MARCH 31, 1977

WHAT NEW TV TARIFFS WOULD MEAN/74

CCDs moving in on digital signal processing/97

Monolithic control chip simplifies switched power supplies/113

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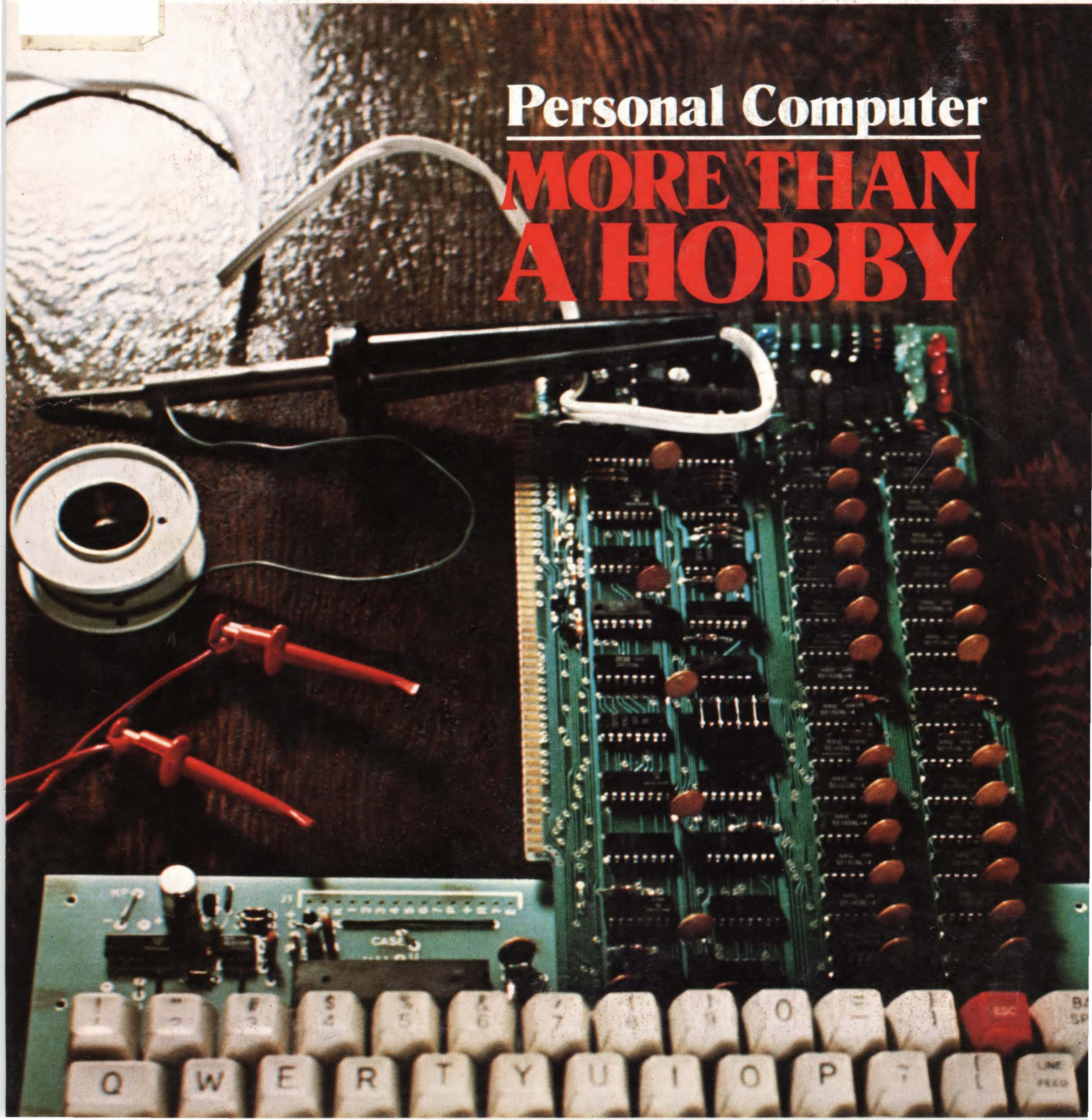

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Circle 2 on reader service card

Electronics

The International Magazine of Electronics Technology

Vol. 50, No. 7 • March 31, 1977

Highlights

Cover: Taking computers personally, 89
To everyone's surprise, the two-year-old personal computer is blossoming into a major industry, serving small businesses as well as hobbyists. This special report surveys the explosive growth of the small firms making up the industry and reports on the toe-in-the-water stances of the big semiconductor firms.

Art director Fred Sklenar photographed the cover.

Automakers plan more digital engine controls, 71
Electronic fuel-management systems are beginning to pop up in American cars. Already, however, the Big Three are planning to fold the systems into more capable digital electronics that will control other engine functions as well.

CCDs take on digital signal processing, 97
Low power and high density make charge-coupled devices attractive for digital processing functions suited to the pipeline approach. The CCD state of the art has advanced to the point where digital processing chips are about to be fabricated and tested.

Software eases traffic flow among devices, 108
Speedy transfer of data and instructions among the microprocessors making up a multiprocessor system is crucial. The solution is to write software assigning this task and that of communicating with the operator to one of the processors.

And in the next issue . . .
A preview of Electro77 . . . LSI applications in communications: a special report . . . at last, an SCR model for computer-aided designing.

Electronics

Publisher's letter

Personal computers are less than two years old, but are already spawning an industry of their own. For a look at that industry, turn to the special report that begins on p. 89. It covers such topics as hardware and software suppliers, the wait-and-see attitude of semiconductor houses, and the uses some hobbyists have found for their machines.

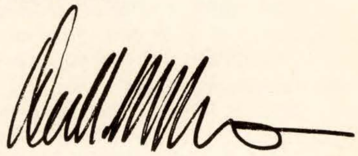
One thing not detailed in the report, though, is a pervasive and influential aspect of personal computing: a nationwide grapevine. Senior editor Larry Curran, who put the story together from his own reporting and field reports, was almost as impressed by the grapevine's efficiency as he was by the multiplicity of suppliers and the jobs owners are doing with their computers.

"It was fascinating," Curran says. "The grapevine is probably as extensive and percolating with information as the semiconductor industry grapevine."

After they had been interviewed by *Electronics* field staffers, people soon spread the word along the grapevine that *Electronics* was doing a major report. People began calling Larry in Boston from all over the country to chip in with a contribution for the article.

"What interested me most," Curran continues, "is that most of these unsolicited calls weren't from people with self-serving interests. They truly wanted to guide us to others that they believe are making worthwhile contributions—in educating users, for example. I was directed to the president of one of the better-organized computer clubs in this manner and got good guidance from colleagues on the staffs of the top computer-user magazines, leading us to users who have interesting applications

Not only does personal-computer news spread far and wide, but it also spreads quickly. Says Curran: "While many users are applying the machines to their music hobbies, maybe one of the reasons the word about our story got around so speedily is that a good many of these people are also ham radio operators. Some, I know now, got on the air and sounded off."



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Circle 4 on reader service card

Readers' comments

Competition is the key in Japan

To the Editor: I wish to comment on several remarks attributed to our U. S. competitors in the article on semiconductors in the Feb. 17 issue [p. 72].

The first was a remark, which I would like to reinforce, to the effect that "the Japanese are setting reliability standards that pose a problem for U. S. firms to meet." In fact, this is one of the single most important factors that NEC Microcomputers has been able to capitalize on in entering the market. This becomes especially important for repeat business with the same customers.

The Japanese standards for quality and reliability are higher than those generally found in the U. S. Not only are they an asset to us in the U. S. market, but they might also explain why some of the American manufacturers are not meeting with the success they may have anticipated in entering the Japanese market.

On the other hand, there were comments to the effect that our U. S. competitors wish to have a chance to penetrate the Japanese market. This certainly requires a little clarification. It is my understanding that U. S. manufacturers currently have about 30% of the Japanese semiconductor market. This seems to me to be a significant penetration already. The U. S. manufacturers' problem is to hold this 30% in view of the Japanese reliability standards and their technical competition.

Finally, quotes having to do with the disparity in import taxes charged in each country do not reflect the total picture. They overlook the fact that a number of U. S. manufacturers have factories in Japan to which the import duties do not apply, and they fail to account for the fact that U. S. companies get a significant tax relief on profits made from exports. When these two factors are taken into account, it is not apparent that the real disparity is as great as indicated.

Roger H. Bender, president
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News update

■ Variable speech control—a low-cost method of speeding or slowing the playback of recorded speech without altering its pitch or tone—is finally emerging on the commercial scene after nearly a dozen years and several million dollars in research and development. The impetus for the move is coming from the VSC Co., a newly-formed company that has acquired all patents, licenses, technology, trademarks, and rights to the process developed by Cambridge Research and Development Group of Westport, Conn. [*Electronics*, April 15, 1976, p. 32].

The new firm begins operations in San Francisco this week and shortly will begin to manufacture systems and market them throughout the world, says Tom Straus, former Cambridge Research administrative director who joined VSC, a venture that commences with an initial funding of $19 million, all from private investors.

VSC will offer its technology and marketing services to all on a nonexclusive license basis and is prepared to provide the technical assistance usually required by licensees to apply the technology to their own equipment, adds Marvin Flaks, VSC's chief executive officer. Japan's Matsushita Electric Industrial Co. Ltd. and Sony Corp are among those already taking licenses and actively developing products involving VSC. The system builds specially developed ICs into sound-reproducing equipment to eliminate the so-called Donald Duck effect.

Bruce LeBoss

■ AMP Inc., which has designed a plastic chip carrier that can be either reflow soldered or socketed to a printed-circuit board [*Electronics*, March 17, p. 89], is not letting the matter rest there. The Harrisburg, Pa., company has added something to the design: an optional heat sink to raise the carrier's power dissipation to 3 watts from the present 0.25 W. The heat sink, which is a Kovar stud with aluminum fins, is press-fitted into the top of the package, where it takes the place of the normal top cover. **Jerry Lyman**

24 bits of D to A from AMD.

Editorial

Tariffs: are they the answer?

It's not surprising that the recommendation by the U. S. International Trade Commission to raise tariff rates on imported color and monochrome television receivers did not entirely please everyone in the industry. Considering the complexity of the issues and the size of the market at stake, it would be impossible for the commission to satisfy all the varied interests, especially the consumer, who stands to be hardest hit should the tariff hikes be implemented.

Tariff protection is a short-term protection at best. It can only buy a bit of time that can be used to find a long-term answer. It is, however, significant that—even among the international trade commissioners who found that imports of television sets were hurting domestic manufacturers—there is still doubt as to just what American producers would do with the protection provided by a tariff. Apparently, if the ITC hearings were any guide, neither the manufacturers nor the unions concerned with preserving U. S. TV production have a clear plan beyond seeking Federal assistance.

