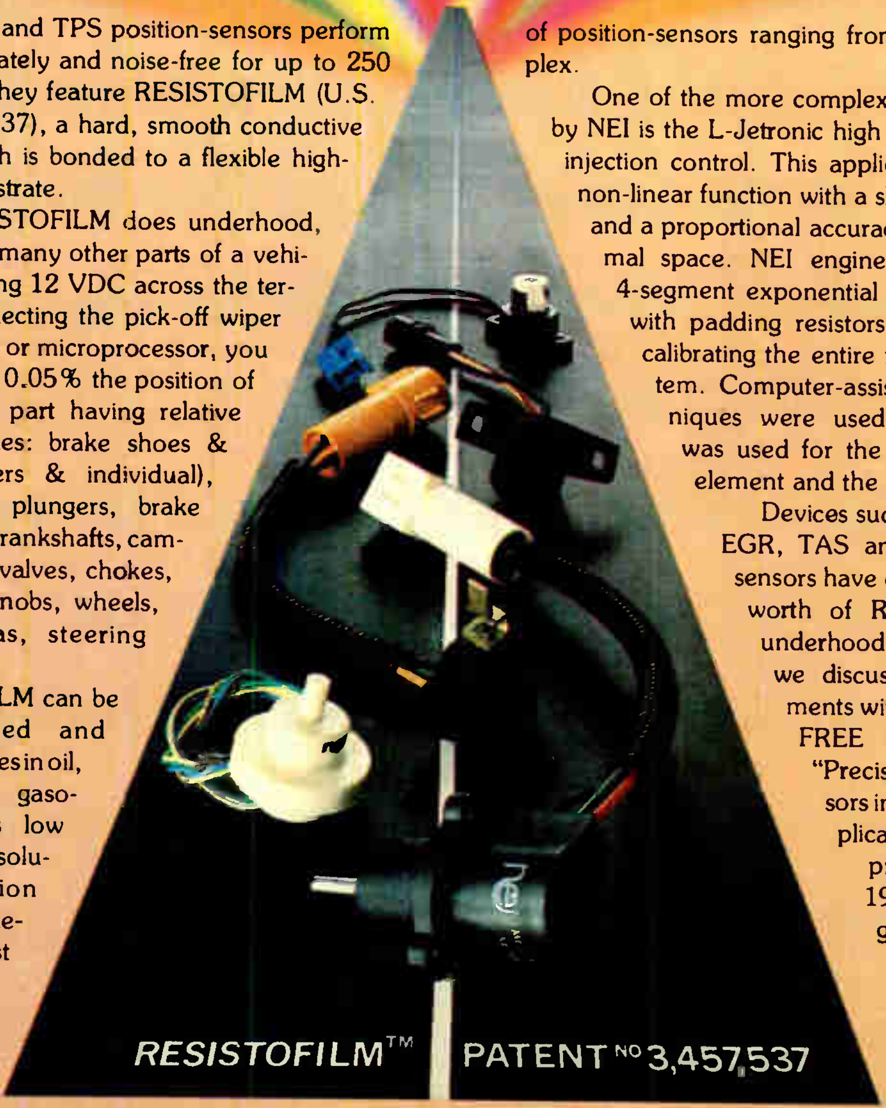

One of the more complex devices supplied by NEI is the L-Jetronic high performance fuel injection control. This application required a non-linear function with a slope ratio of 40:1 and a proportional accuracy of 1% in minimal space. NEI engineers developed a 4-segment exponential function element with padding resistors which allow for calibrating the entire fuel injection system. Computer-assisted design techniques were used. RESISTOFILM was used for the variable resistive element and the padding resistors.

Devices such as this and our EGR, TAS and TPS position-sensors have demonstrated the worth of RESISTOFILM in underhood applications. May we discuss other requirements with you?

FREE ON REQUEST: "Precision Position-Sensors in Automotive Applications," a paper presented at the 1978 SAE Congress & Exposition by William Wheeler, Laboratory Manager, NEI R&D Dept.

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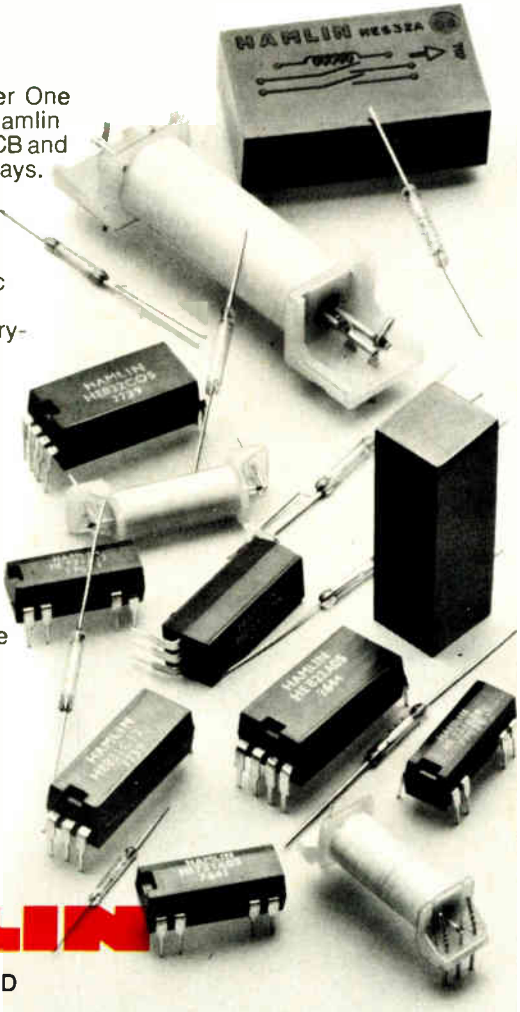

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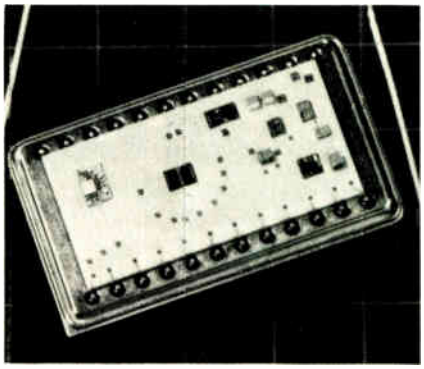


±½ LSB in 2.0 μs, maximum. Small-signal bandwidth for the reference input is 0 to 2.4 MHz.

The transistor-transistor-logic–compatible hybrid has a slew rate of 20 V/μs and output ranges of ±5 V and 0 to −10 V. Packaged in a 24-pin dual in-line package, it is available in an industrial temperature version for $199 and in a MIL-STD-883B version for $289.

Hybrid Systems Corp., Crosby Drive, Bedford, Mass. 01730 [386]

Synchro-to-digital converter can do without tachometer

Besides having a transistor-transistor-logic–compatible 10-, 12-, or 14-bit digital output, a series of synchro-to-digital converters provide a dc voltage output that is proportional to velocity. The ±10-V dc velocity output can be used as a feedback signal in closed-loop systems and also in place of the output from a tachometer.

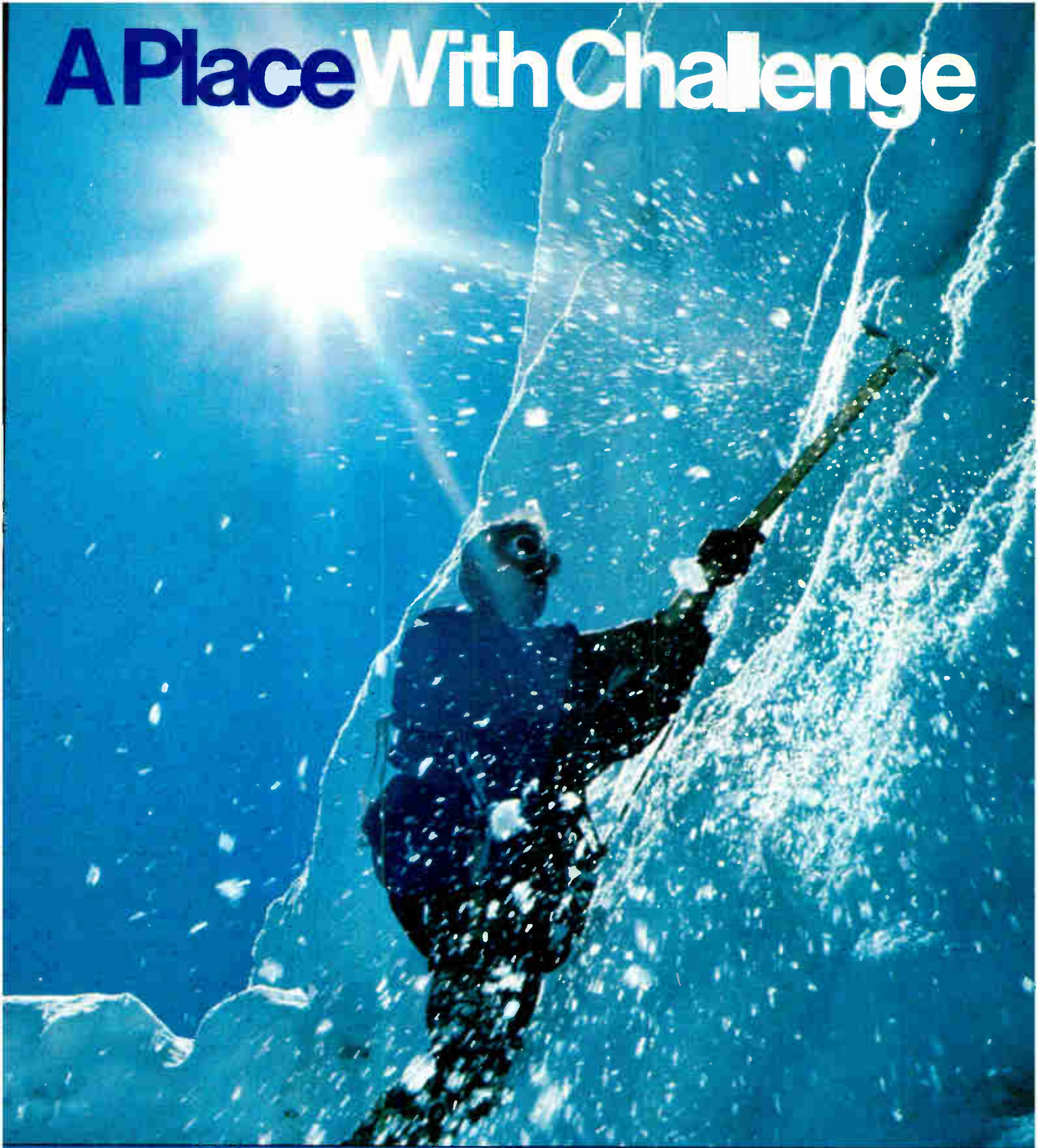
Designated SDC410C, the converters require a 26-V or 115-V ac reference input and operate from +15-, −15-, and +5-V dc supplies. They convert synchro or resolver inputs of 11.8 V or 90 V at 400 Hz, or 90 V at 60 Hz, into parallel binary outputs representing an angle that is accurate to within ±4 minutes of arc. The converters can track inputs at rates of up to 10,000°/s.

In production quantities, the converters sell for $350 each. Delivery time is four weeks.

Computer Conversions Corp., 6 Dunton Court, East Northport, N. Y. 11731. Phone (516) 261-3300 [387].

World Radio History

A Place With Challenge



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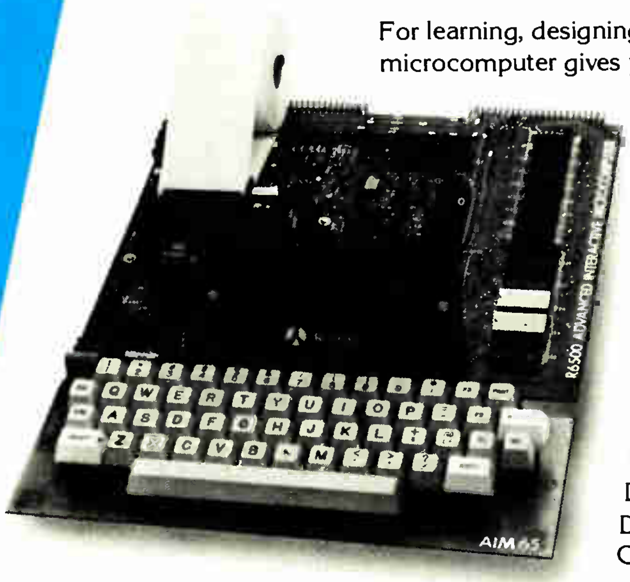

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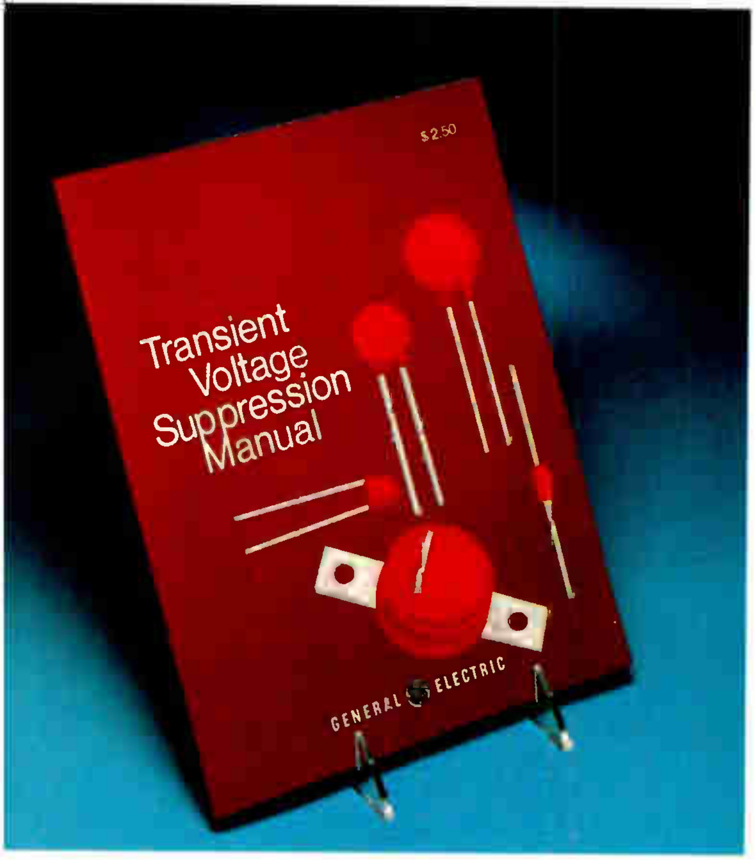

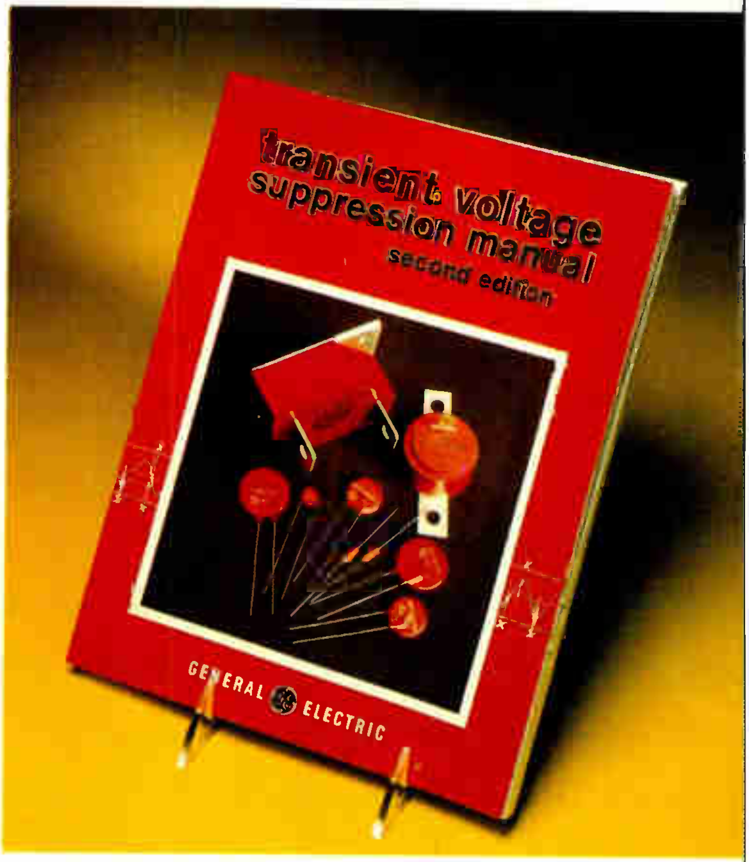

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The E-H Model 4 and Model 16B Programmers can handle every NMOS EPROM made today, 4K to 32K plus the devices of the future, up to 128K, with only two keystrokes. **No personality boards required!** Matter of fact, the Model 4, priced at $2,495* is the **best price performer in the industry.**

Flex-pin matrix,™ an E-H innovation, allows all device programming environments to be generated and controlled by software. So **Software Personality**™ requires no hardware changes from one PROM manufacturer's pinout to another's, or from one device density to another. This saves you lots of time and money with simple device selection using two keystroke commands, thus eliminating expensive inventories of personality boards.

Both the Model 4 and Model 16B programmers include standard capabilities that other manufacturers call options. They contain 2K x 8 RAM, extensive move, list, and alter address operations, fully buffered and powered down (cold) sockets that prevent accidental device damage, plus an easy-to-use serial I/O port to talk to other systems.

The **Model 4,** with its device flexibility and low cost, is ideal for both software development and field service applications. The in-circuit emulation feature enhances your software development and check-out capabilities.