One could well ask if American companies, fearful of not being able to meet Japanese competition, want Uncle Sam's protection at any cost to the consumer. The fact is, American consumers have perceived genuine value in Japanese-made consumer goods, in terms of price and performance—and not just in TV receivers, but also in audio equipment, citizens' band transceivers, and calculators.

That value has been perceived as well by major U. S. retailers, who are exploiting the advantages in buying private-label color sets from Japanese sources, with price a prime concern. And even U. S. TV makers know a good value when they see one, as they prepare to market Japanese-made home video-tape recorders here.

What's more, even if tariffs are imposed, the Japanese presence will not disappear. Within the last few years, two U. S. TV producers have been taken over by Japanese firms, and Japanese companies have set up manufacturing facilities in the U. S. to produce sets here.

If the Japanese are guilty of "dumping," and benefit from other unfair advantages over U. S. competition as some have charged, those inequities should be eliminated despite the political and economic complexities involved. The U. S. Government must lead here, by investigating those charges and taking all legal steps needed to end any such practice. Once that is done, no tariff would be necessary.

Given a fair and orderly market, it is inconceivable that American industry should be beaten on its own home grounds at its own technological game, in which it had enjoyed unchallenged superiority for so many years. The rules of the game have not changed, only the players. U. S. manufacturers must do their part by showing an aggressive commitment to innovative exploitation of technology, a continued investment in production automation, and a recognition that the whole world is now the arena.

For its part, the U. S. Government must insure that American TV manufacturers are not forced to play with handicaps imposed by factors over which they have no voice or control. Given that degree of support, we're confident that American TV industry can compete—without tariffs.

People

Selling overseas has boomed for TRW Datacom's Ashley

Going from "zero business" five years ago to $80 million sales by 1976, entirely outside the U. S., itself is a pretty fair record. But it is just the beginning, maintained Robert L. Ashley, vice president and general manager of TRW Datacom International, as he signed up this month to sell overseas the word-processing equipment made by Lexitron Corp., Chatsworth, Calif.

A TRW Inc. subsidiary based in Los Angeles, Datacom has going for it an unusual marketing concept for high-technology products and systems. "I'm not aware of any other company doing it this way," says the 49-year-old Ashley, a veteran of the electronics industries for 20 years, the last 14 of them at TRW in a variety of management posts. In return for exclusive non-U. S. rights, Datacom provides what amounts to a turnkey marketing organization for companies that need to sell abroad but cannot, for whatever reason, do it themselves. Having more than 1,500 people spotted at 150 locations in 50 countries, "we solve a major timing problem with a unified marketing force," he says. "This can save a company two or three years, which could be the life of some technological products."

Expanding. Ashley calls the deal with Lexitron "the first step of an expansion into related fields of intelligent office and business systems"—and out of the data-processing and -communications areas where it began. Datacom's principal products at present are Datapoint data-processing and data-entry terminals. In fact, it was originally organized to handle foreign Datapoint marketing when parent TRW was involved in the early 1970s with helping Datapoint, which had operating troubles. Datacom became a separate entity in 1973.

Other products include Computer Entry Systems' optical-character-recognition equipment, Centronics printers, and TRW Electronics' line of transaction terminals.

Seller. Ashley believes he can save a firm two or three years in building sales abroad.

Ashley's goal to "become a major part of TRW centers on adding other major related products and building them in a similar way."

Datacom is also toying with the idea of reversing the present flow by selling equipment from foreign firms inside the U. S. "We've already talked to several and will talk with more," Ashley observes.

Technology can cut Comsat costs, says RCA's Garman

The engineering challenge in communications satellites is no longer a matter of getting them to work, according to Arthur A. Garman. It is a matter of applying technology to cut the cost, says the new manager of satellite programs at RCA Corp.'s Astro-Electronics division.

"It's harder to manage the programs than to achieve the technology that's required," says the mild-mannered Englishman, a veteran of the communications and Navy navigation-satellite programs at RCA. "The emphasis today is on cost effectiveness and scheduling. We can do most of what we want to do with present technology."

With costs in mind, the former manager of advanced programs at the RCA division in Princeton, N.J., enjoys making the technological changes that improve the performance of communications satellites and lower their per-channel costs. One such change—aboard the com-

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Reli-ability:

The unique design features of the Altair 8800b, which have set the standard for the microcomputer industry, make it the most reliable unit of its kind. The Altair 100-pin bus, the now-standard design used by many imitators, has been "standard" all along at MITS. The unique Front Panel Interface Board on the Altair 8800b isolates and filters front panel noise before it can be transmitted to the bus. The all-new CPU board utilizes the 8080A microprocessor, Intel 8224 clock generator and 8216 bus drivers.

Flex-ability:

Meeting the diversified demands of an ever-increasing microprocessor market requires flexibility: not just hardware flexibility but software flexibility as well. MITS software, including the innovative Altair BASIC language, allows the full potential of the Altair 8800b computer to be realized.

8K ALTAIR BASIC has facilities for variable length strings with LEFT$, RIGHT$, and MID$ functions, a concatenation operator, and VAL AND STR$ functions to convert between strings and numbers.

Extended ALTAIR BASIC allows integer, single and double precision variables, automatic line numbering and renumbering, user-defined string functions, PRINT USING for formatted output and a powerful EDIT command for editing program files during or after entry. Extended statements and commands include IF . . . THEN . . . ELSE, LIST and DELETE program lines, SWAP variables and Trace On and Off for debugging.

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In all versions of ALTAIR BASIC you get the ease and efficiency of BASIC for the solution of real world problems.

Package II, an assembly language development system for the Altair 8800b, includes system monitor, text editor, assembler and debug.

Afford-ability:

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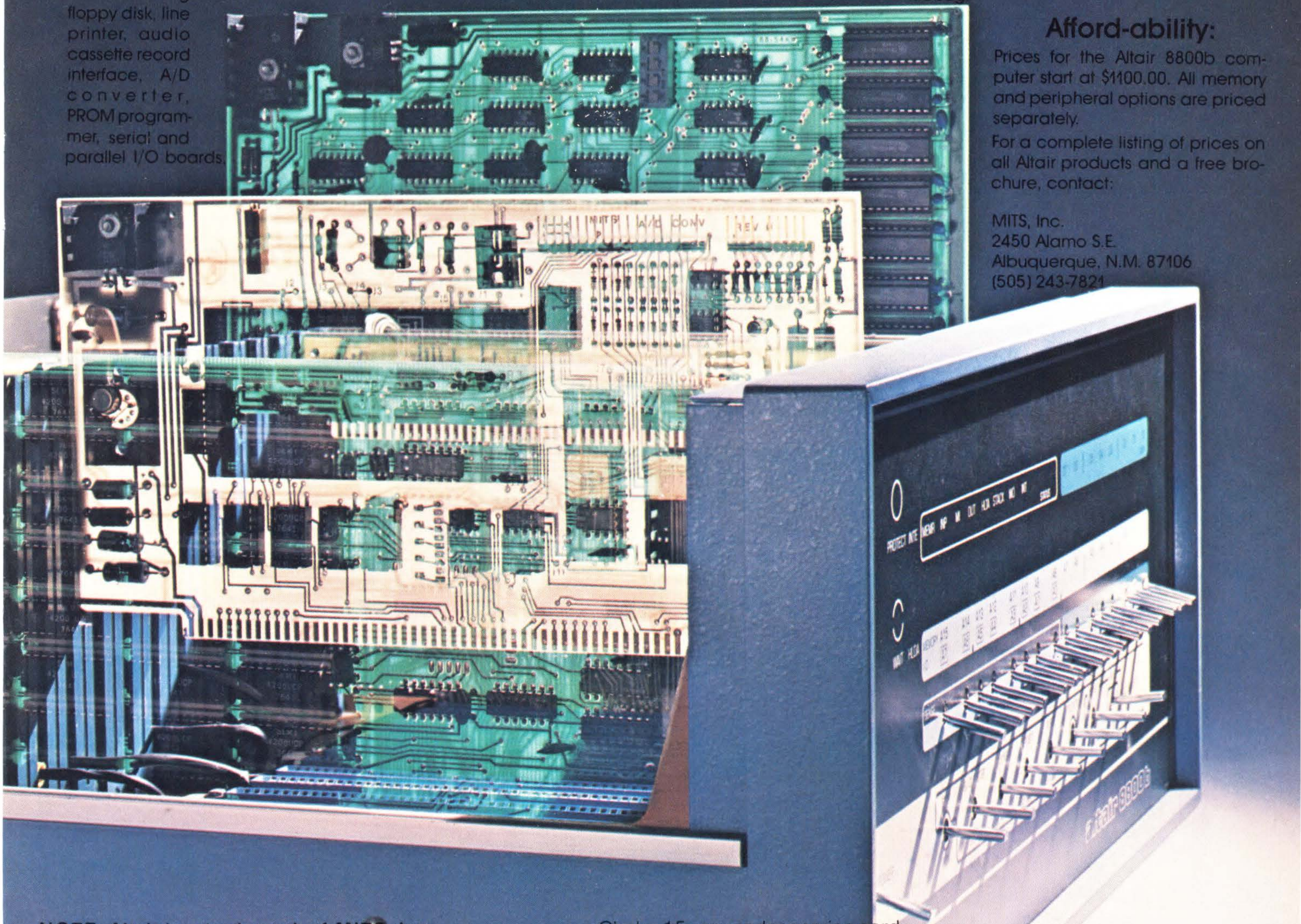

NOTE: Altair is a trademark of MITS, Inc.

Circle 15 on reader service card

People

Sat man. By the 1980s, Art Garman thinks we may have too much channel capacity.

pany's next success, as Garman calls it—will come with next year's launch of Anik II, the second-generation communications satellite for Canada's Telesat Corp.

Dual band. Anik II will be the first operational telecommunications satellite with a dual-band frequency arrangement, he points out. In addition to the usual 6-gigahertz/4-GHz bands for communicating up to and down from the satellite, it also will use 14-GHz and 12-GHz bands that permit smaller antennas on the ground and cheaper ground stations.

A former employee of British Aircraft Corp. who joined RCA in 1963, the 50-year-old Garman awaits other technological changes. Among these is a switch from traveling-wave-tube amplifiers to solid-state power devices for that higher band of frequencies. As well as reducing the amplifiers' size, solid state will make them more efficient.

"We're also looking forward to switching from nickel-cadmium to nickel-hydrogen batteries," he says. "Nickel-hydrogen promises lifetimes of more than 10 years, well beyond the 7 or 8 years of nickel-cadmium."

He wonders about the impact of the Space Shuttle when it comes to launching satellites for international communications. We already have in orbit a tremendous amount of capacity for voice, data, and TV. It's really not a question of what technology can do but whether the market will be there."

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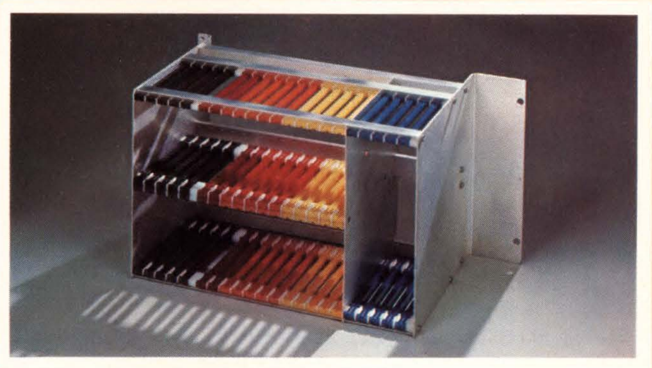

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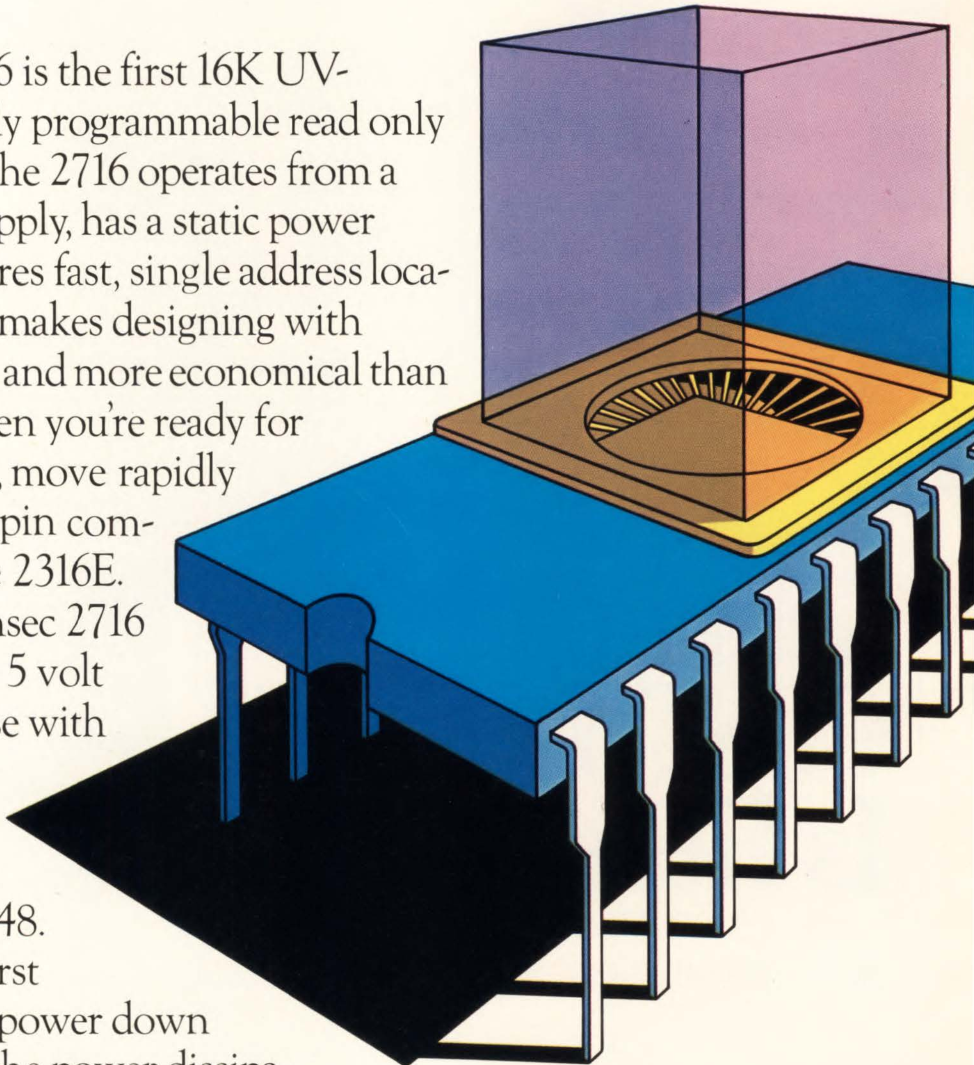
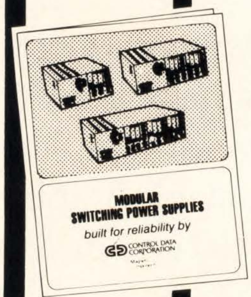
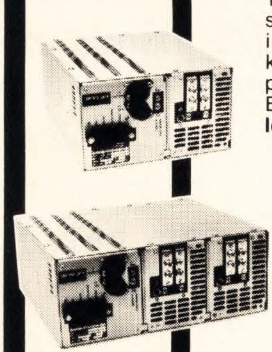


The Intel® 2716 is the first 16K UV-erasable and electrically programmable read only memory (EPROM). The 2716 operates from a single 5 volt power supply, has a static power down mode and features fast, single address location programming. It makes designing with EPROMs faster, easier and more economical than ever before. Then, when you're ready for production quantities, move rapidly to Intel's new pin-for-pin compatible 16K ROM, the 2316E.

Since the 450 nsec 2716 operates from a single 5 volt supply it is ideal for use with the newer higher performance +5V microprocessors such as Intel's 8085 and 8048. The 2716 is also the first EPROM with a static power down mode which reduces the power dissipation without increasing access time. Active power dissipation is 525 mW while standby power is only 132 mW—a 75% savings.

The 2716 has the simplest and fastest method yet devised for programming EPROMs—single pulse TTL level programming. No need for high voltage pulsing because all programming controls are handled by TTL signals. Now you can program on-board, in the system, in the field. You can program any location at any time—either individually, sequentially or at random, with the 2716's single





Meetings

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

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

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

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

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

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

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

Twenty-third International Instrumentation Symposium, Instrument Society of America, Dunes Hotel, Las Vegas, Nev., May 1 – 5.

Eurocon 77—Communications (European Conference on Electrotechnics), IEEE, Venice, May 3 – 6.

Design Engineering Conference and Show, ASME, McCormick Place, Chicago, May 9 – 12.

Electronic Components Conference, IEEE, Stouffer's National Center Inn, Arlington, Va., May 16 – 18.

Naecon—National Aerospace and Electronics Conference, IEEE *et al.*, Dayton Convention Center, Dayton, Ohio, May 17 – 19.

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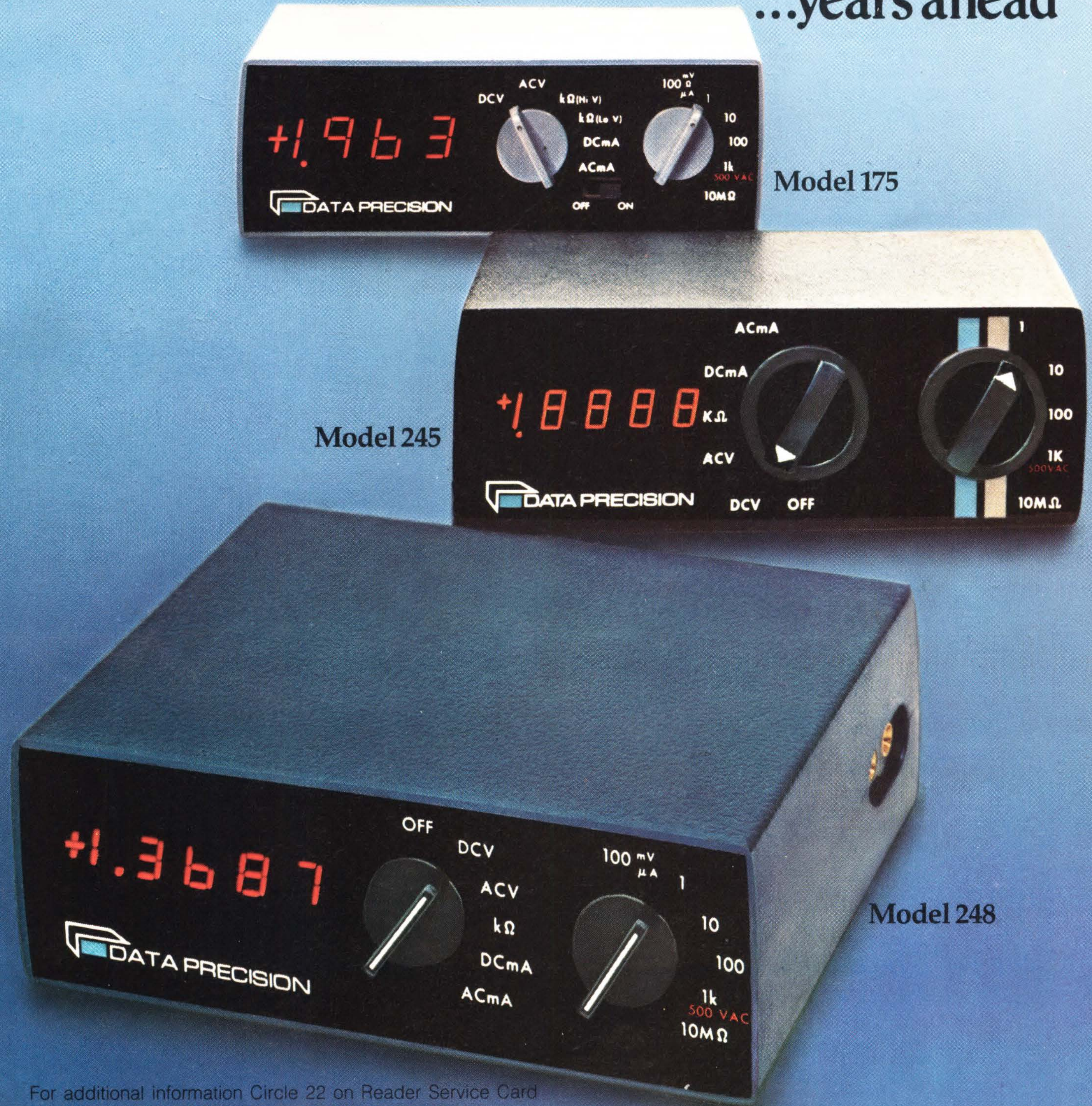