The **Model 16B** is designed to support your production requirements. It programs 16 EPROMs in one operation. Prior to programming, the devices are checked for proper insertion, continuity, shorts, opens, and sufficient ground and power supply levels. In addition to high quality production capabilities, the 16B gives you the same in-depth data manipulation features of the Model 4.

Get all the facts on the new **Software Personality**™ Programmers. Call or write for the data sheets. **E-H International, Inc.,** 515 Eleventh Street, Oakland, CA 94607. (415) 834-3030.

*U.S. Domestic Price Only

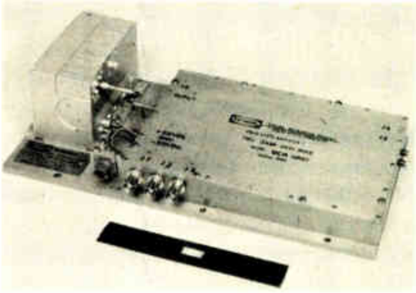
within a narrow ±0.25-dB range.

Priced from $150 for single units to $75 in 2,000-lot quantities, units are deliverable in about 60 days.

Coastcom, 2312 Stanwell Dr., Concord, Calif. 94520. Phone E. A. Gilmore at (415) 825-7500 [405]

Land-mobile transmitter delivers 5 W in 10-lb package

The BCM-5005 transmitter, intended for use in mobile land communications systems, uses gallium-arsenide field-effect transistors to deliver a minimum output of 5 W. The 10-lb unit incorporates an rf power amplifier, a crystal-controlled phase-locked source, a transistor-transistor-logic–compatible enable switch, and a phase shifter for differential phase-shift keying.



The C-band transmitter provides a 300-kHz-wide channel at the operating frequency that is selected by means of a plug-in crystal. Its frequency is stable to within ±10 kHz and noise is kept to −44 dBm/MHz or less. Delivery time is three to four months.

Raytheon Co., Special Microwave Devices Operation, 130 Second Ave., Waltham, Mass. 02154. Phone Russell Mason at (617) 899-8400, Ext. 4749 [406]

Uhf antenna keeps its presence secret

There are times when it does not pay to advertise the fact that an automobile is equipped with ultrahigh frequency communications equipment, as when the owner is a narcot-

The Ultimate "Brickwall" Filters

Up to 230 dB/octave.
1 Hz to 100 KHz, local/remote programming, dual Low Pass or Band Pass, built-in gains, >80dB dynamic range.

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IMPOSSIBLE? 230dB/octave attenuation in a moderately priced, wide-range programmable filter with superb passband and stopband characteristics? Not impossible, but it *did* take a decade of technological leadership in signal processing to develop these state-of-the-art elliptic filters.

WHAT DO YOU NEED? We offer two versions: Model 752A is dual-channel low-pass, tunable over 1Hz—100Khz, by remote digital or local manual means. Each channel provides passband flatness within 0.5dB p-p, 115dB/octave rolloff. Phase match between channels, typically, is 1° or better. Use them separately for two-channel anti-aliasing, cross-correlation, etc; *and cascade them to get 230dB/octave rolloff* . . . for the ultimate in alias rejection.

Or choose Model 751A, a tunable high-pass/low-pass (adjustable bandpass) elliptic. Independently programming Low and High cutoffs allows you to set both center frequency and bandwidth anywhere in the 1Hz to 100KHz band; same rolloff rates, same programming. Speaking of programming, choose BCD or optional IEEE STD 488 . . . both built in.

THERE'S MORE? You bet. Too much for this space. More than 80dB dynamic range. Programmable gains (e.g., 0 dB to +60dB in 10dB steps in the Model 751A) . . . exceptional frequency-setting resolution and much more.

GET THE FACTS ON THESE BRILLIANT NEW DESIGNS. Call or write for the catalogs, engineering notes, and our 24-page "mini-textbook" on filter theory and applications.

Model 751A.
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Rockland Systems Corporation,
Rockleigh Industrial Park,
Rockleigh, NJ 07647
(201) 767 7900

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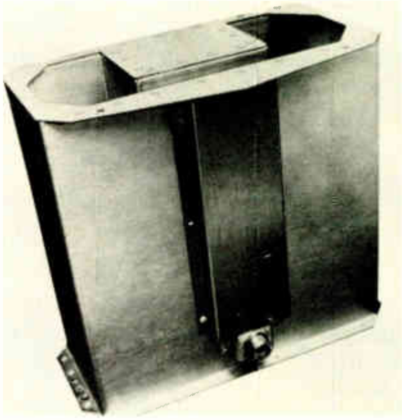
ics agent working undercover or when he happens to live in an area that is rife with vandalism. For such delicate situations, there is now a mobile antenna that will not broadcast such information.

Made of reinforced aluminum, the ASP-1000 cavity-backed slot antenna mounts through a car's trunk in the space intended for a rear-deck speaker and matches to a typical 6-by-9-in. oval cutout. The concealed unit produces a vertically polarized radiation pattern and can be tuned to the required operating frequency by making two simple adjustments with a screwdriver.



The ASP-1000 operates in the 406-to-512-MHz land-mobile band and has a minimum bandwidth of 5 MHz. It is rated for 125 W of continuous power and has a nominal impedance of 50 Ω. The unit is available from stock with discounts for sizable orders and has a resale price of $150.

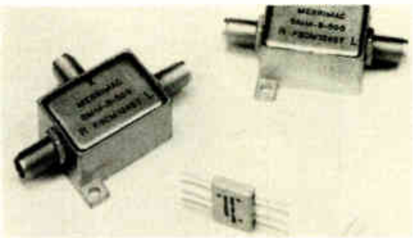
The Antenna Specialists Co., 12435 Euclid Ave., Cleveland, Ohio 44106. Phone Bob Beebe at (216) 791-7878 [407]

Mixers with 27-dBm range come in choice of package

Designed for such applications as pulse modulation, image rejection, and phase detection, a series of high-dynamic-range mixers is offered in the flat pack and SMA-connector packages shown, as well as in a plug-in housing for printed-circuit boards. The mixers use a local-oscillator level of 27 dBm and accept inputs in the 1-to-1,000-MHz range. The output frequency range is dc to 1,000 MHz.

Conversion loss is between 7 and 9.5 dB, and the third-order intercept point is 35 dBm. Single units cost $145 to $160 depending on package, and delivery is from stock to four weeks.

Merrimac Industries Inc., 41 Fairfield Pl., West Caldwell, N. J. 07006 [409]



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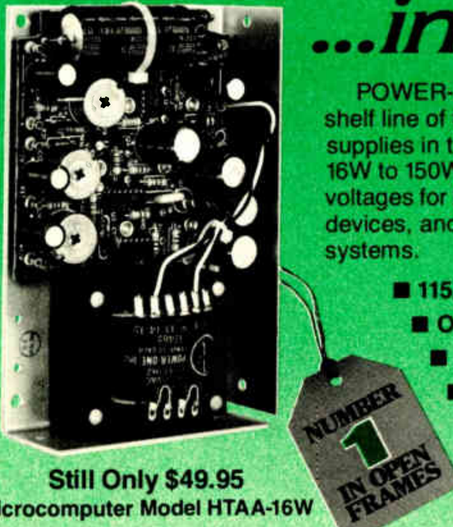

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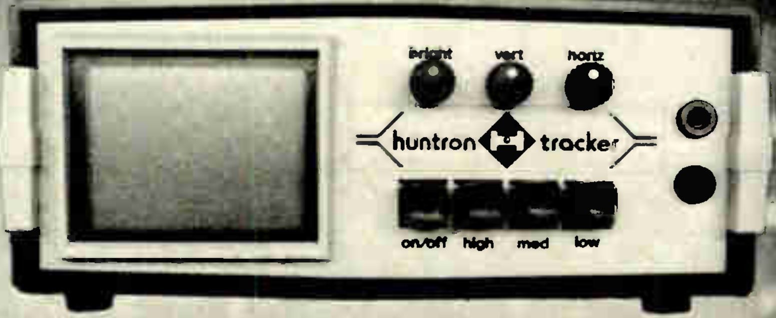

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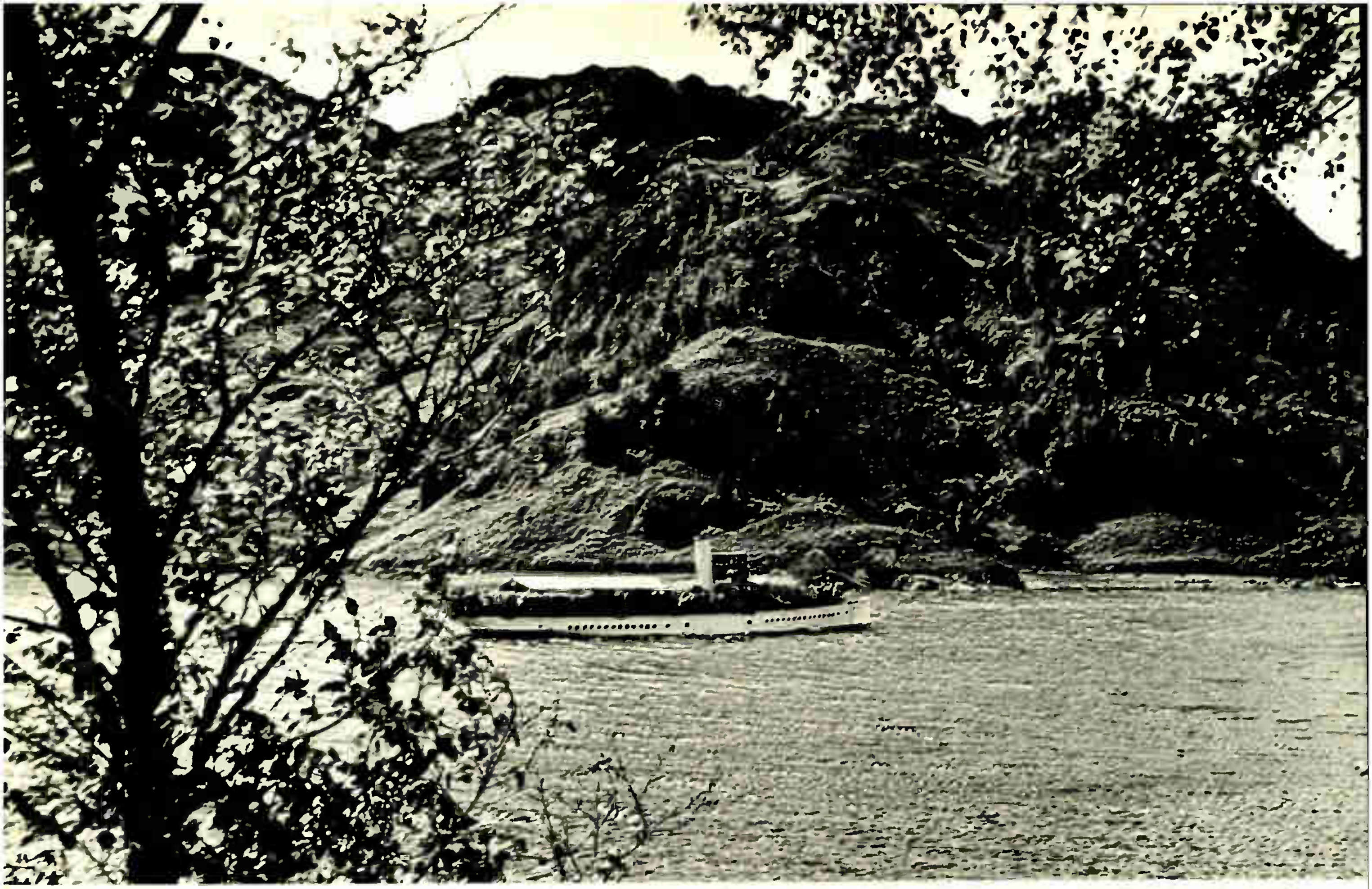
Circle 225 on reader service card



Loch Katrine in the Trossachs — where Glasgow draws much of its exceptionally pure water

Glasgow's unique industrial resource -unfailing supplies of the purest water in Europe

The lochs which ring the city do much more than make Glasgow an attractive centre for the tourist. They make it an attractive base for industries that need pure and abundant water.

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There is another reason why Glasgow is so attractive to industries heavily dependent on fresh water. Because Glasgow's water is so available, so close at hand, it is inexpensive water.

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First and foremost, Glasgow has room for new industry. Nearly five million square feet of factory space, in units to suit any size of company, are immediately available. And there are over 300 acres of industrial building land, offering sites of five acres up.

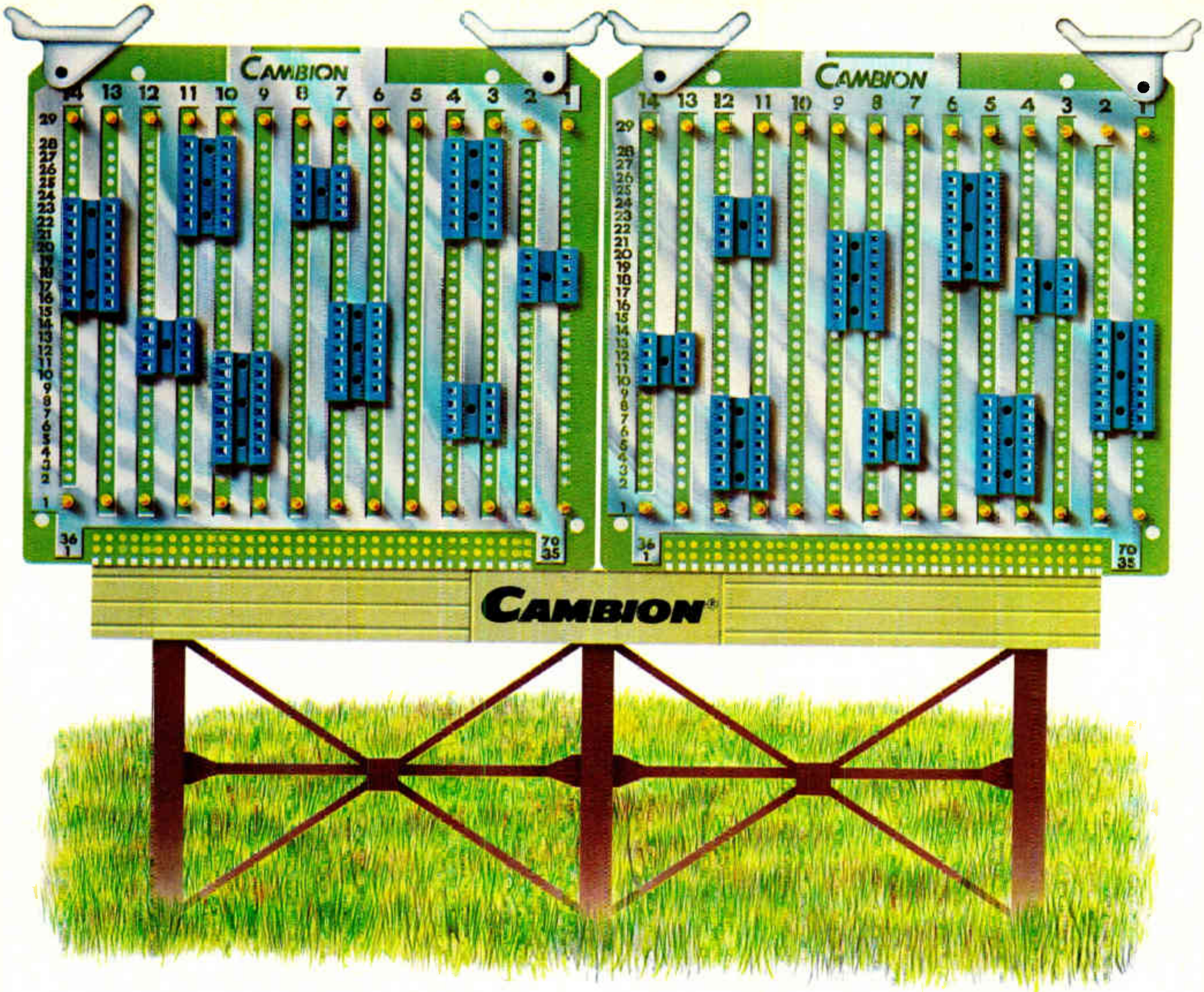
So you won't be cramped for space. Nor will you be isolated in some remote industrial estate. All these sites are well inside the city – making it easy to recruit and keep staff.

Glasgow's other resources

Glasgow has other resources, too. A well-educated workforce, traditionally orientated towards sophisticated industrial processes. The service and sub-contracting resources of a major industrial centre – tool-making, packaging, printing, maintenance. Excellent links to the rest of the U.K., and to foreign markets, by road, rail, sea and air. And the leisure facilities of a great city, surrounded by some of the finest countryside in the world.

But, for the full story, contact D. S. Logan, Industrial Development Officer, City of Glasgow District Council, Sun Life House, 116 West Regent Street, Glasgow G2 2RW. Telephone 041-332 9700.