Model 175

Model 245

Model 248

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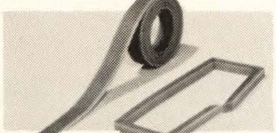
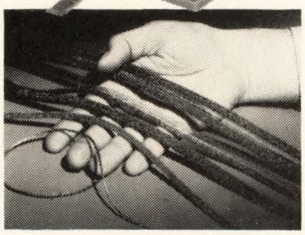
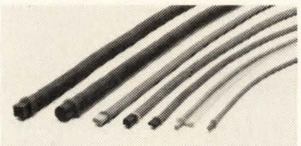
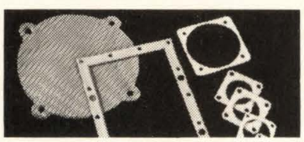
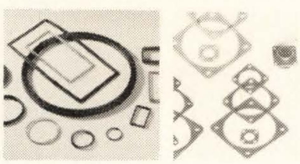

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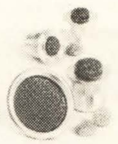
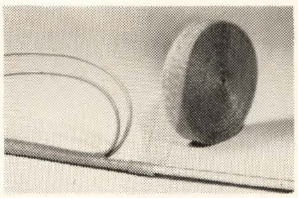
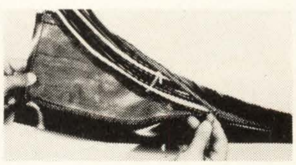
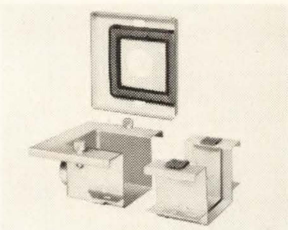
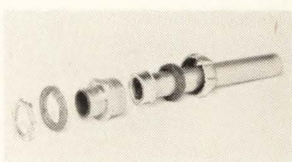

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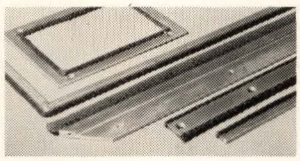
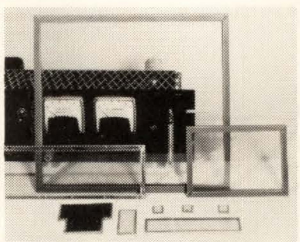
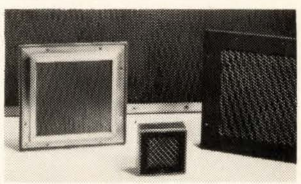
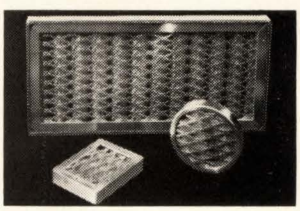

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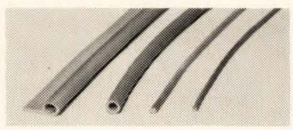
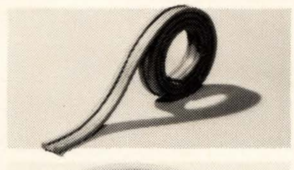
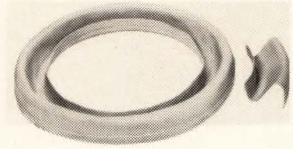

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Electronics newsletter

Semiconductor sales to rise 20% in '77, WEMA says

Sales by U.S.-based semiconductor companies during 1977 will climb to $4.1 billion—nearly 20% above the 1976 record output, forecasts WEMA, the trade association. According to data compiled by WEMA's semiconductor industry group, which represents more than 40 U.S. semiconductor manufacturers, **the rise will continue at a slower pace through 1978 and 1979.** Sales in 1979 are expected to grow 12% to $4.6 billion and then increase 9% to $5 billion in 1979.

Rebounding from a depressed year in 1975, U.S.-based semiconductor firms' shipments during 1976 jumped more than 30% to a record total of $3.4 billion. For the first time, shipments of integrated circuits exceeded those of discrete devices.

U.S. companies are expected to garner about two-thirds of the 1977 total world market of $6.1 billion. About 67% will stay in the U.S., Western Europe will consume about 20%, and Japan about 5%.

The forecast anticipates sales of discrete devices will reach $2.8 billion in 1977, of which U.S. companies will sell 57%. Digital bipolar integrated circuits will grow to $952 million with 80% of the market going to U.S. companies, which also will have 80% of the $1.5 billion market for digital MOS circuits and 70% of the $744 million market for linear ICs.

Nippon to ship 150-ns 16-k RAM in April . . .

Beating most American semiconductor manufacturers to the punch, Nippon Electric Co. Ltd. will be making its 150-nanosecond, 16,384-bit random-access memory available worldwide in mid-April. The part is fully compatible with the industry standard, Mostek's 4116 RAM. Only Mostek is supplying the high-speed 4116, although Intel and Texas Instruments have available 200- and 300-ns versions. the μPD416D, which also will be available in 200-, 250-, and 300-ns speeds, has an active maximum power dissipation of only 462 milliwatts, with typical values specified at a low 300 mw. **This gives it one of the best speed-power specifications of any 16-k dynamic RAM.** Nippon Electric says that, starting in September, total production of all four parts will be 100,000 units a month.

. . . and unveils 18-pin 4-k RAM with 150-ns access

At the same time, the company, through its Lexington, Mass. marketing arm, NEC Microcomputers Inc., has unveiled an 18-pin 4,096-bit RAM that follows the TI pinouts, and spots **150-ns access while consuming just 28 milliamperes.** The company says that the power consumption is significantly lower than that of comparable parts.

NEC also announced newer versions of its 16-pin 4-k RAM with lower power consumption than its earlier 16-pin part, and a low-power version of its original 22-pin 4-k RAM, on the market since 1975. The new and redesigned units are available as packaged components, or NEC will design and build memory boards with up to 128,000 words per board.

GE extends VIR to 22 more sets, adds IR remote

Expanding its use of the vertical-interval-reference signal to adjust color intensity, General Electric Co. has added VIR to 22 models of its 1978 line of 25-inch and 19-in. color receivers. The VIR module processes the transmitted signal and automatically adjusts color intensity to the transmission standard. **About 90% of U.S. broadcasters insert this code**—containing chroma, luminance, and black-reference code—on line 19 of each field of composite video.

In addition, GE has introduced on nine models an infrared remote tuning system mated to an electronic tuner capable of gaining random access to 82 channels. A hand-held remote command unit has three light-emitting diodes to transmit code-modulated infrared signals to the set.

RCA to market small earth station

RCA American Communications Inc. of Piscataway, N.J., will seek Federal Communications Commission approval for a receive-only earth station it plans to market for low-cost distribution of audio programs to broadcast stations throughout the U.S. The RCA Satcom satellites will function as a single repeater/amplifier in the sky. The FCC recently approved the use of antennas down to 4.5 meters in diameter as receive-only earth stations [*Electronics*, Jan. 6, p. 33], but the station undergoing tests atop the New York headquarters of United Press International uses a six-foot-diameter antenna made by Prodelin Inc. of Hightstown, N.J. **UPI officials could buy as many as 5,000 stations** at $6,000 to $8,000 each.

First chips using new I²L process emerge at GI

New automobile clock and frequency-divider circuits are among the first devices from General Instrument Corp.'s Microelectronics group **to use a new integrated-injection-logic process, Giant IV,** developed jointly by GI's research group at the University of Utah in Salt Lake City.

The 4-digit, 12-hour clock chip, CK3500, operates directly from a 3.58-megahertz crystal, the same as that commonly used in television sets for color reference. Housed in a 28-pin dual in-line package, it drives a 7-segment light-emitting diode display without additional resisters or drivers.

The AY-9-1000 is a 2^{16} counter/divider in a 16-pin DIP or 8-lead TO-type package that allows users to divide down from a high frequency (such as the crystal) to a low frequency. Both chips are currently available as samples, and volume quantities are to be available in the second quarter.

Relay built with thick-film process by Hamlin

Using thick-film hybrid techniques with assembled and tested discrete components, Hamlin Inc. has developed a tiny new optically coupled solid-state relay. The bare-bones unit requires an external snubber network for inductive loads, **but is capable of handling a full 2 amperes with zero-voltage switching.** The new relay's single in-line package measures 1.6 by 0.75 inches, and is a mere 0.3 in. thick. When it goes into production in June, it will sell for around $5 in 1,000-piece lots, but its price could fall dramatically with the nearly automatic assembly it was designed for.

Addenda

Look for a number of bipolar-memory makers to introduce programmable read-only memories with the pinout of Intel's popular MOS PROM, the 8,192-bit 2708. Though not erasable like the Intel part, the new devices—from Signetics and National—**offer higher speed and single 5-volt operation.** . . . Using a new self-aligning n-channel MOS-gate technique, **National is designing a 128-kilobit ROM,** expected to be available this year. It's also now showing samples of a 65,536-bit ROM in a 28-pin package. Both parts are fully static, require a single 5-V supply, and access in the 300-to-450-nanosecond range. . . . Though it has yet to master the double-level polysilicon process for its 16-kilobit dynamic RAM, Texas Instruments **expects to see prototypes this year of a 65-k part.** Samples, when they are ready, will cost about $100.

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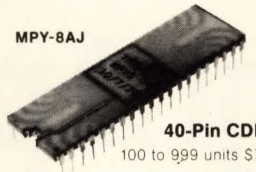

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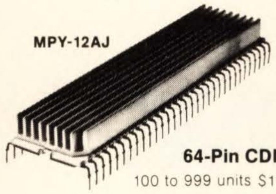

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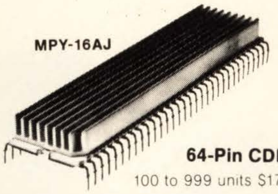

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16 by 16 Bits – Smaller chip improves performance – 64-pin DIP easy to use – dissipates 5 watts with built-in heat sink – perfect for micro/mini applications – signal processing – price $300 each in 1-9 quantities.

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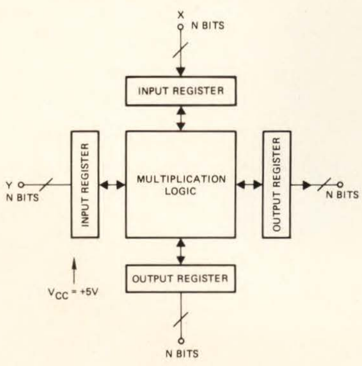

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All of Rockwell's one-chip computers offer powerful, user-oriented I/O ports that eliminate costly interface circuitry in overall systems.

I/O features, including bidirectional ports, flexibly designed drivers and receivers, and serial input/output ports, provide you with powerful system options.

Many types of displays can be driven directly. Analog-digital conversion is easy. And serial I/O ports offer a new dimension of capability by giving you simple, "no-cost" interfacing for multi-computer systems.