GLASGOW
city to build on



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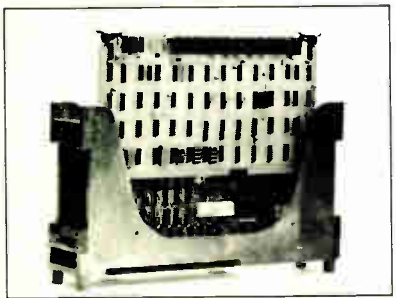
Circle 227 on reader service card



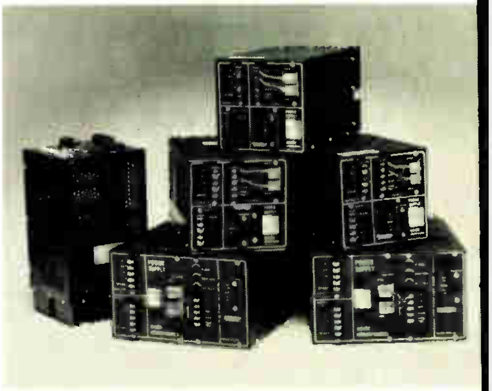
Power supplies

Multiple-output supply powers cathode-ray tubes

Noteworthy for its high stability, the model RHSR15C high-voltage power supply is a multiple-output unit intended for use with cathode-ray tubes. It provides three tightly regulated voltages: 15 kv at 50 μA, 500 v at 200 μA, and a focus voltage that can be adjusted from 4 to 5 kv at 500 μA. The 15-kv ultor voltage and 500-v first-anode voltage are accurate to within 1% and stable to within 0.02% over 24 hours after a 20-minute warm-up; they have a temperature coefficient of 50 ppm/°C. The adjustable focus supply has the same long-term stability and temperature sensitivity. The three outputs will track each other, keeping their potential ratios within 0.04%, over the range from 10° to 50°C.

Window comparators, which monitor the output voltages, are activated if any supply deviates from its nominal output by 25%. This illuminates a front-panel indicator, identifying the defective supply. In addition, overvoltage-protection and current-limiting circuitry minimize the probability of damage to the CRT or power supply in case of failure of either or both of them. The RHSR15C sells for $3,000 and is available from stock to 10 weeks.

Spellman High Voltage Electronics Corp., 7 Fairchild Ave., Plainview, N. Y. 11803. Phone Dom Galluzzo at (516) 822-2130 [341]



Triple-output units meet German emi specifications

Six additions to the Sub-Modular Switcher line provide +5- and ±12- or ±15-v outputs. Called the RT series, the units are differentiated by their 5-v power ratings of 100, 200, or 300 w. All meet the radiated and conducted electromagnetic interference specifications of Verband Deutscher Elektrotechniker.

For reliability, the modular supplies are constructed from individual input, converter, and output submodules on a single plug-in printed-circuit board that eliminates interconnecting harnesses. The units offer such features as soft start-up, 40-ms holdover storage, and remote sensing and inhibit.

Regulation of the units is 0.1% + 5 mv for a 10% change in line voltage or a 100% load change, and response time for a 25% load change is 500 μs. The 115/230-v units' output ripple is 5 mv rms, 50 mv, peak to peak, maximum. Prices start at $375 for a 100-w unit and all models come from stock with a five-year warranty.

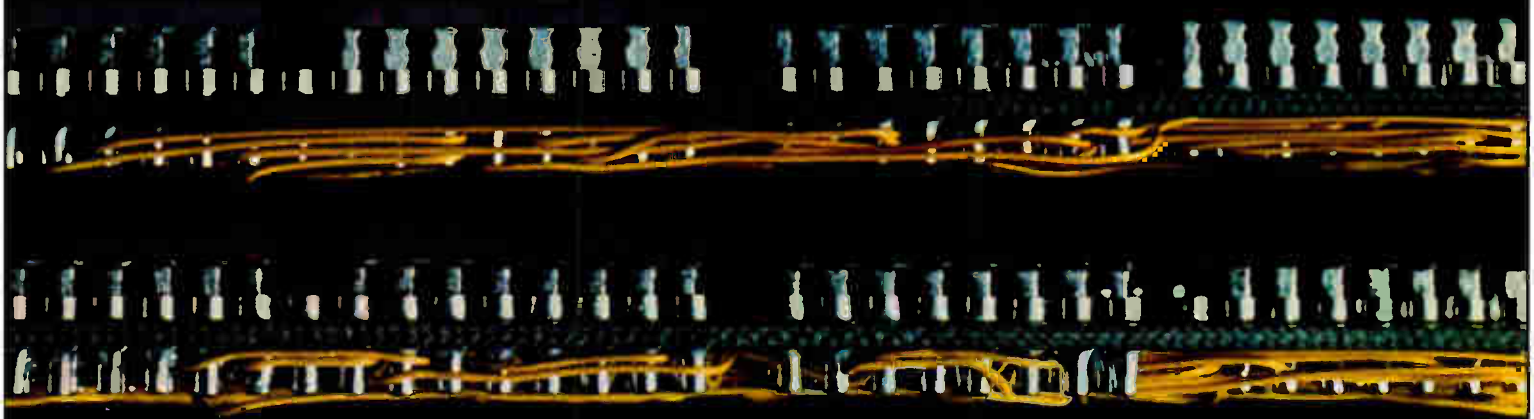
ACDC Electronics Division, Emerson Electric Co., 401 Jones Rd., Oceanside, Calif. 92054. Phone (714) 757-1880 [344]

Three supplies tailored to Persci disk drives

Users of Persci disk drives no longer have to build their own triple-output power supplies or use multiple supplies to obtain the combinations of current and voltage they require. Three open-frame units have been designed specifically to fulfill those requirements: the model CP272 for Persci models 70, 270, and 277; the CP302 for the 299; and the HTAA-16W for the 1070 controller.

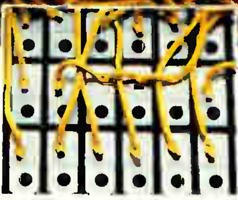
The CP272 and CP302 supply +5, −5, and +24 v, to which the 272 adds an unregulated 8-to-10-v output. The HTAA-16W puts out +5, −12, and +12 v. All units have

NOW YOU CAN GET BOTH PACKAGE DENSITY AND CIRCUIT DESIGN FLEXIBILITY.



Planar boards on 0.6 inch centers. Photograph shown 2x size.

Introducing Augat's patented Planar stitch-wire. A high speed, low cost system that eliminates the high engineering cost of breadboarding, complete circuit card prototyping and extensive debugging. As a result, turn around time can be cut by one-half to one-third.

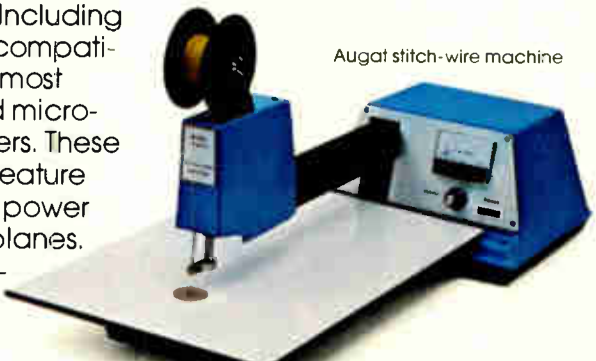


Augat's stitch-wire system works like this. After components are mounted on Planar boards, a stitch-wire machine welds insulated wire to stainless steel pads.

Wiring instructions can be furnished using punched tape programs or wire lists. You can also do special wiring configurations including twisted pairs or wiring on the component side. Changes can also be made simply, either by stitch-wire machines or by hand soldering.

Adopting stitch-wire is easy, because Augat stocks the wiring machines and a wide range of general purpose Planar boards. Including boards compatible with most mini and micro-computers. These boards feature large etched power and ground planes. The combination of large planes and low profile wiring makes them ideal for high speed logic. What's more, we can design and produce stitch-wire boards to your specifications. Or we can provide the boards and equipment you need to do the job.

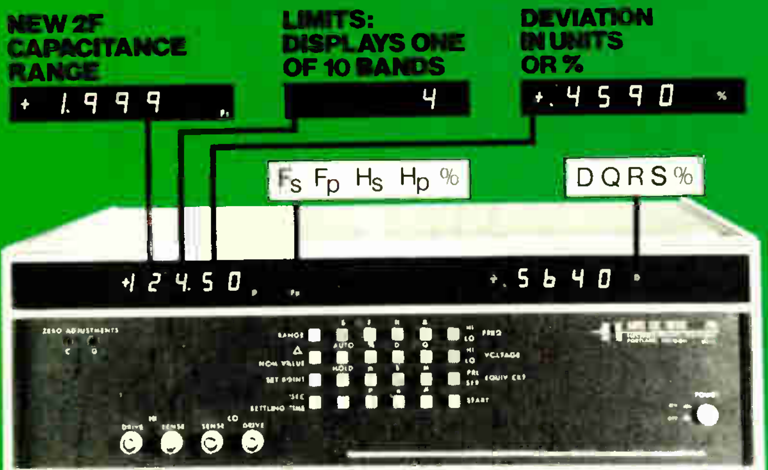
Augat stitch-wire offers density and flexibility advantages you can't get anywhere else. To find out how you can get started with stitch-wire, write Augat Planar Systems, Inc.,
14751 Califa Street,
Van Nuys, California 91411.
Tel. (213) 786-3974.



Augat stitch-wire machine

AUGAT®

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



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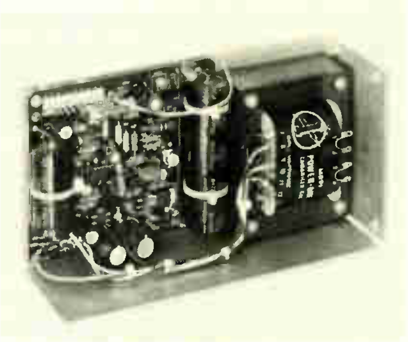
Circle 230 on reader service card



±0.05% regulation for a 10% line change and for a 50% load change. Transient response for such a load change is 30 μs, and output ripple is a maximum of 3.0 mv, peak to peak. The units work from 115 or 230 v ac lines.

The CP272, CP302, and HTAA-16W are priced at $79.95, $95.95, and $49.95, respectively, in single quantities. They all come with a two-year warranty for parts and labor.

Power-One Inc., Power One Drive, Camarillo, Calif. 93010. Phone (805) 484-2806 [343]

Unit for CRTs provides power for anode, intensity, focus

The model 769 is a cathode-ray-tube supply that produces an anode voltage of 8 to 12 kv at 150 μA with peak-to-peak ripple of 0.2%. In addition, the unit provides intensity and focus voltages at 1 mA of 400 and 100 v, respectively. The unit accepts 15- to 35-v dc inputs. Protected for reverse polarity to 50 v, it is available in large quantities for $100 from stock.

EMCO High Voltage Co., 2444 Old Middlefield Way, Mt. View, Calif. 94043 [345]

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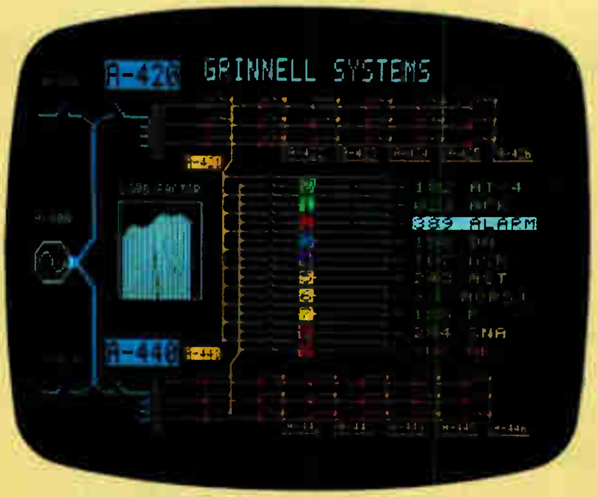

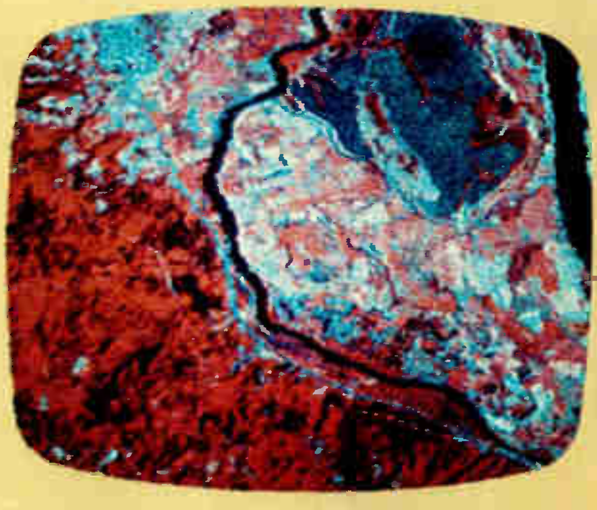

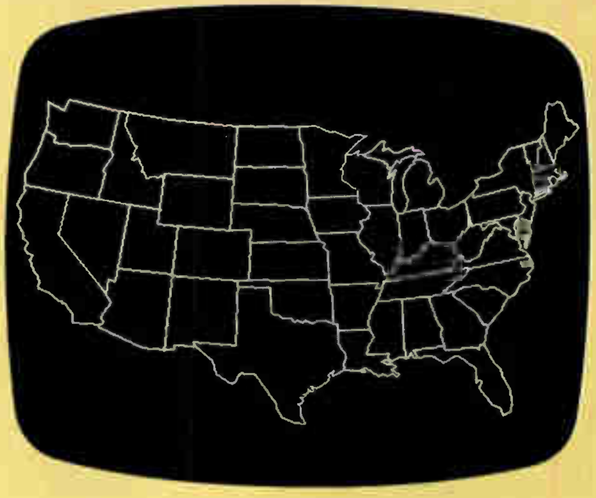

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JM38510

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/052-02	Quad 2-Input NOR Gate	4001
/052-03	Dual 4-Input NOR Gate	4002
/055-02	Hex Non-Inverting Buffer/Level Shifter	4010
/050-02	Dual 4-Input NAND Gate	4012
/051-01	Dual D-Type Flip-Flop	4013
/057-03	Dual 4-Stage Serial-Input/Parallel-Output Shift Register	4015
/050-03	Triple 3-Input NAND Gate	4023
/052-04	Triple 3-Input NOR Gate	4025
/055-03	Hex Inverting Buffer/Level Shifter	4009
/055-04	Hex Non-Inverting Buffer/Level Shifter	4050

Acceptance pending on remaining 4000 Series

Full service continues

Mil Std 883B Class B and C Qualified

Standard 4000B Series (over 100 types) and custom

Production line certified to Mil M 38510

All sides of CMOS Technology

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SOLID STATE SCIENTIFIC

Montgomeryville, Pa. USA 18936 INC.

Check off data you require and mail coupon with your company letterhead

Yes, I want the following Hi-Rel information:

- ☐ Have salesman call for price and delivery information.
- ☐ Mil-M 38510 QPL literature.
- ☐ Mil-Std 883B literature.
- ☐ BCP-Microprocessor family literature.

Information about the other sides of SOLID STATE SCIENTIFIC

- ☐ Microprocessor Products
- ☐ Memory Products
- ☐ Custom LSI Circuits
- ☐ 4000 Series CMOS
- ☐ Watch Circuits
- ☐ Clock Circuits
- ☐ Smoke Detector Circuits
- ☐ 1802 Users Manual (send $5)
- ☐ RF Power Transistors
- ☐ SSS Product Summary

Attention Hi-Rel Marketing.
SOLID STATE SCIENTIFIC INC
MONTGOMERYVILLE, PENNA. 18936

Name __________

Position __________

Company __________

Street __________

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RELAX...it's amazing how an easy mind puts you in touch.

We're the easy mind people, TRW Capacitors. Our new X659F can solve your packaging problems. We call it "the new dimension capacitor". It's the smallest possible size—at the smallest possible price. The advanced design of the new TRW X659F utilizes very thin gauges of metallized polyester with design highlights such as capacitance values to 20.0 MFD, dissipation factors less than 1.0%. Electrically, the new X659F is interchangeable with our X663F. Same rugged durability and long stable life.

Oval shape allows either vertical or flat, horizontal board-hugging mounting. It's ideally suited to small portable equipment for commercial and instrument grade products.

So if you have a packaging problem, relax and send for complete specifications and applications information on the new X659F Capacitor. Call or write: TRW Capacitors, An Electronic Components Division of TRW Inc., 301 W. "O" St., Ogallala, Nebraska 69153. Tel: (308) 284-3611.

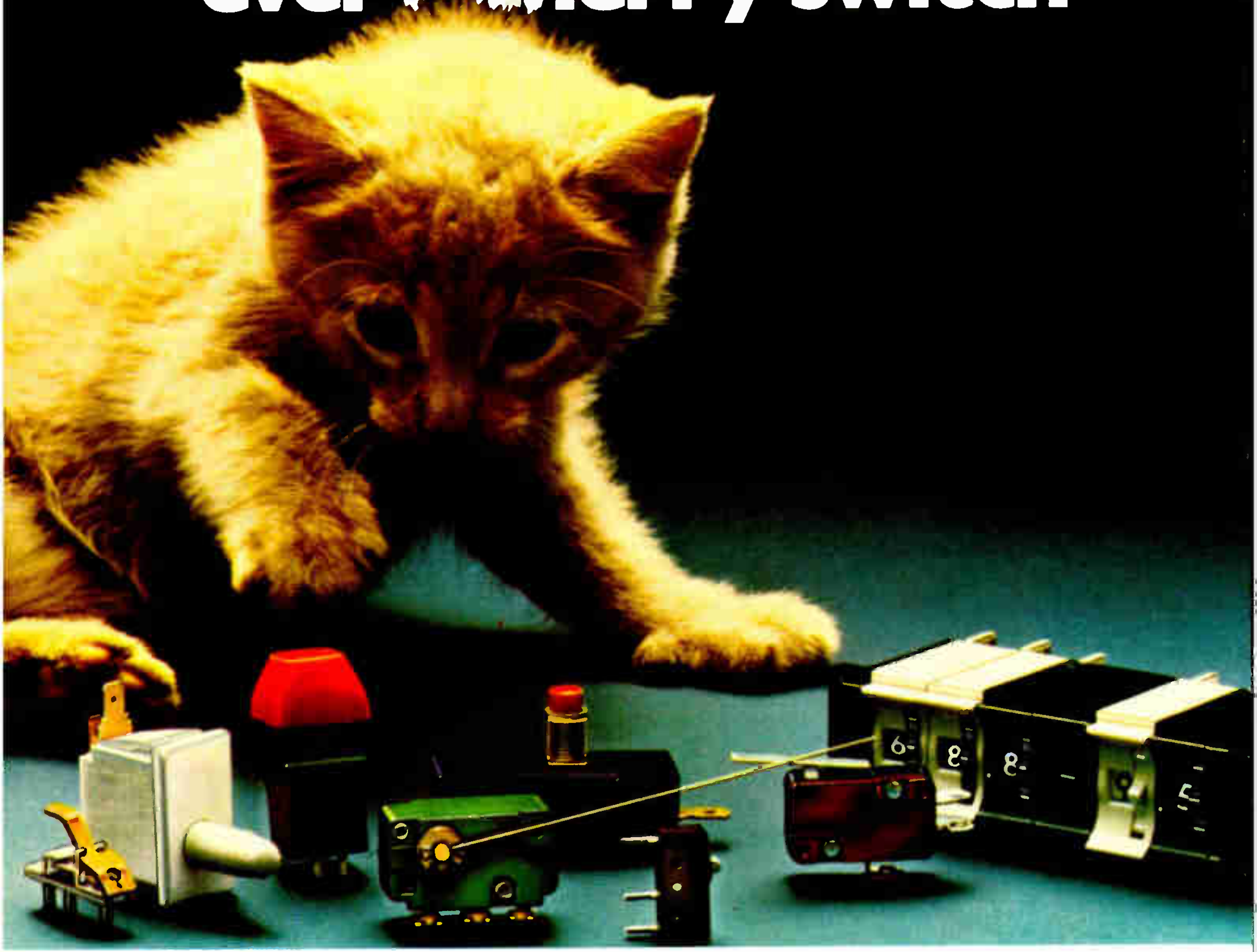
Actual size 022 MFD 400VDC

TRW CAPACITORS

ANOTHER PRODUCT OF A COMPANY CALLED TRW

Circle 233 on reader service card

There's a little tiger in every Cherry switch



...but we're pussycats to do business with

Our products are tough, but our people aren't... and that's the beauty of dealing with Cherry.

You see, we can control the quality of our switches because we fabricate most of our own parts (moldings, stampings, springs, printed circuits, etc.) And we can keep the price down because we're loaded with automatic equipment to handle high volume.

But the real difference is in the *people* you work with at Cherry...from your first contact with a technically trained sales representative...through careful analysis and recommendations by engineers who are really concerned about *your* problem... to production scheduling and customer service men who follow-up and expedite to make sure we keep our delivery promise to you.

Of course we're proud of our modern facilities and equipment...but what we're proudest of is our reputation for customer service. Try some.

Test a free sample "tiger" from the pussycats at Cherry. Ask for our latest catalog which contains complete information on all our switches and keyboards, and we'll include a free sample switch. Just TWX 910-235-1572...or PHONE 312-689-7700... or circle the reader service number below.

CHERRY®

CHERRY ELECTRICAL PRODUCTS CORP. • 3608 Sunset Avenue, Waukegan, Illinois 60085
SWITCHES and KEYBOARDS — Available locally from authorized distributors.

Circle 234 on reader service card

Products newsletter

Rechargeable lithium cell developed

Lithium batteries, long known for their high energy density, have heretofore been available only in primary form—they could not be recharged. Now, however, in a development that could be the breakthrough for which electric-vehicle designers have been waiting, the Battery division of Exxon Enterprises Inc., Somerville, N. J., has come up with a 2.4-V button cell **with a theoretical energy density of 100 watt-hours per pound and the capability to be fully discharged and then recharged.** The LTS-90, which delivers 70 mA-hr at 1 mA, is unique in that it exhibits a linear relationship between its state of charge and its voltage. The cell comprises an anode consisting of from 63% to 92% lithium, a titanium-disulphide cathode, and a nonaqueous electrolyte. It sells for $7.50 each in 100-piece lots.

400-V MOSFET switches a kilowatt

A new line of high-power metal-oxide-semiconductor field-effect transistors includes a unit with a drain-source voltage rating of 400 V, a drain-current rating of 5 A, and a maximum drain-source resistance of 1.0 Ω. Designated the IRF305, the power transistor is one of **a new class of devices built by International Rectifier Corp. with an as yet undisclosed technology, which the El Segundo, Calif., firm asserts is definitely not V-MOS.** The 305, like the other members of the family, has a maximum power dissipation of 125 W and is housed in a TO-204AA (TO-3) case. It sells for $34 in small quantities.

West German resistor maker discovers U. S. . . .

Picking up on the trend set by several Japanese electronics companies, Draloric Electronic Corp., one of Europe's leading producers of precision metal-film resistors, has opened a manufacturing facility in this country. **Located in Norwich, Conn., the plant should be in full production by the end of this month.** Draloric's metal-film resistors will equal or exceed MIL-R-10509 (RN 55) and MIL-R-55182 (RNR 55) characteristic C. The firm is a division of AEG Telefunken, with headquarters in Selb, West Germany.

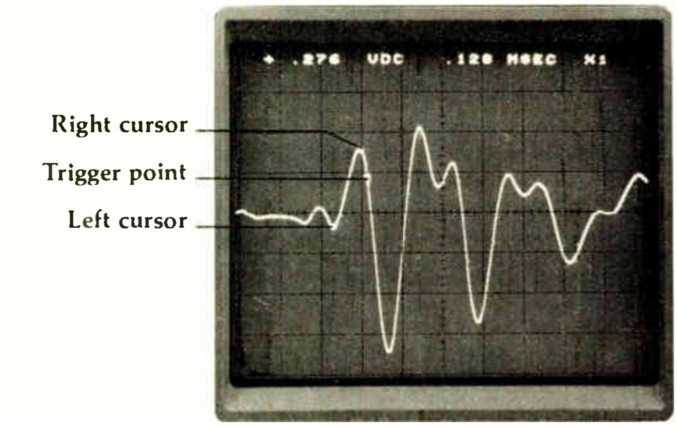
. . . and so does Italian company

SAES Getters/U. S. A., Inc., which previously obtained all of its getters from its parent company in Milan, **is now manufacturing lightweight barium getters for the television-tube industry at its new facility in Colorado Springs.** According to David Green, vice president and general manager, this is the first step of a planned expansion into full-scale production of several getter product lines in this country.

Here's another 4-K static RAM

NEC Microcomputers Inc., Wellesley, Mass., is jumping into the 4,096-bit complementary-metal-oxide-semiconductor static memory arena with its μPD444/65-14 random-access memory. **Joining entries from RCA and Intersil with a nonsynchronous clock-based chip, the company is offering the 444 in an 18-pin package.** Deliveries will take from 30 to 60 days, starting in December. NEC says that prices will be competitive.

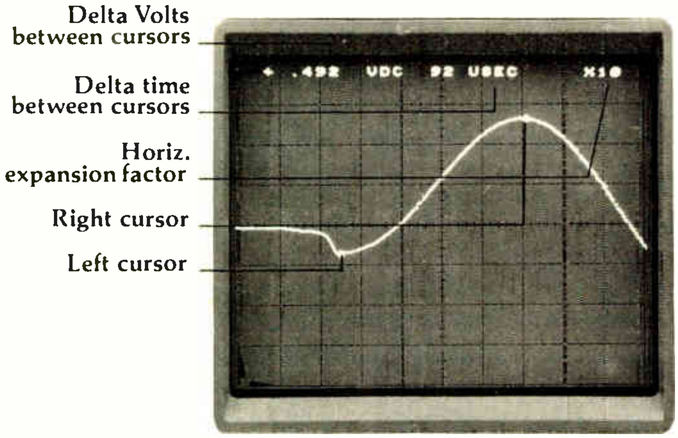
Three ways digital storage makes our 820 a super scope.



1 Capture one-time analog events.

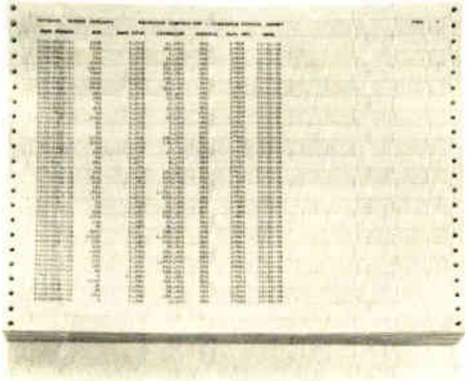
There's no better way to record one-time events than our 820 Digital Storage Oscilloscope. It captures analog signals, converts them to digital data, then stores that data in semiconductor memory.

Digital storage techniques enable us to give you "pre-trigger" recording, a Biomation exclusive. You can actually begin recording a random signal before you know it's going to occur, and apportion the 820's memory to record data both before and after the trigger. And set the trigger level to prevent false triggers.



2 Expand the display for detail analysis.

When you need to analyze the event in detail, you can expand the display 2, 5, 10, 20 or 50x. Movable cursors let you pinpoint the portion of the waveform you want to study. And on-screen digital readout of time and voltage is automatic.



3 Perform computer data analysis.

Digital storage gives you maximum analysis flexibility. You can transfer the data, already digitized, to mag tape, disc or other permanent storage. Or you can read the data out directly to a programmable calculator or computer system.

The 820 is the latest product in our six-year history of using digital storage techniques to help you capture and analyze analog signals. Other Biomation products enable you to convert your scope to a "super scope" by adding digital storage. For more information, or to arrange a demonstration in your lab, call Don Dedinas, (408) 988-6800. Or write us: 4600 Old Ironsides Drive, Santa Clara, CA 95050.

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The first thing you need to know about our DC Voltage and Current Standards:

$1,050.

Shown:
Model MV100J with
electronic galvo/ΔVM option
($1345. total)

We have 12 models of DC Voltage and Current Standards priced* from $725. This selection lets you buy what you need without paying for what you don't want. A wide range of features, functions and options are available. Call Bob Ross at (617) 268-9696 while supplies last at these prices.

Specifications (depending on model)
Ranges: ± 10nV to ± 1100 VDC
Resolution: As much as 0.1 ppm
Accuracies: ± 0.002% to ± 0.005% of reading
Compliance Current: 50 to 100 mA

*USA price only.

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DEVELOPMENT
CORPORATION
11 Hamlin St., Boston, MA 02127, Tel: (617) 268-9696

Circle 237 on reader service card

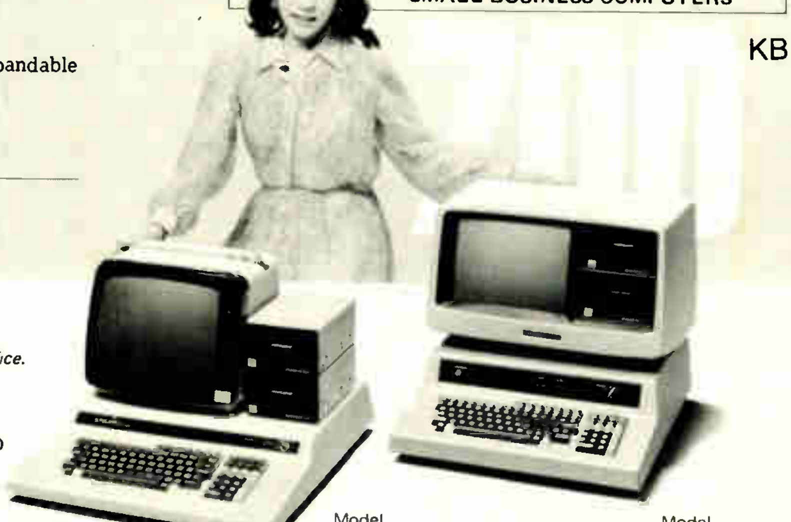
Minicomputer functions captured in a microcomputer package

SORD

M200
MARK-II Series
SMALL BUSINESS COMPUTERS

- Z80 CPU
- 64K bytes RAM
- 350KB/700KB mini-floppy disk drives expandable to 1.4M bytes
- Two RS232C ports built-in
- Extended BASIC Interpreter

Options
- Extended BASIC Compiler
- FORTRAN-IV Compiler
- COBOL available in Dec. 1978



Model
M203 MARK-II

Model
M223 MARK-II

Interested distributors and OEM's please contact our office.

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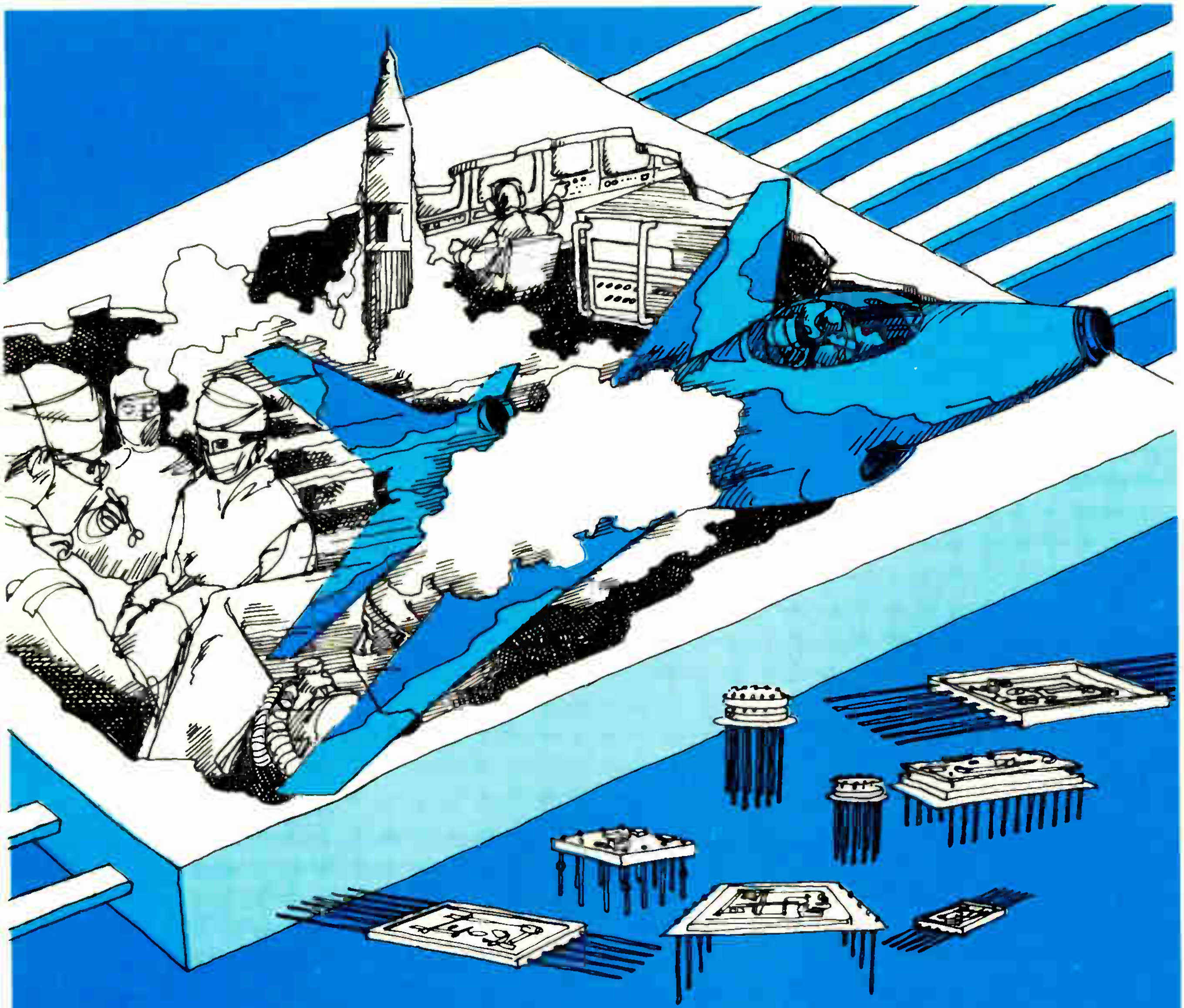
Circle 144 on reader service card



CTS puts a lot into hybrid circuits. And hybrid circuits into a lot!

Sixteen years experience in cermet circuitry and eleven in active hybrids add up to a lot of sophisticated capability. And it all goes into CTS hybrid circuits.

With that experience guiding our design activity, the CTS technical team can create an active hybrid circuit that meets your requirements, *whatever the application . . .*

At CTS, exacting standards beyond MIL STD 883 *are a way of life* used in the production of High Reliability *implantable grade* Medical Electronics. The same exacting standards are used in all Hi Rel airborne and military applications and can benefit your applications.

This Hi Rel capability also complements and enhances the *known* CTS capability in commercial and industrial active hybrids and cermet resistor/trimmer networks.

CTS Microelectronics is dedicated to its single specialty: active & passive hybrids. This dedication, based on the wealth of experience and capability already achieved, is your finest assurance that CTS is here to stay . . . in hybrid circuits.

Find out NOW how your Hybrid Circuit can benefit from CTS capability.