Rockwell flexibility assures cost-effective design.

Rockwell's one-chip computers give you design options you couldn't afford with other logic approaches.

During the design stage you can add or reduce functions, allocate I/O differently and make dozens of other changes by simple reprogramming or by moving to another software-compatible chip within the family.

Powerful instruction sets increase efficiency.

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

More than 80% of Rockwell's instruction types can be executed in one byte and in a single cycle. Special ROM instructions allow many subroutine calls to be handled in one byte. Table look-up instructions for MM77 and MM78 chips provide easy look up of stored data and easy keyboard decoding with minimal programming.

The PPS 4/1 family of one-chip computers.

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

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

Rockwell design aids also help lower your system cost.

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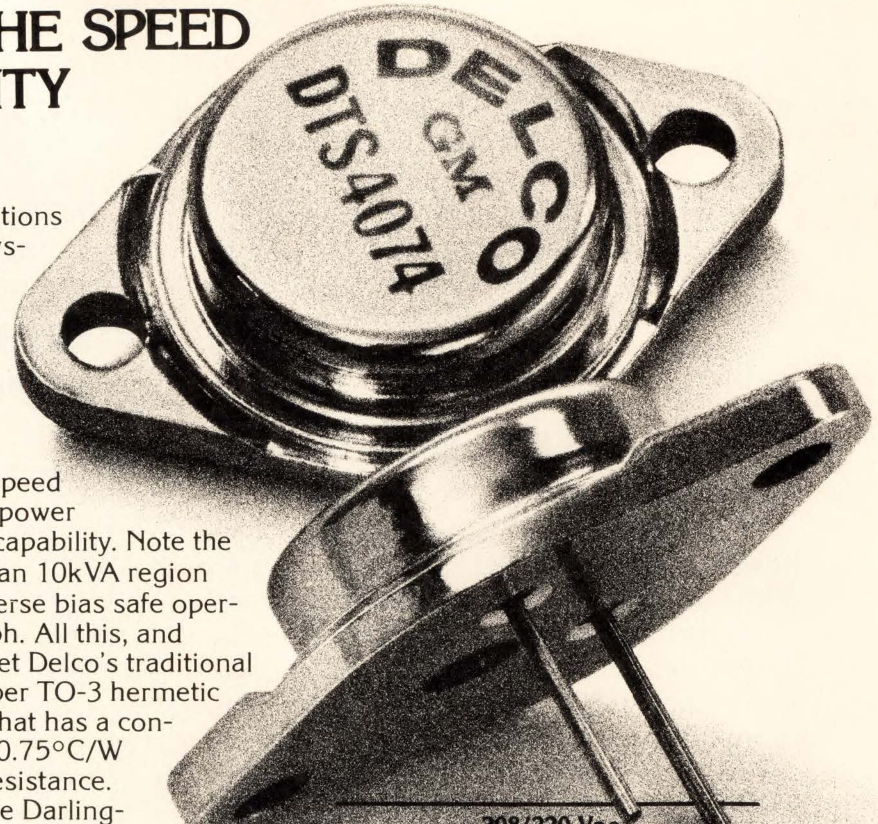
Rockwell International

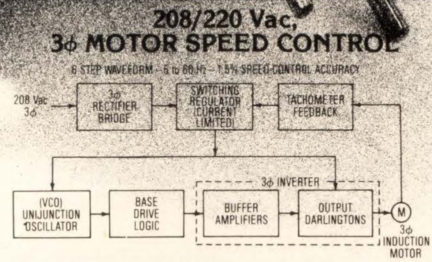
DELCO'S NEW 25-AMPERE HIGH VOLTAGE DARLINGTONS WITH THE SPEED AND ENERGY CAPABILITY YOU ASKED FOR.



Good news for motor speed control designers who have expressed a need to upgrade horsepower ratings. The 25-ampere gain of these new Darlingtons permits increased horsepower ratings of existing AC motor speed control systems and a reduction in paralleling in new designs. However, grouping of t_{off} is available for current sharing in designs with parallel Darlingtons. A speed-up diode is built into the DTS-4074 and DTS-4075 permitting data sheet t_f typicals of $1.0_{\mu s}$. Drive circuit techniques involving $I_{B2} \geqq 2A$ and a Baker clamp produce t_f typicals in the $0.4\text{-}0.6_{\mu s}$ range for the DTS-4066, DTS-4067, DTS-4074, and DTS-4075.

Our experience with tolerances, faults, transients, and start-stall conditions in most systems convinces us that these Darlingtons have the right trade-off between speed and peak power handling capability. Note the greater than 10kVA region of the reverse bias safe operating graph. All this, and you still get Delco's traditional solid copper TO-3 hermetic package that has a conservative 0.75°C/W thermal resistance.

These Darlingtons are already in high volume production and are available on distributor shelves. For prices, applications literature and data sheets, visit your nearest Delco sales office or Delco distributor, or mail in the coupon on the right.



MAJOR PARAMETER LIMITS

Type	h_{FE} @25A	h_{FE} @10A	V_{CEO} (sus)	V_{CE} (sat) @20A	I_{CEO} @600V
DTS-4066	5	75	350V	3.5V	0.25mA
DTS-4067	10	150	350V	2.0V	0.25mA
DTS-4074	5	75	350V	3.5V	0.25mA
DTS-4075	10	150	350V	2.0V	0.25mA

TYPICAL SWITCHING

	DTS-4066 DTS-4067	DTS-4074 DTS-4075
t_r	0.5μs	0.5μs
t_s	5.0μs	3.2μs
t_f	4.5μs	1.0μs

NPN triple diffused silicon Darlingtons are packaged in solid copper cases conforming to JEDEC TO-3 outline dimensions.

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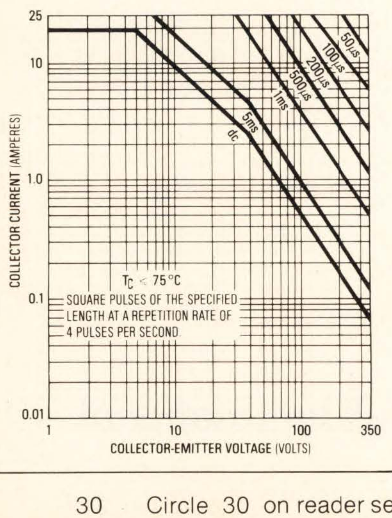
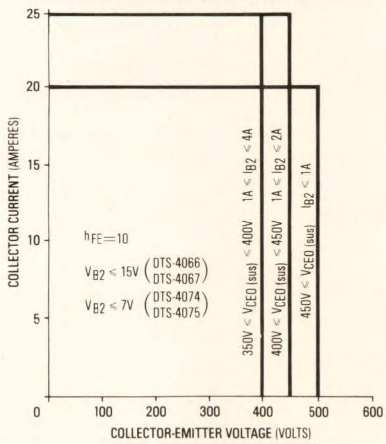


CLAMPED INDUCTIVE SWITCHING PERFORMANCE



FOR MORE INFORMATION ABOUT DELCO'S NEW 25-AMPERE HIGH VOLTAGE DARLINGTONS, MAIL THIS COUPON TO:

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General Motors Corporation
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Radar system to increase accuracy of Navy missiles

Synthetic-aperture radar teams with angle-measuring techniques for all-weather weapons system for 1980s

The U.S. Navy is developing an all-weather attack system that will enable pilots to launch their missiles before they fly within range of enemy surface-to-air batteries. The need for the radar-guided system, to be ready in the early 1980s, was brought home graphically in the Vietnamese and Yom Kippur wars when sophisticated and lethal Soviet SAMS forced attack craft to release their own missiles outside the SAMS' range. At that distance, they were often inaccurate.

The Navy believes it may be able to achieve the necessary accuracy with a radar-guided weapons system that combines a synthetic-aperture radar with new angle-measurement techniques. The result could be a new all-weather attack system it hopes will be operational in the early 1980s.

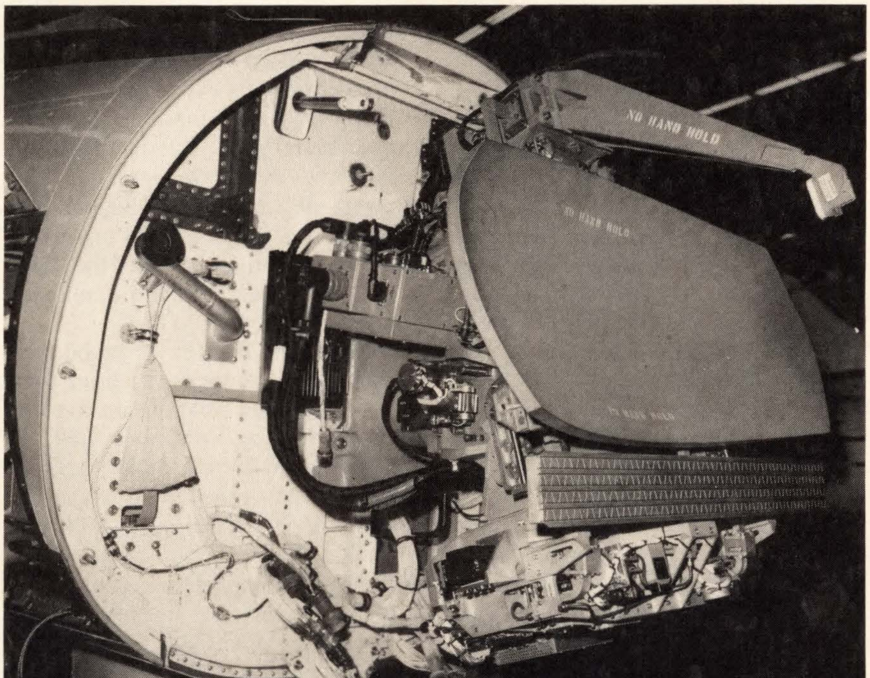
The synthetic-aperture radar gives the radar-guided weapons system (RGWS) very high resolution at long ranges. While such radars are not new, they have been used only in missile systems like the Standard ARM and Shrike that home in on enemy emitters, says a spokesman for the Naval Air Systems Command in Washington, D.C.

"Real" beams. Current Navy all-weather air-to-surface systems are limited to the Harpoon missile and to free-fall weapons relying on "real" aperture radar data for target positioning. In the latter case, says the spokesman, "the attacking aircraft is well within the projected surface-to-air threat envelope of the enemy at typical release ranges." With the Harpoon, he says, "precise target position, stand-off capability, and a viable high-accuracy guidance technique are lacking."

The system integrator, Grumman Aerospace Corp. in Bethpage, N.Y., is flight-testing the RGWS concept [*Electronics*, Sept. 2, p. 51]. It relies on modified off-the-shelf equipment, combined with radar imagery "that has significantly improved range and azimuth accuracy when compared to real-beam systems," he adds.

The synthetic-aperture radar improves the imagery by storing, as the plane flies past a target area, return signals that cover a larger area than that illuminated directly by the radar beam. These signals are then processed to reconstitute an image with increased resolution, one in which the antenna acts as if it were larger than it really is—hence, synthetic.

The radar for the system is a modified AN/APQ-148/156 supplied for the Grumman/Navy A-6E Intruder all-weather attack aircraft by Norden division, United Technologies Corp., Norwalk, Conn. It already has an interferometer for



Guide. Modified AN/APQ-148/156 radar is being flight-tested aboard a Grumman/Navy F-14. The long rectangular unit below the radar dish is an interferometer that continually measures the azimuth between the target and the released weapon.

determining elevation.

Norden is adding an interferometer that allows the RGWS to continually measure the azimuth between the target and the released weapon. This technique, developed by Grumman, is of critical importance in boosting the accuracy of the delivery system. Steering commands, continually updated to null the azimuth difference between the weapon and target directions, are sent to a transponder in the weapon. When the weapon is close enough, it is pitched over into a vertical downward trajectory. Commands continue to maintain a zero relative difference in both range and azimuth to the target until the weapon hits its target.

"On a range/azimuth cell-resolution basis, the RGWS is projected to provide an approximate 1,500-fold improvement over current real-beam radars," the spokesman continues. Stand-off ranges "should increase at least tenfold." The RGWS could be used on all-weather aircraft such as the A-6 and on the F-111 of the Air Force, he says. The concept could also be applied to new aircraft and weapons as well.

The program's first phase, now about to end, called for 24 flight tests with radar processing and image generation on the ground. A weapon will not be integrated with an airborne radar until later phases, which the Navy has yet to fund. □

Military

Martin Marietta unveils production model of airborne laser target tracker

A new laser tracker for close-support Air Force aircraft goes a long way toward assuring first-pass destruction of tanks and other ground targets even when the pilot cannot see them. The system, called Pave Penny, was shown publicly for the first time March 22. Similar systems are in development, but Pave Penny is the first laser target tracker in the U.S. military inventory to reach production.

Being built by Martin Marietta Aerospace Co., Orlando, Fla., for the Aeronautical Systems division at Wright-Patterson Air Force Base, Ohio, the first units are aboard the A-10 close-support aircraft built by Fairchild Republic Co., a division of Fairchild Industries. Pave Penny consists of a 32-pound detachable pod mounted on a fuselage pylon aligned along the A-10's bore sight, a control panel in the cockpit, adapter electronics that integrates the pod with the fire-control and navigation systems, and gear for testing the system on the ground.

The tracker locks onto signals reflected by a target that has been illuminated with an infrared neodymium-doped YAG-laser target designator either carried by friendly ground forces or flown in a designator aircraft. In this it differs from the radar-guided weapons system being developed for the Navy (see previous story), which needs no external target designator but is housed entirely in the plane.

William Leff, manager of advanced systems at Martin Marietta, says Pave Penny is intended "to allow target acquisition beyond the pilot's visual range and to provide a high kill probability on the first pass," even when a plane is maneuvering to avoid ground fire.

Advantages. It gives strike pilots a number of advantages, whether they are using guided weapons or conventional ordnance, continues Leff. It eliminates the use of smoke markers at the target that could warn an enemy of impending attack. It permits true "launch-and-leave" operations with guided weapons without flying over the target, and it improves the accuracy of unguided-weapon delivery by continuously updating the target position for a weapon-delivery computer if the plane is equipped with one.

In operation, the gimbal-mounted receiver, which houses optics and a silicon p-i-n-diode detector, is put through a search mode by the pilot. When the receiver picks up the signal from the laser-illuminated target, a diamond-shaped reticle is projected on the pilot's head-up display while the tracker remains automatically locked onto the target even during jinking maneuvers. The pilot can drop either a laser-guided or conventional bomb. Moreover, the reticle can be superimposed over the gunsight of the nose-mounted, seven-barrel 30-millimeter gatling gun that fires up to 4,200 rounds per minute.

Pitch-and-roll gimbals are in the forward-pod section, while the center section contains control electronics to process target-acquisition signals, plus a voltage regulator and dc-dc converter. The cockpit control panel has systems-status indicators, plus switches for the pilot to control the pod's search width or test the pod and adapter electronics.

Conversion. Once the pilot has begun a search and the receiver locks onto an illuminated target, the adapter unit in the avionics bay takes over to convert the pod's line-of-sight angles into aircraft coordinates. This generates the pitch and yaw signals that drive the optical gunsight, head-up display, a remote attitude and direction indicator and the weapon-system computer.

While the A-10 does not have such a computer, Maj. Tony Zang, operations officer of the A-10 test force, says that Pave Penny improves conventional weapon delivery. Even if the target is not visible, the pilot need only substitute the diamond reticle for the target, Zang explains, because he knows that Pave Penny has locked onto the illuminated spot the diamond represents.

Martin Marietta has received more than $40 million for research and development, plus production of the first 204 pods and other airborne and ground equipment. Air Force plans call for equipping all 733 A-10s and 383 A-7Ds with the system. Martin Marietta is also designing the adapter/integration unit that would put Pave Penny on the F-16, as well. □

Optoelectronics

Image sensor adds CCDs to photodiodes

Engineers at Reticon Corp. have developed a new family of solid-state image sensors that combine its established photodiode line-array technology with that of its chief competitor, charge-coupled devices. What it calls a charge-coupled photodiode could give the Sunnyvale, Calif., firm an even greater share of a $10 million market that is growing at 10% to 15% annually in such applications as optical-character recognition, facsimile systems, point-of-sale terminals and industrial processing.

Diodes, CCD. To date, line-scan arrays have been fabricated either with photodiode arrays or CCD structures as sensors. Both use the light-sensitive characteristics of metal-oxide-semiconductor structures to sense light levels. The main difference between the two is that the photodiode is basically a light sensor that stores information in its junction much like a capacitor. A CCD element, on the other hand, is basically a capacitor that can sense light.

John Rado, president of Reticon, says the CCD sensor is not as good because its so-called "transparent electrode" is not transparent. In addition, the electrode absorbs strongly at short wavelengths, reduces quantum efficiency, particularly in the blue, and causes strong interference throughout the visible spectrum.

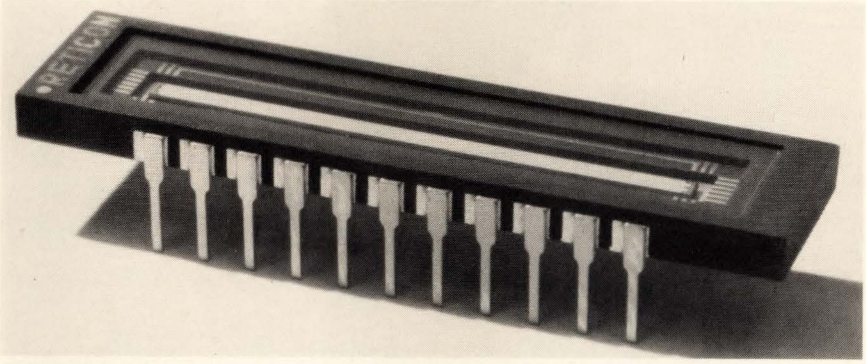
"Where CCD arrays have it all over photodiodes," says Rado, "is in the peripheral circuitry used to process the information after it is dumped out of the sensors." Present photodiode arrays use the equivalent of a MOS shift register to accept serial information from the sensors. CCD line-scan arrays use a four-phase shift-register structure that can dump information in parallel, resulting in higher signal-to-noise ratios.

In the new family of arrays, the actual sensing aperture is still a series of diffused photodiodes, interdigitated on 16-micrometer centers. "Now, however, the readout is provided by four-phase CCD shift registers similar to what's used in the CCD line-scan arrays," says Rado. The photo-generated charge on odd and even elements of such a photodiode structure is dumped upon application of a transfer pulse into two CCD registers. These then transmit the charge to an output-charge-detection circuit that is also included on the chip.

The outputs of the two CCD registers are then multiplexed off chip to obtain a full-wave "box-car"-type sample-and-hold video output with substantially reduced fixed-pattern noise. Since this output has a small capacitance (1 picofarad versus 40 to 50 pF with standard photodiode arrays), the output-signal voltage and signal-to-noise ratio are very high, says Rado. "At the same time, it offers the higher quantum efficiency and uniform response of photodiodes," he says, "as well as freedom from blooming" [spill-over of charge into adjacent structures]. The diffused photodiode provides a spectrally smooth full silicon response that is unaffected by the polycrystalline layer covering the sensing area in CCDs.

The new arrays, he says, also have dark-current characteristics at least an order of magnitude below that of available CCDs, thus making them usable at clock rates corresponding to integration times as long as 40 milliseconds at room temperature. At about 100 kilohertz, where standard CCD arrays exhibit a dark current that is almost 30% of the maximum output, the new arrays, by contrast, have a dark current of less than 1% of maximum, Rado says.

The devices are being designed as 256-, 1,024- and 1,728-element arrays in a dual in-line package sealed with a quartz window. Commercial introduction of the new device family is expected in the second quarter of 1977 at prices competitive with available CCD and photodiode arrays, Rado says. □



Better view. Linear charge-coupled photodiode array from Reticon senses light with diffused photodiodes but reads an image out through analog CCD shift registers.

Photovoltaics

Honda's zip comes from the sun

Zipping around Los Angeles streets at up to 25 miles an hour, a retired philosophy professor is showing how solar cells can power an electric car. A Honda CVCC, fitted out with nine 10.6-watt solar-cell modules for charging six 6-volt batteries that run two 3½-horsepower motors, has been operating pretty successfully, claims its owner, Wallace C. Moore.

Terming himself a "sort of catalyst," Moore spent 18 months getting the project moving. He got Honda to provide a car at a discount and haunted solar-cell manufacturers until he persuaded Sensor Technology Inc. of Chatsworth, Calif., to install nine of its modules on the roof of the tiny car.

Batteries needed. The cell array produces about 3 amperes per hour in the sunlight. An eight-hour expo-

Ready for a spin. Solar-cell modules on Honda produce about 100 W for car owner Wallace C. Moore, center. Kees Van Der Pool, left, is marketing manager of module manufacturer Sensor Technology Inc. Irwin Ruben, right, is the company's president.

sure charges the batteries for more than an hour's driving time. As with other electric cars, a big limitation is the lack of more efficient, higher-density rechargeable batteries, Moore observes. Recent developments in lithium batteries may lead to a solution, but he has been told that availability of batteries at power levels high enough to run an auto is about three years away.