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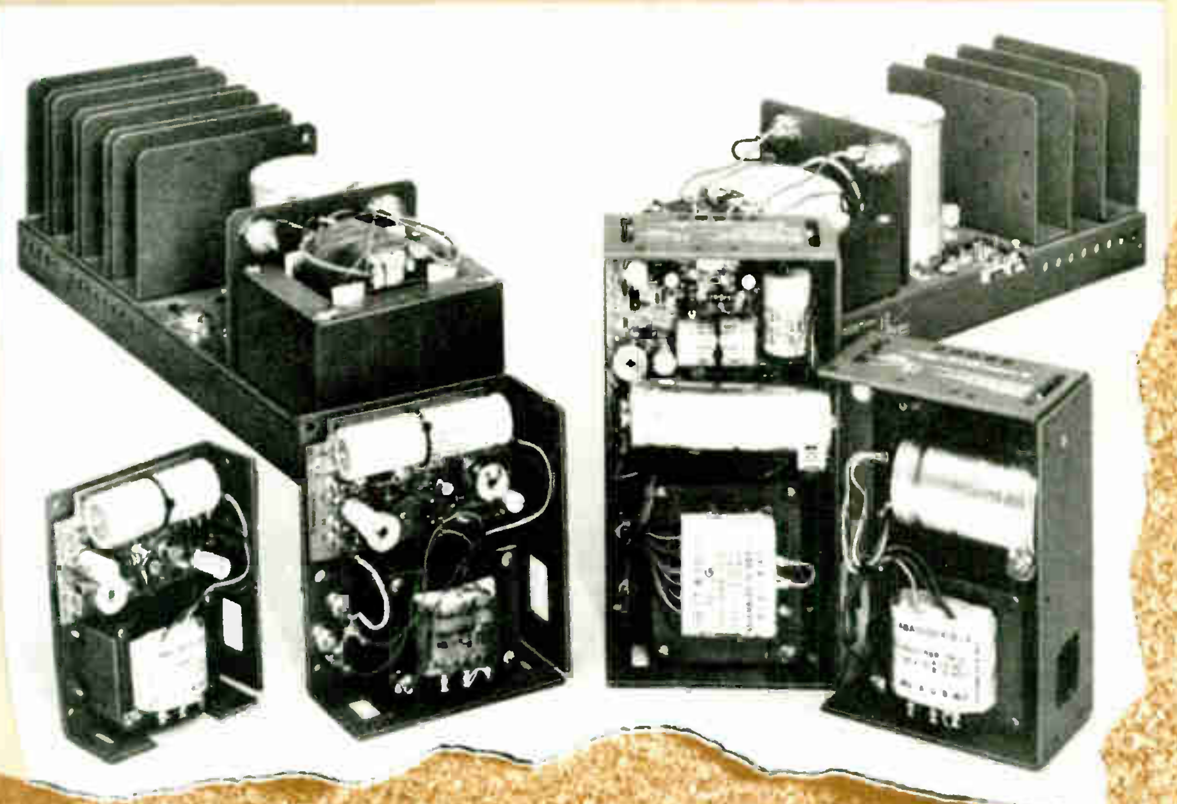
Circle 238 on reader service card

Circle 239 on reader service card →

LAMBDA ANNOUNCES NEW PRICE CUT ON LO SERIES POWER SUPPLIES

Up to 20% discount on quantities of 25.

Prices effective November 1, 1978. One day delivery on all models.



LAMBDA ELECTRONICS

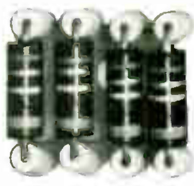
The world's largest manufacturer of low cost open frame power supplies. Proven the most reliable on the market.

24 reasons why you shou
power supplies from Lan

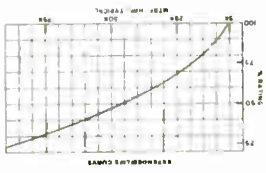
1
Thermally engineered—ventilation holes

2
Sheet Metal: 0.125in Aluminum
Finish: Grey, Fed. Std. 595 No. 26081

3
Sprague electrolytic capacitors



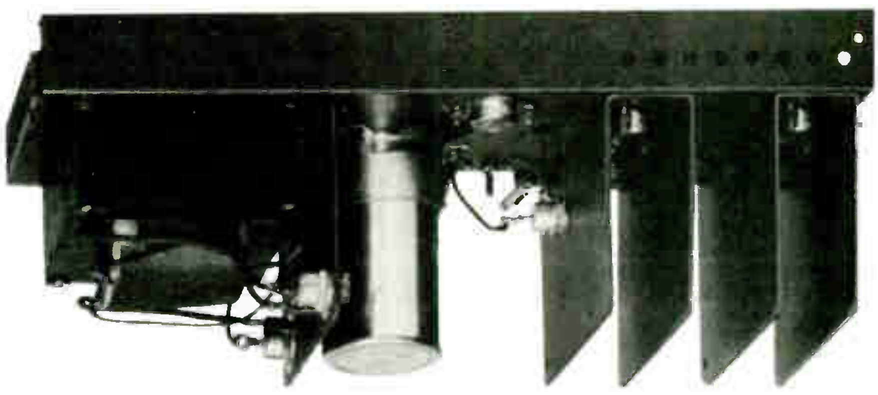
8
Flame retardant resistors



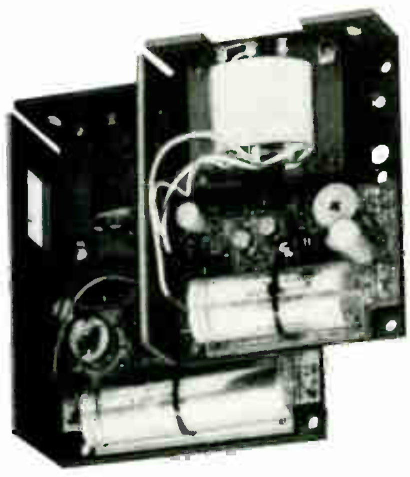
9
Extended life—known calculated MTBF curve

10
110/220 VAC, 50-60 Hz standard all models

11
Listed in Underwriter's Laboratories Recognized Components Index



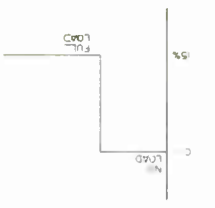
12
56 models, 6 power packages, single dual and triple outputs



0.03%

16
Temperature Coefficient . . . 0.03% °C

17
Ripple . . . 1.5 mV RMS



18
Regulation
Load 0.15% for 100% load change
Line 0.15% for 105 to 125 VAC

19
Convection cooled—3 mounting positions, no external heat sinks or forced air cooling required

Ne
tu

6 Amp Monolithic OV Protectors
$5.00 Qty 1 $3.40 Qty 1000

TO-3 PACKAGE, NO EXTERNAL COMPONENTS NEEDED

LAMBDA OVERVOLTAGE PROTECTORS
L-6-OV, L-12-OV, L-20-OV, L-35-OV Series

General Description

The Lambda overvoltage protector prevents damage to the load caused by excessive power supply output voltage due to improper adjustment, improper connection, or failure of the power supply. Load protection is accomplished automatically by effectively short circuiting the output terminals of the power supply when a preset limit voltage has been exceeded. The trip-point limit voltage cannot be adjusted. To reset overvoltage protector, remove AC input to power supply allow overvoltage protector to cool, and reapply power.

Overvoltage Protector Performance Specifications

PARAMETER	SYMBOL	L-6-OV SERIES		L-12-OV SERIES		L-20-OV SERIES		L-35-OV SERIES	
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
On State Current	I_{DC}	–	6A	–	12A	–	20A	–	35A
On State Voltage	V_{DC}	–	2.5V	–	1.3V	–	1.4V	–	1.6V
Non-Repetitive Peak Surge Current*	I_p	–	70A	–	200A	–	260A	–	350A
Standby Current	I_s	–	25mA	–	5mA	–	5mA	–	5mA
Operating Temperature (Blocking)**	T_{CB}	-40°C	+100°C	-40°C	+100°C	-40°C	+100°C	-40°C	+100°C
Operating Temperature (Conducting)***	T_{CC}	-40°C	+150°C	-40°C	+140°C	-40°C	+140°C	-40°C	+140°C
Storage Temperature	T_S	-40°C	+150°C	-40°C	+125°C	-40°C	+125°C	-40°C	+125°C
Power Dissipation @ 25°C Derate @ 1.5W/°C above 50°C	P_D		150 Watts						
Thermal Resistance	$R_{\theta JC}$		1.0°C/W						

*For sinusoidal current duration of 8.3 milliseconds max.

**Case temperature for overvoltage protector in non-conducting or "OFF" state.

***Case temperature for overvoltage protector in conducting or "ON" state. Power must be removed and case temperature allowed to drop to 100°C before application of output voltage.

The overvoltage protector must be mounted on external heat sink to maintain case temperature below rated limit. When the overvoltage protector is used with a Lambda power supply, the power supply chassis acts as the heat sink. The L-L-12-OV, L-20-OV, L-35-OV, overvoltage protector is supplied with mating connectors for pins on overvoltage protector (+V and -V engraved on unit).

OVERVOLTAGE PROTECTORS

				PRICE					PRICE					PRICE					PRICE		
NOM SUPPLY VOLTAGE (VOLTS)	TRIP POINT VOLTAGE^A (VOLTS)	6 AMP MODELS	QTY 1	QTY 100	QTY 250	QTY 1000	12 AMP MODELS	QTY 1	QTY 100	QTY 250	QTY 1000	20 AMP MODELS	QTY 1	QTY 100	QTY 250	QTY 1000	35 AMP MODELS	QTY 1	QTY 100	QTY 250	QTY 1000
5	6.5 ± .2 (6.6 ± .2)^B	L-6-OV-5	$6	$4	$3.75	$3.40	L-12-OV-5	$11	$8	$7.50	$6.80	L-20-OV-5	$16	$11.20	$10.50	$9.50	L-35-OV-5	$20	$14.40	$13.60	$12.30
6	7.4 ± .2 (7.3 ± .2)^B	L-6-OV-6	5	4	3.75	3.40	L-12-OV-6	11	8	7.50	6.80	L-20-OV-6	16	11.20	10.50	9.50	L-35-OV-6	20	14.40	13.60	12.30
9	10.5 ± .5 (10.5 ± .4)^B	L-6-OV-9	5	4	3.75	3.40	L-12-OV-9	11	8	7.50	6.80										
10	13.8 ± .5	L-6-OV-10	5	4	3.75	3.40															
12	13.7 ± .4 (13.7 ± .4)^B	L-6-OV-12	5	4	3.75	3.40	L-12-OV-12	11	8	7.50	6.80	L-20-OV-12	16	11.20	10.50	9.50	L-35-OV-12	20	14.40	13.60	12.30
15	17.0 ± .5	L-6-OV-15	5	4	3.75	3.40	L-12-OV-15	11	8	7.50	6.80	L-20-OV-15	16	11.20	10.50	9.50					
18	20.5±1.0	L-6-OV-18	5	4	3.75	3.40															
20	22.8 ± .7	L-6-OV-20	5	4	3.75	3.40	L-12-OV-20	11	8	7.50	6.80	L-20-OV-20	16	11.20	10.50	9.50					
24	27.3 ± .8	L-6-OV-24	5	4	3.75	3.40	L-12-OV-24	11	8	7.50	6.80	L-20-OV-24	16	11.20	10.50	9.50					
28	31.9 ± 1.0	L-6-OV-28	5	4	3.75	3.40	L-12-OV-28	11	8	7.50	6.80	L-20-OV-28	16	11.20	10.50	9,50					
30	33.5 ± 1.0						L-12-OV-30	11	8	7.50	6.80	L-20-OV-30	16	11.20	10.50	9 50					

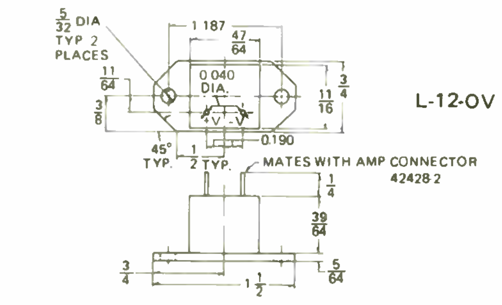
^{A}VOLTAGE TOLERANCE MAINTAINED OVER 0 71°C DUE TO POWER DESIGN ^{B}FOR L-6-OV ONLY

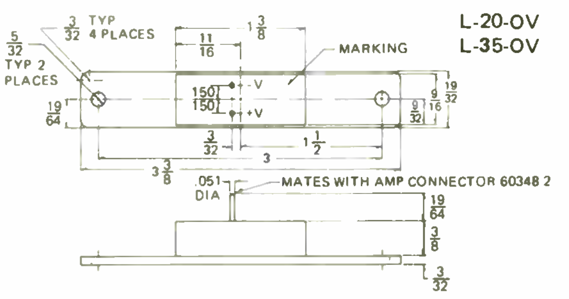
L-6-OV

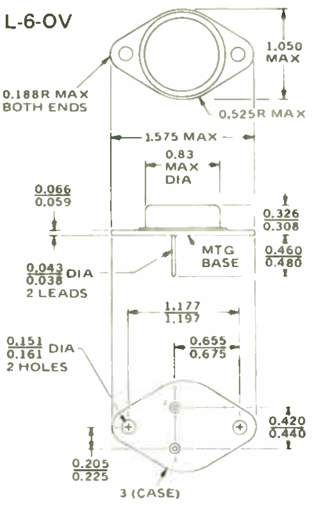
L-12-OV

L-20-OV
L-35-OV

Outline Drawings







PIN CONNECTIONS

1. No connection – but this pin must be left floating for proper operation of OV
2. +V – disconnect to reset
3. (Case) – V

SPECIFICATIONS

Regulated voltage

regulation, line . . . 0.15% for 105 to 125 VAC
regulation, load . . . 0.15% for 100% load change
ripple and noise . . . 1.5mV RMS, 5mV pk-pk with either positive or negative terminal grounded
remote programming resistance . . . . . . 200 ohm/volt
temperature coefficient . . . . . 0.03%/°C

AC input

line . . . . 105-125 VAC/210-250 VAC, 47-440Hz (derate 10% at 50 Hz). Consult factory for operation at frequencies other than 47 to 63 Hz.

Efficiency

minimum. . . . . .25% for 5V, 6V models. 35% for 12V, 15V and triple output models. 48% for 20V, 24V, 28V and dual output models

Overshoot

no overshoot on turn-on, turn-off or power failure.

Ambient operating range

continuous duty from 0° to 60°C

Storage temperature range

–55°C to +85°C

Controls

simple screwdriver output voltage adjustment over voltage range.

Remote sensing

provision is made for remote sensing to eliminate effects of power output lead resistance on DC regulation. Connected for local sensing at factory.

Overload protection

external overload protection; automatic electronic current limiting circuit limits the current to a preset value

Tracking Accuracy

(Dual and Triple Output Models Only) 2% absolute voltage difference, 0.2% change for all conditions of line, load, and temperature.

Mounting

three mounting surfaces on packages Z, Y, X, W; two mounting surfaces on packages V & R; three mounting positions (all models).

Finish

Gray, Fed. Std. 595 No. 26081

Physical Data

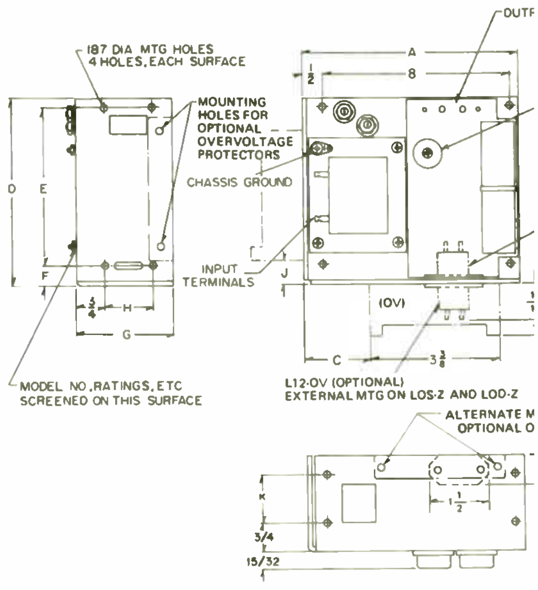
PACKAGE	WEIGHT		SIZE
MODEL	LBS. NET	LBS. SHIP	(INCHES)
LO-Z	2	2-1/4	4-7/8 x 4 x 1-5/8
LO-Y	4	4-1/4	5-5/8 x 4-7/8 x 2-1/2
LO-X	6-1/2	7	7 x 4-7/8 x 2-3/4
LO-W	7-3/4	8-1/4	9 x 4-7/8 x 2-3/4
LO-V	10-1/4	11-3/4	4-7/8 x 13-3/4 x 4-7/8
LO-R	14-3/4	16-1/4	4-7/8 x 16-3/4 x 4-7/8

Guaranteed for 60 days

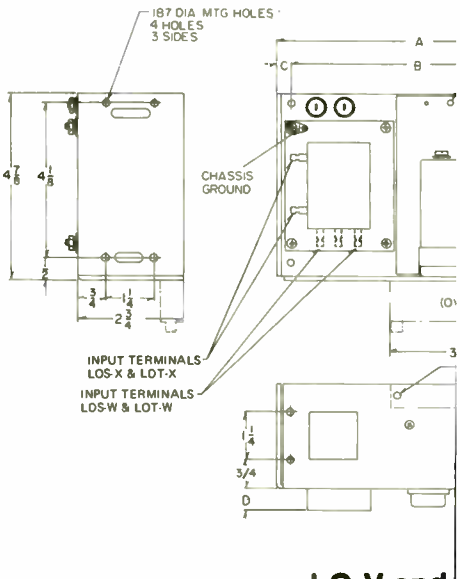
60 day guarantee includes labor as well as parts. Guarantee applies to operation at full published specification at end of 60 days.