Reliability of the solar panels, which reportedly has plagued other experimental electric cars since the technology emerged almost 20 years ago, is not a problem, claims Kees Van Der Pool, marketing manager at Sensor Technology. Cost of equipping the Honda was about $2,700. Each 44-cell module usually costs $317. In quantity, "the price could be cut in half," he says, and power output could be improved by packing more of the 2½-inch diameter, 14%-efficient cells into the module area.

The first experimental auto known to employ solar cells was a 1912 Baker Electric, equipped in 1960 by International Rectifier Corp., a pioneer in the cell business. Still used as a demonstrator, its original 6-by-6½-foot array contains 10,640 10% cells, putting out 200 W. This could be improved to about 280 W by refitting with 14% cells, the firm says.

Moore is reluctant to rely solely on electric power, so he has kept the Honda's engine under the hood. The two electric motors are in the luggage compartment in the rear with the six batteries. The only controls in common are the accelerator pedal and the ignition switch with "left for gas, and right for electric," Moore says.

He emphasizes that his project is "only in the model-T stage. I don't claim to have a finished product by any means and we're working to get any bugs out." His test program is simple enough. He drives the car for everyday purposes to see what problems turn up. □

Avionics

Radar prints weather in rainbow of colors

Color came to airborne weather radar this month when RCA Corp. launched its $24,990 Primus-400, with which it hopes to capture the market for business jets, turboprops, and, perhaps later, helicopters. But RCA may have beaten its prime competitor, Bendix Corp., to the market by only a matter of weeks. However, Bendix' Robert Winston, marketing manager for the Fort Lauderdale, Fla., Avionics division, is saying little about a competitive product until its formal introduction, planned for early April.

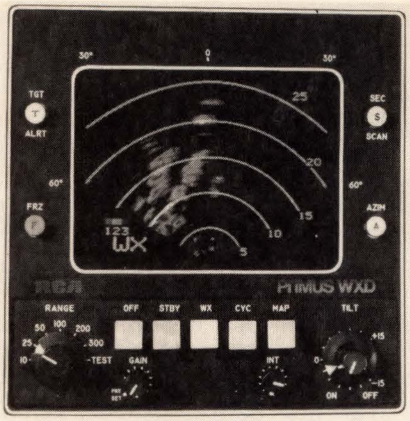
The RCA digital radar represents an upgrading of its $19,600 monochrome Primus-40, introduced last June. The system substitutes a Japanese-made rectangular color cathode-ray tube for the standard monochrome 5-inch-diagonal aircraft-radar screen. The Primus-400 also includes a fourfold increase in the Primus-40's digital random-access memory. Boosted to 128,000 bits, the memory generates a comparable enhancement in the display's resolution and makes color possible.

RCA will not name the Japanese supplier of the color CRT—at least until it sees what Bendix has, says A. J. Freed a marketing manager for RCA Avionics Systems, Van Nuys, Calif., builder of the Primus line.

Color coding. With a 300-mile range, the radar displays dangerous areas of heavy precipitation in red and safer, lower levels in yellow. Areas that are clear or have light precipitation are in green. One advantage of color over monochrome radar, RCA contends, is that it reduces the pilot's workload by enabling him to keep weather presentations in mind for longer periods.

For ground-mapping, explains RCA vice president William L. Firestone, who heads the Avionics Systems division, colors can be varied so that the green weather mode, for example, becomes the greenish blue known as cyan to achieve maximum resolution and remind the pilot of the mode in which he is operating.

The expanded memory of the 37-pound radar makes these color changes possible, Firestone says, although he points out the memory's principal advantage is "elimination of the blockiness" normally associated with digital displays by refining the map and weather contours. With the display's fourfold greater



Color-coded. RCA's new airborne weather radar shows weather and ground-mapping details in color.

resolution, Firestone explains, "the contours of lakes or rivers that once appeared square or rectangular are now smoothed out and are more readily identifiable."

Market. RCA expects to begin shipping its new radar in June, following type acceptance by the Federal Communications Commission. Firestone doubts that the higher price of the color system will be a deterrent "when you have an aircraft investment of $2 million to $3 million." As for market size, the company estimates it at approximately 75% of the new business jet and turboprop market, which runs between 300 and 400 planes per year, plus another 20% of the retrofit market, or 100 to 125 planes.

The company says it will develop lower-priced models "later this year." Presumably, this will be done in the way it developed lower-cost models of the Primus-40 with fewer features in the Primus-30 and -20 models. Moreover, RCA indicated it is contemplating a helicopter version. That unit would be similar to the Primus-50 monochromatic helicopter radar, which is the same as the Primus-40, except for a beacon mode added for navigating while weather patterns are displayed.

The Primus-400 has three basic units—a 9,345-megahertz transmitter with a 10-kilowatt coaxial magnetron and a receiver with a 7-decibel noise figure; a color display with a 60° or 120° sector scan, and a horizontally polarized flat-plate antenna of various sizes. □

Industrial

DEC introduces plant-management system that offers real-time data to managers

Although computers are widely used in factories for process control, a system that provides both real-time control and information about inventory and work in progress is difficult to find. But Digital Equipment Corp. is offering that capability in a family of products that operates from a common data base in a distributed plant-management system.

Jerry Cox, manager of technical services for the Maynard, Mass., company says DEC is the only one offering as off-the-shelf hardware everything from analog input and output interfaces to the unified data base in a host computer. Loren Gilmore, manager of engineering and process control-systems at the headquarters of International Harvester Co. in Chicago, agrees. DEC introduced its management system at an International Harvester foundry in Waukesha, Wis.

To Gilmore, the main appeal of the system is that it gives him and other managers the ability to query the data base from an interactive terminal and get answers fast. "I think it's the first system that can do this, transmitting at high data rates over a simple twisted-wire pair."

The answers deal with such information as what work was done in the factory during the course of a day, the cost associated with different manufacturing steps, and what remains in inventory. Generally, the basics for such information is put into the central computer in a batch, usually once a day. Factory managers can get the information, with the cost data calculated by the computer, a day, or possibly even a week, later.

International Harvester uses the system to tie together the foundry's electric-furnace controls, weighing

Cryogenics cuts noise in 300-GHz receiver

Cryogenic cooling, used effectively to reduce noise at microwave frequencies, has been exploited to do the same thing in the millimeter-wave range. An experimental receiver operating at 200 gigahertz and up has been built with a 20-megahertz instantaneous bandwith and a single-sideband noise temperature calculated at 1,320 K. This noise temperature, which corresponds to a noise figure of 7.4 decibels, is approximately six times better than that of the best uncooled mixer receivers. Some helium-cooled indium-antimonide bolometers have delivered comparable performance, but they have very narrow bandwidths—2 MHz at best.

The result of a collaboration between Jochen Edrich of the University of Denver and Donald B. Sullivan and Donald G. McDonald of the National Bureau of Standards, Boulder, Colo., the receiver is tunable over the frequency range of 200 to 325 gigahertz. Its mixer is a point-contact Josephson junction mounted in a single-mode waveguide, while its intermediate-frequency amplifier is a low-noise ruby maser. The mixer, the maser, the system's horn antenna, and all of the interconnecting waveguide are operated at a temperature of 4 K.

The local-oscillator signal is supplied by an external 300-GHz backward-wave oscillator, which is tuned to produce an i-f of approximately 9 GHz. Surprisingly, less than a microwatt of local-oscillator power is required for optimum receiver performance.

Supported mainly by the National Science Foundation, the research is expected to have its most immediate application in radio astronomy. Over the longer term, as the lower-frequency parts of the spectrum get more crowded, it may also prove useful in broadband communications. □

systems, inventories, and a separate data-collection system. DEC's Cox emphasizes, however, that his company is not providing a turnkey system. Customers must write applications software and install their own wiring. Then they can hang rugged DEC terminals on the bus, called the Dataway.

A typical factory might have several kinds of devices: analog-to-digital converter hardware to take data from sensors such as chromatrographs or thermocouples, three kinds of microprocessor-controlled work stations, a data multiplexer, an input/output subsystem consisting of an LSI-11 microcomputer in an industrial enclosure, and the plant's host computer—a PDP-11/34 or 11/70. The data base of 7.5 to 28 megabytes is in the host's disks.

The work stations accept a standard identification card for gaining entry to the system. Each station also has a 32-character alphanumeric display that tells the worker what to do at each step of the job. The work stations and multiplexer communicate on the Dataway through microprocessor firmware, and the system uses high-level languages like Cobol, Fortran, and Basic.

A typical system, including the PDP-11/34 host computer, the LSI-11-based I/O subsystem, 10 basic work stations, three time and attendance stations, three area work stations, a line printer, and two supervisory cathode-ray-tube terminals, sells for about $200,000. □

Displays

Braille may aid blind phone operators

Lights flash on a computer console to signal a telephone operator when a caller needs help—on a person-to-person call, for example, or when the call is collect. But the Southwestern Bell Telephone Co. thinks blind people could handle the console if they had a braille version of those lights.

Alternative. Braille cells (white strip at bottom) spell out information normally provided on lighted push buttons and lamps.

To test its theory, the company has hired a blind person in Little Rock, Ark., to work with a new device that translates data from some 90 push buttons, lighted push buttons, and lamps to 12 braille cells, each with solenoid-operated pop-up pins arranged in the 2-by-3-dot braille matrix. "We expect the blind operator to act as efficiently as a sighted counterpart," says Derek Rowell, director at the Sensory Aids Evaluation and Development Center at the Massachusetts Institute of Technology, Cambridge, Mass., which engineered the device for Bell.

Tests to begin. According to Carl Woodyear, personnel relations manager for Southwestern Bell in Little Rock, the tests of the system are about to begin. "We first want to see if our blind operator can compete with sighted operators," he says. "If she can, we'll then have to look at cost and patent problems." There is no deadline for the project, he adds.

Derek Rowell's center at MIT had been working on what he calls "the blind man's equivalent of a CRT terminal" when it received funds for the Bell project. Applying his technology to Bell's Traffic Service Position System was "a matter of getting all the information about the phone calls from the keyboard and coding it for the blind operator," says Rowell. The operator is alerted to a call by a "beep" in a set of earphones. To complete calls, the blind person manipulates push buttons as a sighted operator would.

The new device sits in a stand-alone cabinet connected to the main computer-operated console. It uses a Motorola 6800-based microcomputer with 2,048 bytes of read-only memory to continuously scan the lamps of the conventional display. Programmed in assembly language, the microcomputer analyzes the sequence and hierarchy of operations in the computer console and then prepares messages for the operator's braille cells.