DIMENSIONAL DRAWIN

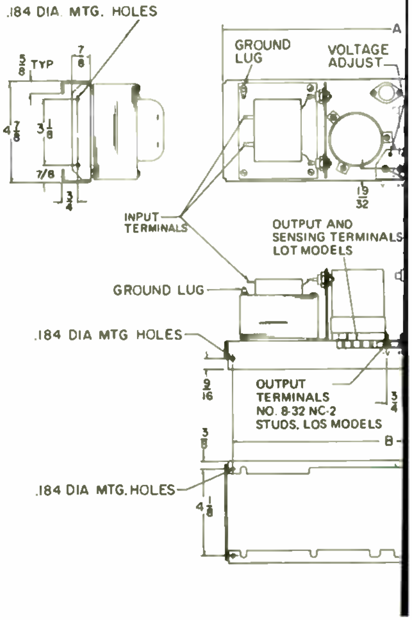
LO-Z and



LO-X and



LO-V and



Why Lambda is the world's largest manufacturer of low-cost, open-frame power supplies.

QUALITY

Only the Lambda LO series gives you all these high quality feature

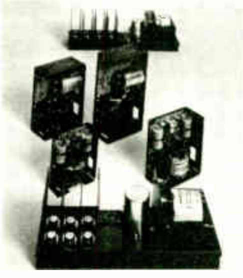
- All hermetically sealed semiconductors.
- Balanced thermal design with a known, defined level of quality.
- Sprague electrolytic capacitors.
- Quality controlled through Lambda manufacture of all its own sheet metal, transformers and P.C. boards.
- Purchased components rigidly specified by Lambda.
- Plated through hole printed circuit board.
- Flame retardant resistors.
- Teflon wiring in hi-temp location.

You'll get fewer failures with Lambda LO series power supplies. And the cost of failures is more important than the costs of repairing low-cost power supplies.

Costs to repair	Your Estimate	Lambda Estimate
Packing for shipment	—	$10
Cutting No Charge Purchase Order	—	25
Freight Charges (2 ways)	—	15
Receiving, incoming test and inspection	—	25
Total to implement guaranteed repair		75
To get cost of failure add:		
Field Service Call	—	200
Cost of down time (actual and product reputation)	—	?
		275+
3 failures will cost you		825+
15 failures will cost you		4125+

If you spend as much as $10 each for on-site repair of 15 failed low-cost power supplies, you will save $970 on t cost of implementing the guarantees.

The lowest cost power supplies are those with the fewest failures regardless of guarantees and initial price ..... Lambda quality means LO series power supplies have fewer failures than any other low-cost, open-frame power supplies

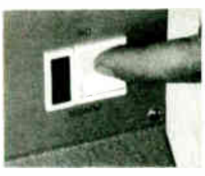


LAMBDA ELECTRONICS
515 BROAD HOLLOW ROAD, MELVILLE, L.I., NEW YORK 11746 (516) 694-4200

DIVISION of Veeco INSTRUM

---

ld buy your open frame
nbda and pay no more.

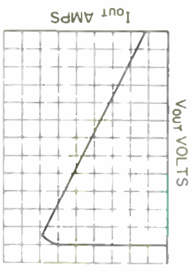


20
overshoot on turn-on, n-off, or power failure

21
Worldwide direct factory field sales force to serve you

22
Quality controlled through Lambda manufacture of all its own sheet metal, transformers and P.C. boards

23
Lambda monolithic overvoltage protector accessory available from $3.40 qty 1000



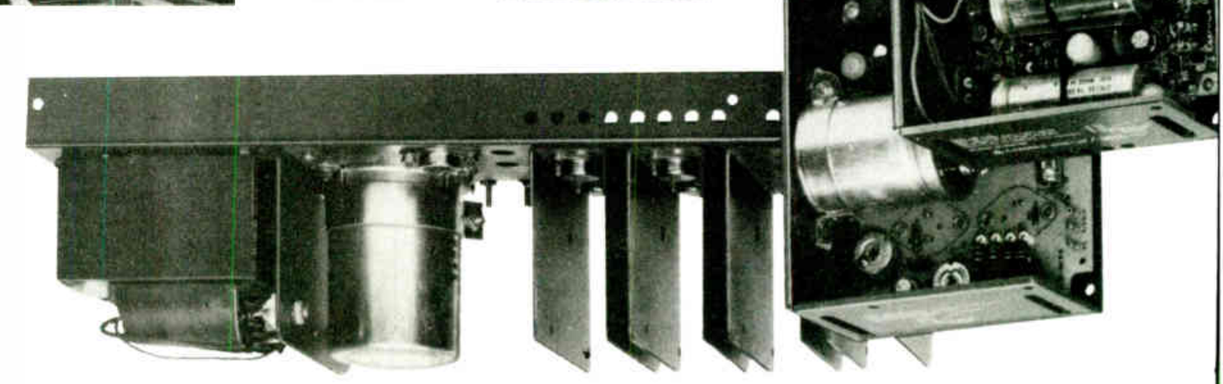
24
Foldback current limiting

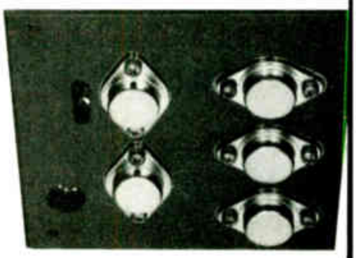
13
One day delivery

LAMBDA'S DISTRIBUTION CENTERS
McAllen, Texas;
Carson, Calif;
High Wycombe
Bucks, England;
Orsay, France;
Achern, W. Germany
Montreal, Canada;
Yokohama, Japan;
Tel Aviv, Israel

14
Worldwide distribution from stock from Melville, N.Y.

15
35,000 Sq. ft. Mexican production facility to handle any single order up to 30,000 power supplies

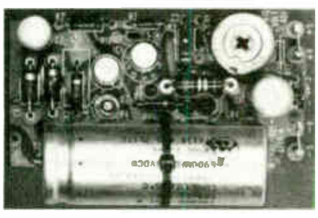




4
l hermetically sealed semiconductors

5
IC Regulator

6
Vacuum impregnated transformer



7
Plated through hole printed circuit board

VOLTAGE & CURRENT RATINGS LO SERIES

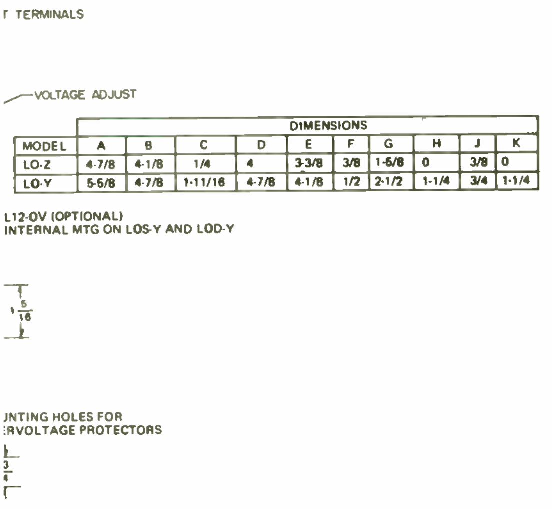
5V, ± 15 to ± 12 VOLTS * ADJ. TRIPLE OUTPUT

MODEL	REGULATION (LINE OR LOAD)	RIPPLE (RMS)	VDC	MAX. CURRENT (AMPS) AT 40°C	50°C	60°C	PKG. SIZE	DIMENSIONS (INCHES)	PRICE QUANTITY 1	25	100
LOT-X-5152-A	0.15%	1.5mV	5	3.0	2.2	1.4	X	7 x 4-7/8 x 2-3/4	$ 97	$ 80	$ 72
			±15 to ±12	0.50	0.375	0.20					
LOT-W-5152-A	0.15%	1.5mV	5	6.0	4.5	3.0	W	9 x 4-7/8 x 2-3/4	121	100	90
			±15 to ±12	1.0	0.75	0.40					
LOT-V-5152-A	0.15%	1.5mV	5	9.0	7.3	5.2	V	4-7/8 x 13-3/4 x 4-7/8	169	140	126
			±15 to ±12	2.0	1.4	0.75					
LOT-R-5152-A	0.15%	1.5mV	5	12.0	9.5	7.0	R	4-7/8 x 16-3/4 x 4-7/8	199	165	149
			±15 to ±12	3.0	2.2	1.2					
± 15 to ± 12 VOLTS* ADJ.				DUAL OUTPUT							
LOD-Z-152	0.15%	1.5mV		0.50	0.37	0.25	Z	4-7/8 x 4 x 1-5/8	52	43	35
LOD-Y-152	0.15%	1.5mV		1.0	0.75	0.50	Y	5-7/8 x 4-7/8 x 2-1/2	61	50	40
LOD-X-152	0.15%	1.5mV		2.0	1.4	0.80	X	7 x 4-7/8 x 2-3/4	90	75	61
LOD-W-152	0.15%	1.5mV		3.0	2.2	1.4	W	9 x 4-7/8 x 2-3/4	105	87	70
5 VOLTS ± 5% ADJ.				SINGLE OUTPUT							
LOS-Z-5	0.15%	1.5mV		3.0	2.4	1.8	Z	4-7/8 x 4 x 1-5/8	41	33	27
LOS-Y-5	0.15%	1.5mV		6.0	4.9	3.8	Y	5-5/8 x 4-7/8 x 2-1/2	65	53	44
LOS-X-5	0.15%	1.5mV		9.0	7.6	6.2	X	7 x 4-7/8 x 2-3/4	81	66	54
LOS-W-5	0.15%	1.5mV		12.0	10.5	8.5	W	9 x 4-7/8 x 2-3/4	105	85	70
LOS-V-5	0.15%	1.5mV		17.0	14.5	11.5	V	4-7/8 x 13-3/4 x 4-7/8	124	101	91
LOS-R-5	0.15%	1.5mV		25.0	21.5	17.5	R	4-7/8 x 16-3/4 x 4-7/8	164	134	120
6 VOLTS ± 5% ADJ.											
LOS-Z-6	0.15%	1.5mV		2.5	2.1	1.6	Z	4-7/8 x 4 x 1-5/8	41	33	27
LOS-Y-6	0.15%	1.5mV		5.0	4.3	3.5	Y	5-5/8 x 4-7/8 x 2-1/2	65	53	44
LOS-X-6	0.15%	1.5mV		8.5	7.1	5.7	X	7 x 4-7/8 x 2-3/4	81	66	54
LOS-W-6	0.15%	1.5mV		10.0	9.0	7.3	W	9 x 4-7/8 x 2-3/4	105	85	70
LOS-V-6	0.15%	1.5mV		15.5	13.0	10.3	V	4-7/8 x 13-3/4 x 4-7/8	124	101	91
LOS-R-6	0.15%	1.5mV		23.0	20.0	16.5	R	4-7/8 x 16-3/4 x 4-7/8	164	134	120
12 VOLTS ± 5% ADJ.											
LOS-Z-12	0.15%	1.5mV		1.6	1.3	1.0	Z	4-7/8 x 4 x 1-5/8	41	33	27
LOS-Y-12	0.15%	1.5mV		3.3	2.8	2.3	Y	5-5/8 x 4-7/8 x 2-1/2	65	53	44
LOS-X-12	0.15%	1.5mV		5.7	4.8	3.9	X	7 x 4-7/8 x 2-3/4	81	66	54
LOS-W-12	0.15%	1.5mV		7.0	5.8	4.6	W	9 x 4-7/8 x 2-3/4	105	85	70
LOS-V-12	0.15%	1.5mV		10.8	9.0	6.7	V	4-7/8 x 13-3/4 x 4-7/8	124	101	91
LOS-R-12	0.15%	1.5mV		16.0	13.5	10.5	R	4-7/8 x 16-3/4 x 4-7/8	164	134	120
15 VOLTS ± 5% ADJ.											
LOS-Z-15	0.15%	1.5mV		1.4	1.2	1.0	Z	4-7/8 x 4 x 1-5/8	41	33	27
LOS-Y-15	0.15%	1.5mV		2.8	2.5	2.1	Y	5-5/8 x 4-7/8 x 2-1/2	65	53	44
LOS-X-15	0.15%	1.5mV		4.8	4.0	3.2	X	7 x 4-7/8 x 2-3/4	81	66	54
LOS-W-15	0.15%	1.5mV		6.3	5.2	4.0	W	9 x 4-7/8 x 2-3/4	105	85	70
LOS-V-15	0.15%	1.5mV		9.5	7.6	5.6	V	4-7/8 x 13-3/4 x 4-7/8	124	101	91
LOS-R-15	0.15%	1.5mV		14.0	11.5	8.8	R	4-7/8 x 16-3/4 x 4-7/8	164	134	120
20 VOLTS ± 5% ADJ.											
LOS-Z-20	0.15%	1.5mV		1.0	0.8	0.6	Z	4-7/8 x 4 x 1-5/8	41	33	27
LOS-Y-20	0.15%	1.5mV		2.4	2.1	1.8	Y	5-5/8 x 4-7/8 x 2-1/2	65	53	44
LOS-X-20	0.15%	1.5mV		3.8	3.2	2.5	X	7 x 4-7/8 x 2-3/4	81	66	54
LOS-W-20	0.15%	1.5mV		5.2	4.2	3.2	W	9 x 4-7/8 x 2-3/4	105	85	70
LOS-V-20	0.15%	1.5mV		7.7	6.0	4.3	V	4-7/8 x 13-3/4 x 4-7/8	124	101	91
LOS-R-20	0.15%	1.5mV		11.5	9.5	7.1	R	4-7/8 x 16-3/4 x 4-7/8	164	134	120
24 VOLTS ± 5% ADJ.											
LOS-Z-24	0.15%	1.5mV		0.9	0.75	0.55	Z	4-7/8 x 4 x 1-5/8	41	33	27
LOS-Y-24	0.15%	1.5mV		2.2	1.9	1.6	Y	5-5/8 x 4 x 2-1/2	65	53	44
LOS-X-24	0.15%	1.5mV		3.3	2.8	2.2	X	7 x 4-7/8 x 2-3/4	81	66	54
LOS-W-24	0.15%	1.5mV		4.8	3.8	2.8	W	9 x 4-7/8 x 2-3/4	105	85	70
LOS-V-24	0.15%	1.5mV		6.6	5.2	3.8	V	4-7/8 x 13-3/4 x 4-7/8	124	101	91
LOS-R-24	0.15%	1.5mV		10.5	8.3	6.0	R	4-7/8 x 16-3/4 x 4-7/8	164	134	120
28 VOLTS ± 5% ADJ.											
LOS-Z-28	0.15%	1.5mV		0.8	0.65	0.45	Z	4-7/8 x 4 x 1-5/8	41	33	27
LOS-Y-28	0.15%	1.5mV		2.0	1.7	1.4	Y	5-5/8 x 4-7/8 x 2-1/2	65	53	44
LOS-X-28	0.15%	1.5mV		3.1	2.5	1.9	X	7 x 4-7/8 x 2-3/4	81	66	54
LOS-W-28	0.15%	1.5mV		4.2	3.3	2.4	W	9 x 4-7/8 x 2-3/4	105	85	70
LOS-V-28	0.15%	1.5mV		5.9	4.6	3.3	V	4-7/8 x 13-3/4 x 4-7/8	124	101	91
LOS-R-28	0.15%	1.5mV		9.3	7.5	5.6	R	4-7/8 x 16-3/4 x 4-7/8	164	134	120

* ± 15 to ± 12 volts are each dual tracking outputs;

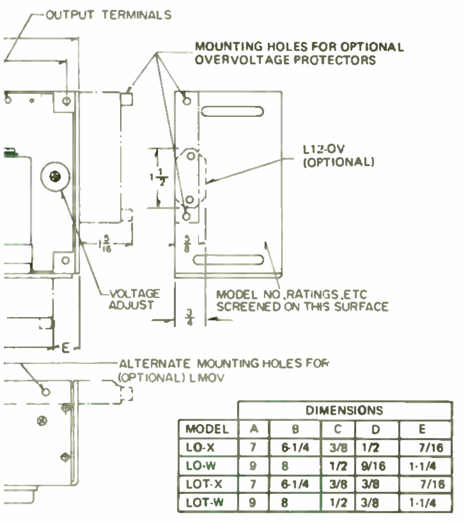
S LO SERIES SUPPLIES

Y series



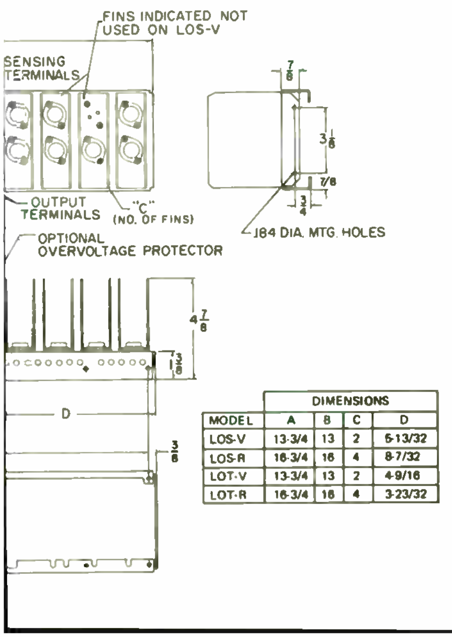
	DIMENSIONS									
MODEL	A	B	C	D	E	F	G	H	J	K
LO-Z	4-7/8	4-1/8	1/4	4	3-3/8	3/8	1-5/8	0	3/8	0
LO-Y	5-5/8	4-7/8	1-11/16	4-7/8	4-1/8	1/2	2-1/2	1-1/4	3/4	1-1/4

W series



	DIMENSIONS				
MODEL	A	B	C	D	E
LO-X	7	6-1/4	3/8	1/2	7/16
LO-W	9	8	1/2	9/16	1-1/4
LOT-X	7	6-1/4	3/8	3/8	7/16
LOT-W	9	8	1/2	3/8	1-1/4

R series



	DIMENSIONS			
MODEL	A	B	C	D
LOS-V	13-3/4	13	2	5-13/32
LOS-R	16-3/4	16	4	8-7/32
LOT-V	13-3/4	13	2	4-9/16
LOT-R	16-3/4	16	4	3-23/32

FEATURES

Convection cooled

no internal fans or blowers or external heat sinking required because of proven thermal design using heavy gauge aluminum chassis and ventilation holes

Regulation

regulation, load — no load to full load -0.15%.
regulation line — 0.15%.

Foldback current limiting

6 package sizes

up to 28 VDC, up to 25 A
available in single, dual and triple outputs

Ripple

1.5 mV RMS

Ambient operating temperature range

continuous duty from 0°C to +60°C

Temperature coefficient

0.03%/°C

AC input

105 to 125 VAC or
210 to 250 VAC, 47-440 Hz

3 mounting positions

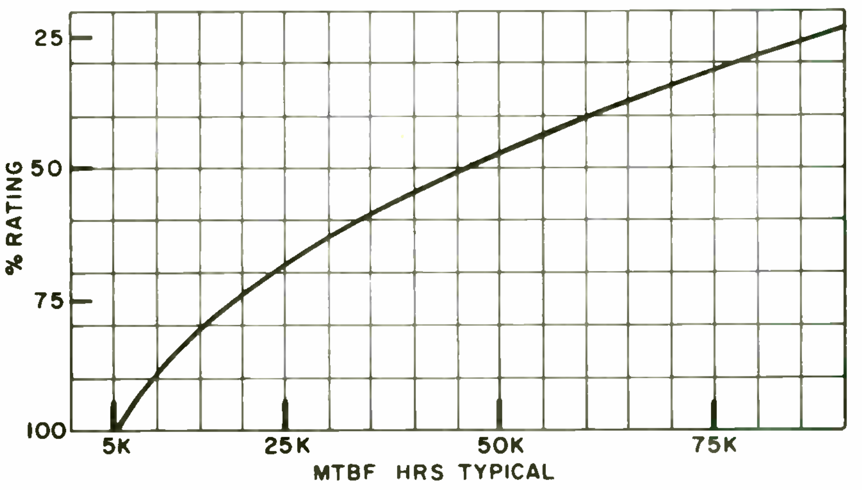
No overshoot or turn-on, turn-off, or power failure

Integrated circuit regulation

integrated circuit provides regulation system, except for input and output capacitors, rectifiers and series regulation transistors.

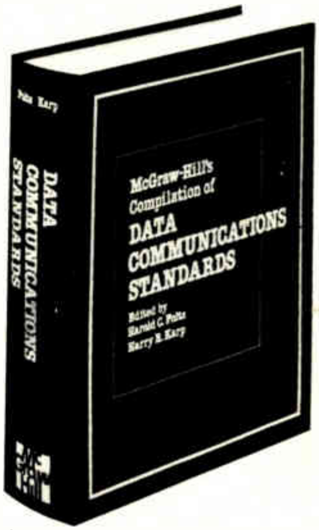
Job-rated calculated MTBF at worst-case condition (minimum voltage output, full load, 40°C, 125 VAC input) all models approximately 5000 hours for increased life at maximum conditions derate current as follows...

EXTENDED-LIFE CURVE



10% current derating	10,000 hours MTBF
20% current derating	15,000 hours MTBF
30% current derating	25,000 hours MTBF
40% current derating	33,000 hours MTBF
50% current derating	45,000 hours MTBF (Equivalent to LAMBDA LX series)

Instant access to all American and International Data Communications Standards



Data communications standards are undeniably necessary and helpful. But... the proliferation of standards by the many committees and groups has left the data communications equipment user and designer searching through numerous publications to find the applicable standards for each job.

Now: that time- and effort-wasting trial is over.

With the publication of this landmark resource, you can quickly and accurately determine exactly which standards apply to the project at hand, and speedily integrate those standards into your own network requirements.

Presents all relevant data communications standards promulgated by:

- Consultative Committee for International Telephone and Telegraph (CCITT)
- International Organization for Standardization (ISO)
- American National Standards Institute (ANSI)
- Electronic Industries Association (EIA)
- Federal Telecommunications Standard Committee (FTSC)

Need to know the latest standards for...

- data transmission over public data networks?
- computers and information processing systems?
- peripheral equipment?
- signal quality and analog and digital interfaces?

It's all here, and more, complete with introductory descriptions of the groups that promulgate the standards... and relational charts of similar interfacing standards produced by different groups.

Edited by
HAROLD C. FOLTS, data communications standards consultant; and
HARRY R. KARP, Editor-in-Chief, *Data Communications*, McGraw-Hill Publications Company
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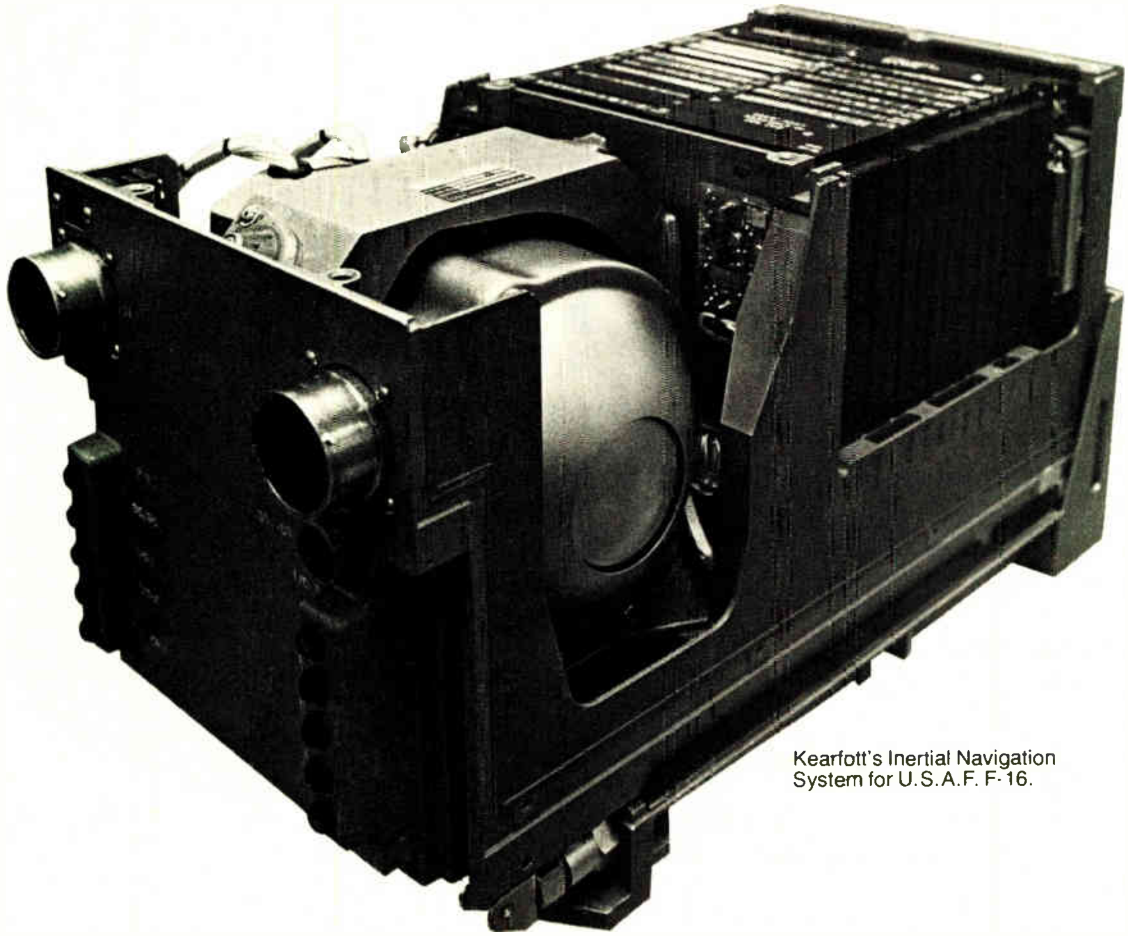
EL 1

THE STANDARD FOR INERTIAL NAVIGATION SYSTEMS



Kearfott's Inertial Navigation System for U.S.A.F. F-16.

Kearfott's Inertial Navigation System (INS) for the F-16 consists of two major line replaceable units—Inertial Navigation Unit (INU), and a Fire Control Navigation Panel (FCNP). It is a prime sensor for aircraft velocity, attitude, and heading, and a prime source of navigation information.

Navigational data are developed from self-contained inertial sensors consisting of a vertical accelerometer, two horizontal accelerometers, and two-axis displacement GYROFLEX® gyroscopes. The sensing elements are mounted in a four gimbal, gyro-stabilized inertial platform with the accelerometers, which are maintained in a known reference frame by the gyroscopes, as the primary source of information. Attitude and heading information is obtained from synchro devices mounted between the platform gimbals.

The system provides pitch, roll, and heading in both analog (synchro) and digital form. In addition, the following outputs are provided on a serial MUX channel (MIL-STD-1553):

- Present Position—Latitude, Longitude, Altitude
- Aircraft Attitude—Pitch, roll, Heading (True and Magnetic)
- Aircraft Velocity—Horizontal and Vertical
- Steering Information—Track Angle Error

In order to permit operation in aided-inertial configurations, the INS accepts the following digital inputs in MUX serial format (MIL-STD-1553):

- Position Update—Latitude and Longitude
- Velocity Update—Velocities in INS coordinates
- Angular Update—Angles about INS axes
- Gyro Torquing Update—Torquing rate to INS gyro axes

Significant features:

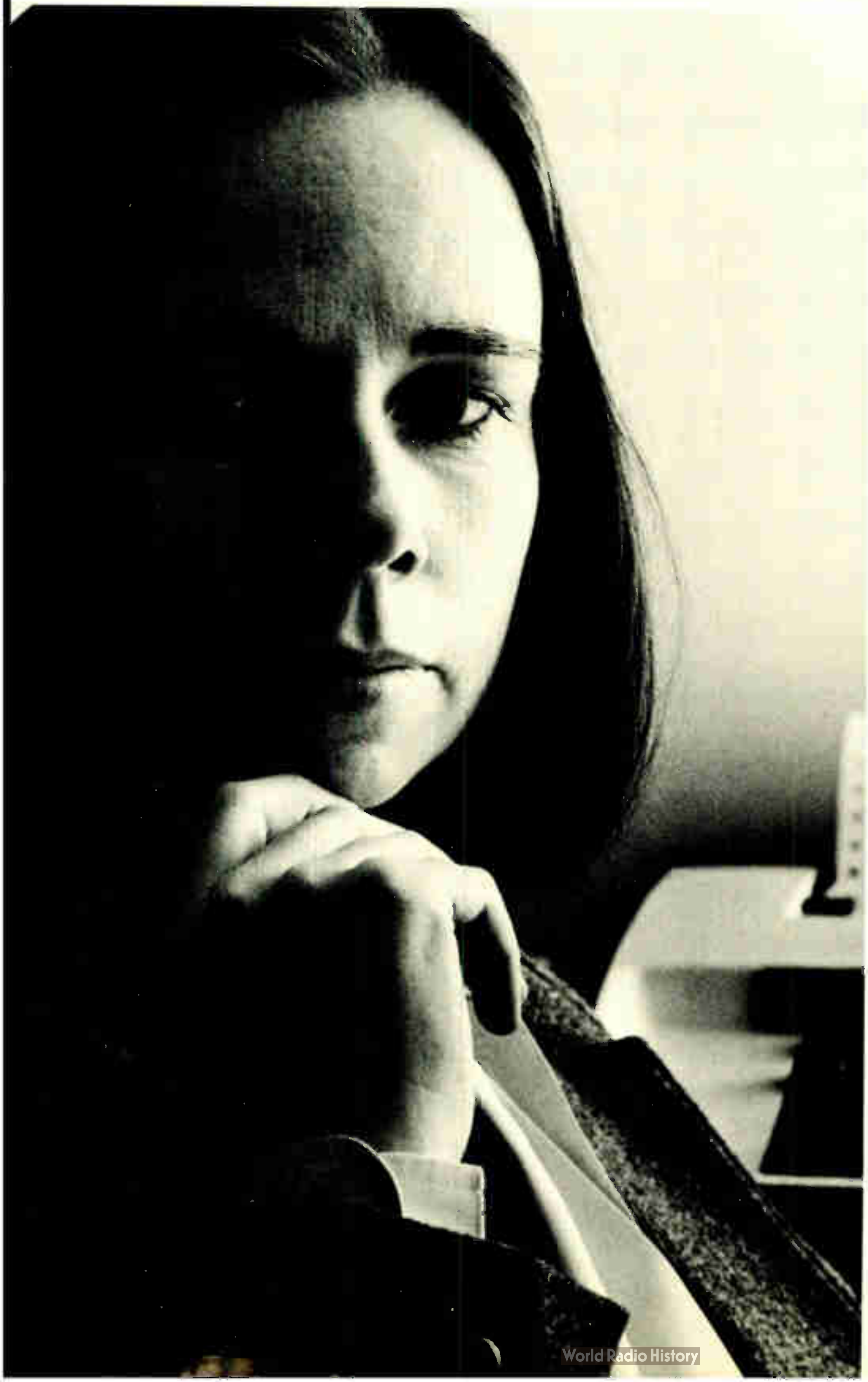
- MUX interface (MIL-STD-1553)
- Lightweight—33 pounds
- Small Size—7.5"h x 15.2"d x 7.5"w
- High Precision—better than 1 nm/h
- Rapid Align—9 minutes at 0° F
- Fast Installation/Removal—rack and panel-type mechanical interface
- Provides Back-up MUX Control in Event of Fire Control Computer Failure

For additional information write to: The Singer Company, Kearfott Division, 1150 McBride Ave., Little Falls, N.J. 07424.

Kearfott

a division of The **SINGER** Company

Maureen Moon recommended WATS for data transmission.



She was solving a larger problem.

It involved calls from various cities waiting to get into an agency computer.

There were several alternatives.

Maureen studied the agency's computer usage data and came up with the most reliable solution.

Using WATS (for low-speed data transmission) also made it the most economical solution.

Her recommendation was not simply a question of technology, but of a creative mind.

Maureen Moon, a Bell System Sales Supervisor, is just one of a number of Bell representatives ready to serve federal departments and agencies.

Call your Bell Account Executive.

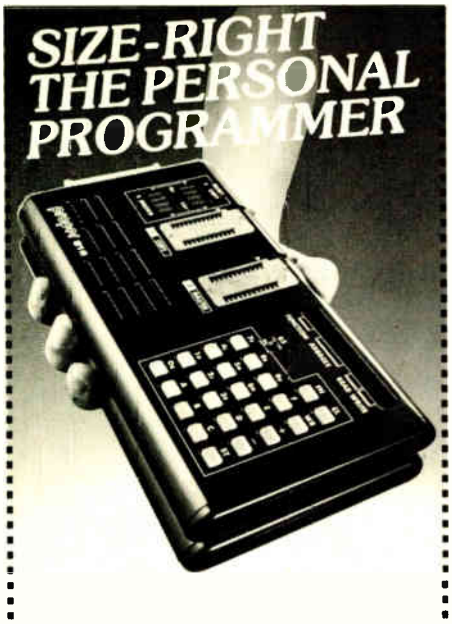
You'll find that their first step—before making recommendations—is to understand how you operate.

They don't necessarily prescribe WATS.

They prescribe what's best for you.

The system is the solution.

Bell System



The Personal Programmer. Proper 816 is it. Proper 816 is ultracompact, so it's easy to use. Highly reliable for a whole host of applications including research, development, production work, field servicing and others. It's designed to be used with PROM's like the 2708 and the 2716. In addition, Proper 816 is an economical writer. Nearly all pins of the PROM's mentioned above feature a TTL level, so there are no related problems when you use Proper 816. What's more, Proper 816 has INTEL drive circuitry which clears drive circuit troubles.

And there are many options for use with TTY, RS232C, or paper tape readers. If it's quality, reliability and low-cost you're looking for, look to Proper 816, the Personal Programmer. It's engineered to deliver.

HAKUTO CO., LTD.
2-29, Toranomon 1-chome Minato-ku, Tokyo 105
P.O. Box 25, Tokyo Central Japan
Tel: 03 (502) 2211 Telex: J22912 BRAPAN

SCANTEC GMBH
(Europe area only)
München, W. Germany
Tel: 089-28 20 48 Telex: 5-216194 MICR D

Circle 250 on reader service card

New products/materials

A system of thick-film compositions for use on porcelainized-steel substrates includes 10 materials: three conductors (palladium-silver, platinum-silver, and silver); six resistive materials, ranging from 15 ohms per square to 1 megohm per square; and a crossover dielectric. A trial kit contains 40 grams of all 10 materials, technical information on the products, and 50 porcelainized-steel substrates; it sells for $495. All materials have been evaluated on substrates made by both Erie Ceramic Arts Co., Erie, Pa., and Alpha Metals Corp., Newark, N. J.

Du Pont Co., Public Affairs Department, Wilmington, Del. 19898 [476]

A two-component adhesive can be used for bonding glass in liquid-crystal and gas-discharge displays and can resist temperatures up to 450°F. Aremco-Bond 561 is transparent, has good strength and resistance to chemical corrosion, and can be screened on in thicknesses of 0.00075 to 0.0015 in. It has a long pot life of 8 hours at 72°F, which reduces waste in many applications. When used in joining display glass, 561 produces shear strengths greater than that of the glass itself. Available from stock, it sells for $40 per pint, $60/quart, and $200/gallon.

Aremco Products Inc., P. O. Box 429, Ossining, N. Y. 10562 [477]

Epitaxial magnetic films grown on gadolinium-gallium-garnet substrates are intended for use in the manufacture of magnetic-bubble memories. The substrates have a diameter of 2 in. and a thickness of 20 mils. Orientation of the substrate is specified to be within 0.3° of the (111) crystal axis. The magnetic films have a thickness of 3.25 ± 0.15 μm and have a bubble-collapse field strength of 155 ± 5 oersteds. The temperature coefficient of the collapse-field strength is $-2\% \pm 0.05\%/^\circ C$. Defect density (pinning defects) is less than three per square centimeter. Samples sell for $350. Custom films are available.

Union Carbide Corp., Electronics Division—Materials Group, 8888 Balboa Ave., San Diego, Calif. 92123 [479]

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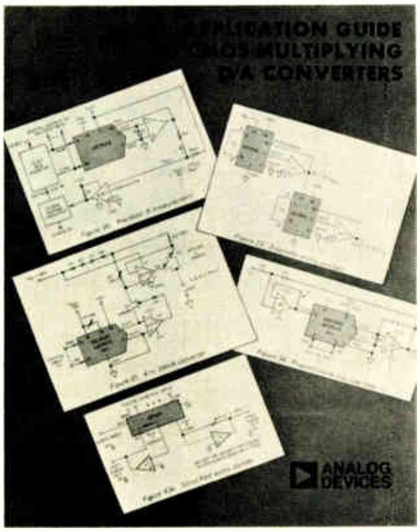
New literature

Plastic materials. Intended primarily for research and development personnel, "New Plastics: Properties, Processing and Potential Uses" contains information on more than 17 new and/or modified plastic materials. This 131-page report gives the potential advantages and limitations of the materials, as well as their physical, mechanical, and electrical characteristics and their different chemical structures. The report sells for $12.50 and is available from National Technical Information Service (NTIS), 5284 Port Royal Rd., Springfield, Va. 22161

C-MOS multiplying d-a converters. "Application Guide to CMOS Multiplying D/A Converters" explains the principles and applications of multiplying digital-to-analog converters. More than 25 ways of using them are given, including measurement circuits, function generation, signal conditioning, digitally programmable control circuits, and audio and synchro applications. An extensive section on theory and keys to successful applications will help both inexperienced and experienced engineers. Analog Devices, Route 1 Industrial Park, P. O. Box 280, Norwood, Mass. 02062. Circle reader service number 422.



Cut cores. For design engineers who require one to several thousand transformer cores unavailable in standard lamination sizes, "Cut Cores" offers a choice of more than 2,500 special shapes and sizes. This 258-page catalog is divided into two sections: the first lists the cores by catalog number in alphanumeric order; the second is arranged in order of increasing dimensions and by material gauge and grade. In addition to dimensional data, the listings include leg area, weight, the number of turns per volt, and the maximum exciting ampere-turns and watt loss. Magnetic Metals Corp., Hayes Avenue at 21st Street, P. O. Box 351, Camden, N. J. 08101 [423]

Electromechanical components. Among the products shown in a 357-page catalog are gearheads, ratio drives, right-angle drives, timing pulleys, timing belts, instrument differentials, linear bushing assemblies with shafts, and bearings and pillow blocks. The "All-in-One Catalog 87" is available from Secs Inc., 19-65 38th St., Long Island City, N. Y. 11105 [424]

Microwave subsystems. Discussed in a 12-page brochure are a 2- and an 8-gigahertz radio-frequency unit designed for digital radio applications. Included are descriptions of communications components like intermediate-frequency amplifiers, low-noise amplifiers, ferrite units, and an up-converter. For a copy of the brochure, contact Aertech Industries, 825 Stewart Dr., Sunnyvale, Calif. 94086 [425]

Semiconductor devices. This 150-page catalog contains information on more than 800 models of semiconductor devices, relays, and solid-state controls, as well as reliability data and application notes. This publication can be obtained from Teccor Electronics Inc., Marketing Manager, P. O. Box 669, Euless, Texas 76039 [426]

Graphics software. A 32-page brochure details four levels of graphics software, encompassing more than 30 software packages. The four levels are: basic software—programming subroutines that provide the basic commands to do every kind of computer graphics; functional software—programs that perform separate functions used repeatedly in plotting jobs; application software—a library of problem-solving programs for many application areas; and Page—an interactive graphics editing software program. California Computer Products Inc., 2411 W. La Palma Ave., Anaheim, Calif. 92801 [427]

Terminal boards, blocks, and strips. Highlighted in the "Terminal Board, Block and Strip" reference guide is the new Hi-Rise thermoplastic series for printed-circuit, insulated feed-through, and flat-mount applications. The catalog is divided into 20 sections that cover a variety of terminals and terminal boards including stud and turret, wire-wrap, and quick-connect types. It also contains information on design application and molded-materials. Kulka Electric, 520 South Fulton Ave., Mount Vernon, N. Y. 10551 [429]

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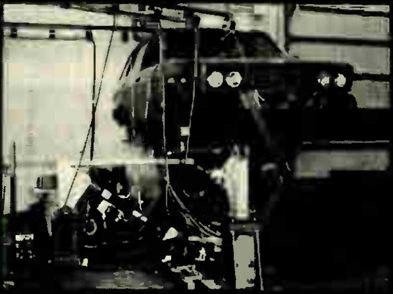

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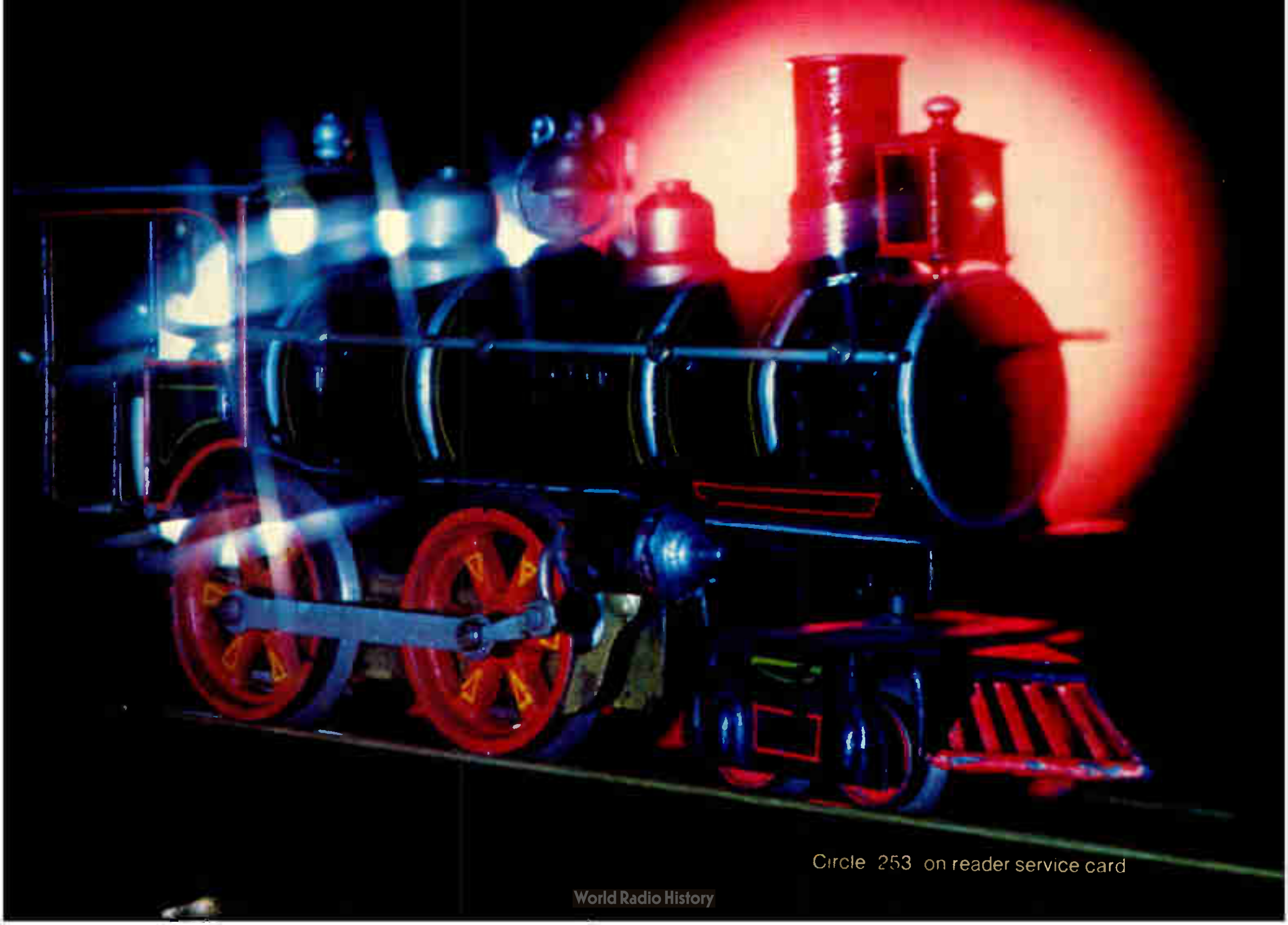

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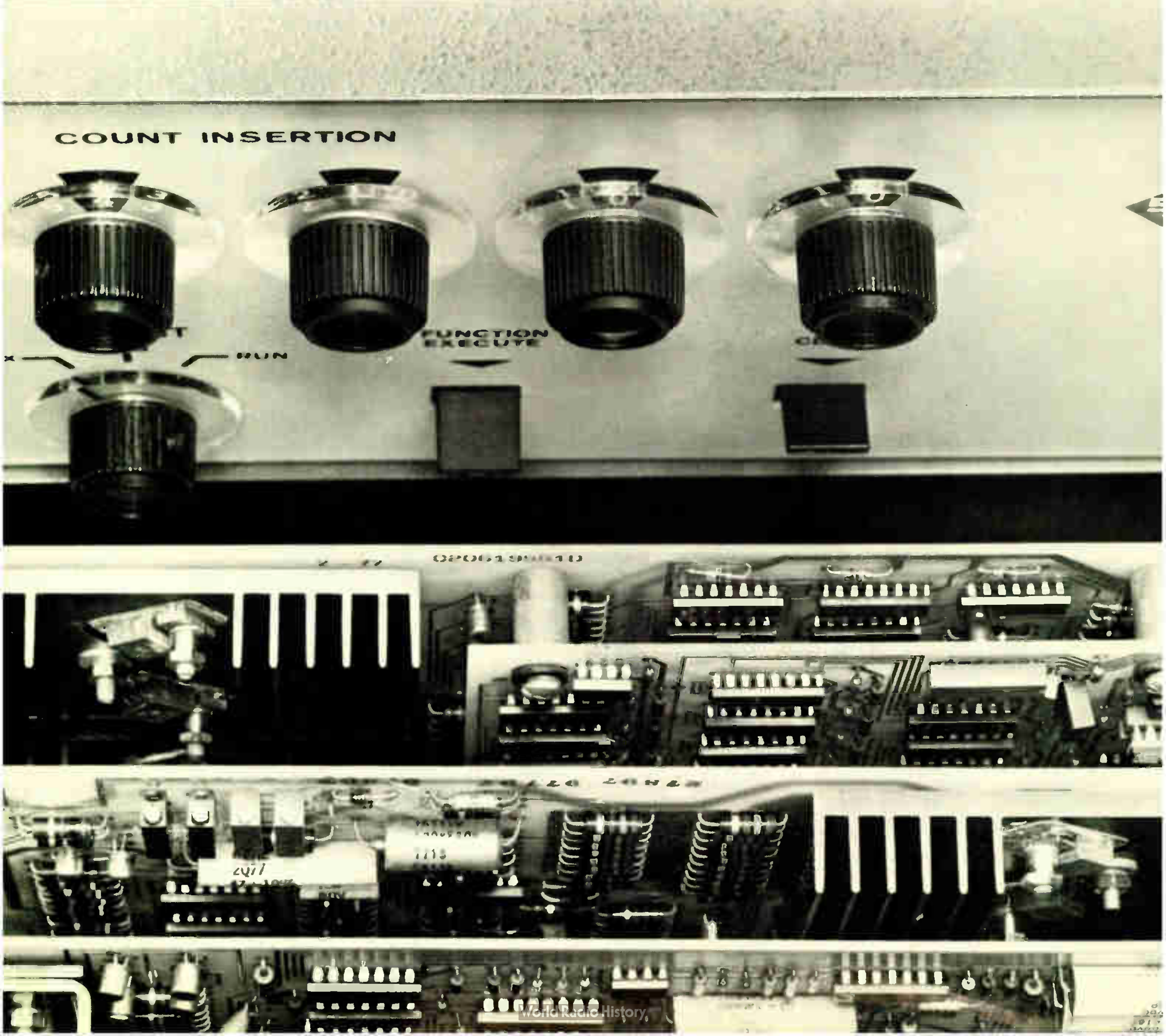

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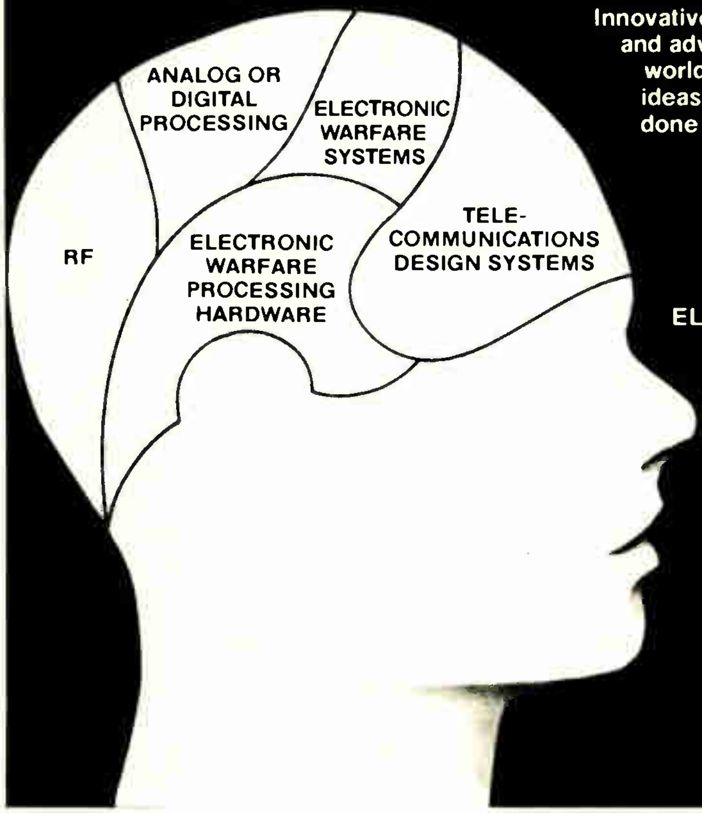

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LSI/DESIGN AUTOMATION FOR THE 80'S

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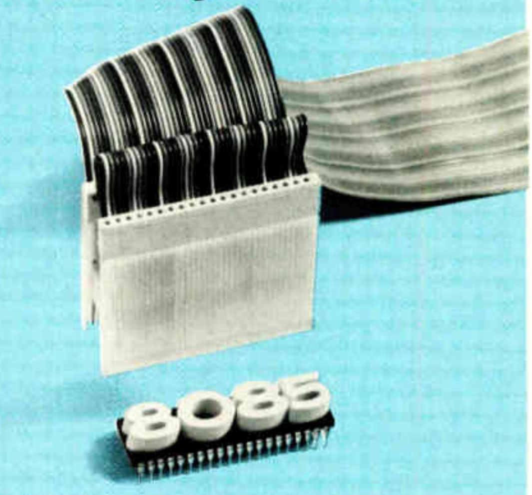

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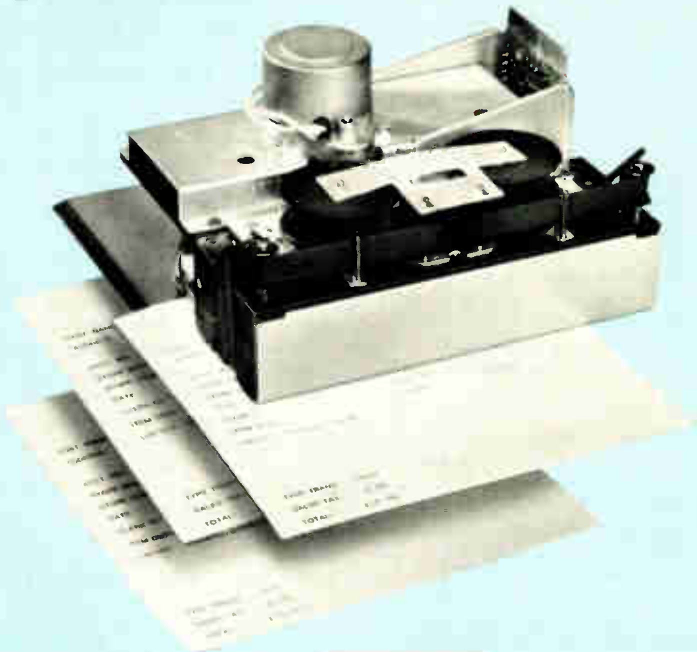

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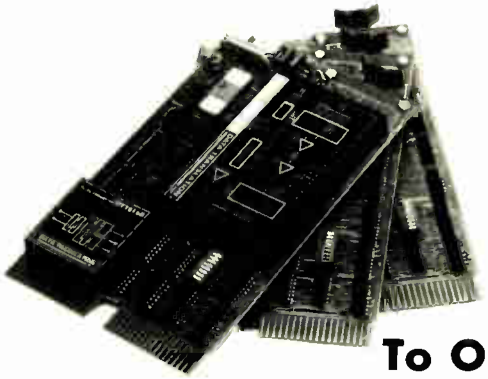

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