Because all the information on a call cannot be "displayed" at once, the operator can scan the traffic console's memory by pushing any of six buttons next to the braille display. These provide information such as charges, time of day, type of call, and calling number.

Rowell notes that MIT's Sensory Aid Center plans to continue its work on the braille alternative to the CRT display. He envisions it as an 80-character row of braille cells that would enable an operator to read a line at a time. "This could be connected in any situation where a CRT terminal is provided," he says, making it possible for blind people to work as computer programmers or in most any job that manipulates data from a remote computer. □

Packaging & production

Program simplifies tester use

People developing test programs for complex digital circuit boards can either spend weeks or months generating them manually or pay a fat fee to an outside service for programs

that may be hard to modify later. But now Teradyne Inc., the broad-line Boston manufacturer of semiconductor and circuit-board testers, has come up with a time-shared software system that generates testing and diagnostic programs for a board in a matter of days.

Fred Macdonald, product manager for functional card testing at the almost $60-million-a-year firm, describes the new P400 as a commercial version of Digitest Corp.'s D-Lasar program, one of the most powerful programs written to aid laboratory and military designers in evaluating logic circuits. The P400 will work with any of Teradyne's L100 series of board testers, "and there are a lot of those testers out there," Macdonald says. Average price of the L100 is $125,000.

Univac mainframes. The P400 program is up and running at University Computing Co. in Dallas, using five Univac 1108 mainframe computers. All a board designer needs is an input terminal to access the 1108, a $1,500 Teradyne-supplied interface between the minicomputer in the board tester and the 1108, and a $395 acoustic coupler that Teradyne will also supply.

To prepare a test program, a technician tells the computer in a simple English-based language what devices are on the board and how their pins are interconnected. NAND-gate equivalent models are then entered for any devices on the board that are not in the central system's library. These models are checked by the 1108s for errors and, when all are correct, the system is ready to generate its first test pattern.

This first pattern typically yields anywhere from 30% to 70% "fault coverage" (the probability that design or manufacturing errors will be picked up by the test program). More test-generation passes, which add test patterns to the program, raise this to above 90%, a figure Macdonald says provides "good probability that the board is good." How many passes are made on the big computer system depends on how much the company has budgeted for computer time. After each pass, the P400 provides, along with an estimated percentage of fault coverage, the time that has been used.

The desired fault coverage reached, the P400 stores the test program on the tape cartridge in the Teradyne tester where it is used to exercise the finished board. Macdon-

News briefs

New trade association formed for semiconductors

The heads of five of the largest semiconductor-device manufacturing companies have formed a new trade association to help them deal with Government regulations, including those affecting trade and energy. The Semiconductor Industry Association will be headed by Bernard T. Marren as executive director. He is the former president of American Microsystems Inc. Members of the executive committee are Robert Noyce, chairman of Intel Corp., Wilfred J. Corrigan, president of Fairchild Camera & Instrument Corp., John R. Welty, vice-president at Motorola, W.J. Sanders III, president of Advanced Micro Devices Inc. and Charles E. Sporck, president of National Semiconductor Corp. The approximately 80 U. S. semiconductor companies will soon be invited to join. Intel's Noyce says his firm does not intend to quit WEMA, the trade association to which many semiconductor firms belong.

SSS to second-source RCA microprocessor

Solid State Scientific Inc. of Montgomeryville, Pa., has signed an agreement to become an alternate source for RCA's CDP 1800 microprocessor family. Like an earlier agreement with Hughes Aircraft Co. [*Electronics*, July 22, 1976, p. 48], the five-year pact calls for RCA to provide SSS with artwork and tooling for the basic 8-bit complementary-MOS central processing unit, the CDP1802, and standard support chips. RCA will also make available evaluation kits, hardware-development systems and software for the microprocessor family.

The deal includes an option on future C-MOS microprocessors, including a silicon-on-sapphire version [*Electronics*, Feb. 3, p. 35]. The odds are that the option will be exercised by SSS, which spent several million dollars and a few years in developing its own SOS process and design techniques but never went into production with the technology. Walt Kalin, C-MOS product marketing manager at SSS, says his firm will make a decision on the SOS microprocessor "in the second half of this year, after we come up to speed on the bulk process."

Electronics executives to appeal

Two Silicon Valley executives convicted of conspiracy to export to the Soviet Union $900,000 worth of semiconductor production equipment without an export license will appeal, say defense attorneys. Gerald M. Starek, the 35-year-old president of I.I. Industries Inc., Sunnyvale, Calif., and Carl Story, 41, vice president, planning and development, were sentenced to 18 months in jail and fined $10,000 by a judge in Santa Clara County. Meanwhile, the two defendants are free on their own recognizance, awaiting a court date that could be as long as eight months away.

Fairchild to sample 65,536-bit CCD in June

"It took another couple of months to shoehorn it in [to the package]," but Fairchild Camera & Instrument Corp., Mountain View, Calif., now says it will have engineering samples of a 65,536-bit charge-coupled-device memory ready by June. The original goal was the first quarter of the year, but the delay was caused by Fairchild's determination to fit the device into a 300-mil-wide package, says Robert Dwyer, director of marketing for metal-oxide semiconductors and CCDs. Price in 100-piece quantities will be $96.61. Texas Instruments had earlier announced it would sample a same-size CCD in April [*Electronics*, March 17, p. 38]. Dwyer does not anticipate that engineers will exactly jump at the products. "It will be similar to the education required seven years ago when we showed core people how to use semiconductor memory," he says.

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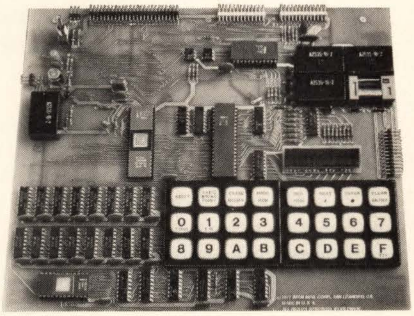

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ald quotes one detailed example to indicate the system's value. Developing the test program manually for a minicomputer's arithmetic/logic unit took six weeks to give 92% fault coverage. The P400 completed the program in eight days, using 53 minutes of 1108 time at a cost of $1,050 to give 96.4% coverage. □

Memories

AMD sells samples of 50-ns devices

Users gladdened by the recent announcements from Intel and American Microsystems of super-fast static RAMs to be available late this year should be even happier at the news from Advanced Micro Devices Inc. The Sunnyvale, Calif., firm is offering samples of a super-fast 4,096-bit static random-access memory, the 60-to-80-nanosecond AM9135/9145J. It expects to be in volume production within the next two months.

What's more, cycle time is only 130 nanoseconds and worst-case power dissipation only 675 milliwatts, quite respectable for that speed. Die size is 25,181 square mils, no more than 175 mil^2 larger than Intel's proposed high-speed 4-k static RAM, the 2147.

Standard processing. What makes the achievement all the more impressive is that the 5-volt part does not need any advanced processing or lithographic techniques. Raju B. Shah, the firm's MOS memory product manager, says the performance of the static devices comes from a combination of state-of-the-art Linox processing, on-chip substrate biasing, and some unique circuit design. For its new RAMs, Intel uses an advanced n-channel MOS process, and AMI uses its V-groove MOS [*Electronics*, March 3, p. 32].

Shah says AMD's oxide-isolation process is a tweaking of the company's standard recessed field-oxide, ion-implanted, silicon-gate MOS technology. The same process is employed in the firm's super-fast version of Intel's 8080A—the 1-microsecond 9080A—and in its 4-k and 16,384-bit dynamic RAMs. Ion implantation for depletion loads [*Electronics*, May 13, 1976 p. 65] is used, plus some scaling down of channel lengths, junction depths, gate-oxide thicknesses and wafer resistivity. But these are not made as small as in Intel's device. The scaling down, combined with reduced device body effects and parasitic junction capacitance from the substrate bias generation [*Electronics*, March 4, 1976, p. 78], contributes substantially to improving the performance of the high-speed parts.

Clocked static. To achieve the 60-to-80-ns access times without strain, AMD engineers use a special circuit design that combines characteristics of both dynamic and static memory. Heretofore, dynamic storage techniques have usually been associated with dynamic decoding and control circuitry, Shah says. Similarly, static storage has traditionally used static support circuitry. "But these associations are not essential and other combinations are possible," he says.

Taking advantages. Available in either a 4-k-by-1-bit or a 1,024-by-4 format, the 18-pin design takes advantage of static storage together with a new clocked-access method. The storage cell is a conventional, fully static six-transistor design. But the decoding and sensing circuitry uses a pipeline technique to help the cell drive the bit lines and a clocked-static approach with both static and dynamic attributes. The clock allows several features to be added that improve both speed and power dissipation. At the same time, the usual disadvantages of clocked circuitry—refresh, among others—have been either eliminated or minimized, says Shah.

A major advantage of this mixed approach over the fully static approach used in Intel's 2147 is flexibility, he says. With minor changes in circuitry, even lower-power versions are possible, he says. And with a few additional tweaks in processing, he predicts, sub-50-ns 4-k parts should be possible. □

Industrial microprocessors to get analog mix

What is the low-cost, one-chip industrial microcomputer of the future going to look like? The devices are likely to get even more complex, with things like differential inputs, signal conditioning, and analog-to-digital and digital-to-analog conversion right on chip, says Van C. Lewing, marketing manager for microprocessors at Fairchild Camera & Instrument Corp., Mountain View, Calif. His predictions were among several others voiced in a panel discussion at the Third Annual Conference of Industrial Applications of Microprocessors in Philadelphia earlier this month.

Other crystal-balling:

- Movement toward the greater accuracy of 16-bit designs for everyday applications as prices come down. Ed Muns, project manager at Hewlett-Packard Co. in Loveland, Colo., likens the projected 16-bit processor's displacement of 8-bit devices to the way these devices crowded out the earlier 4-bit units.
- High-current outputs on the chip for directly controlling a variety of products such as fire-alarm and security systems and electronic games. Lionel Smith, senior applications engineer at Intel Corp., Santa Clara, Calif., says these higher-level outputs, as well as other input/output arrangements, are only facets of future efforts to tailor dedicated processors to industrial and commercial products.

The growing capability of semiconductor houses to mix analog and digital circuitry on a chip will make the addition of the new chip functions possible, points out Fairchild's Lewing. He also looks for a shift in architecture toward serial processing for applications requiring large data bases. "Eighty percent of logic is presently used for tracking pointers and addresses," he says. "And with charge-coupled-device memories coming, the architecture could swing over to the more data-dependent serial processing."

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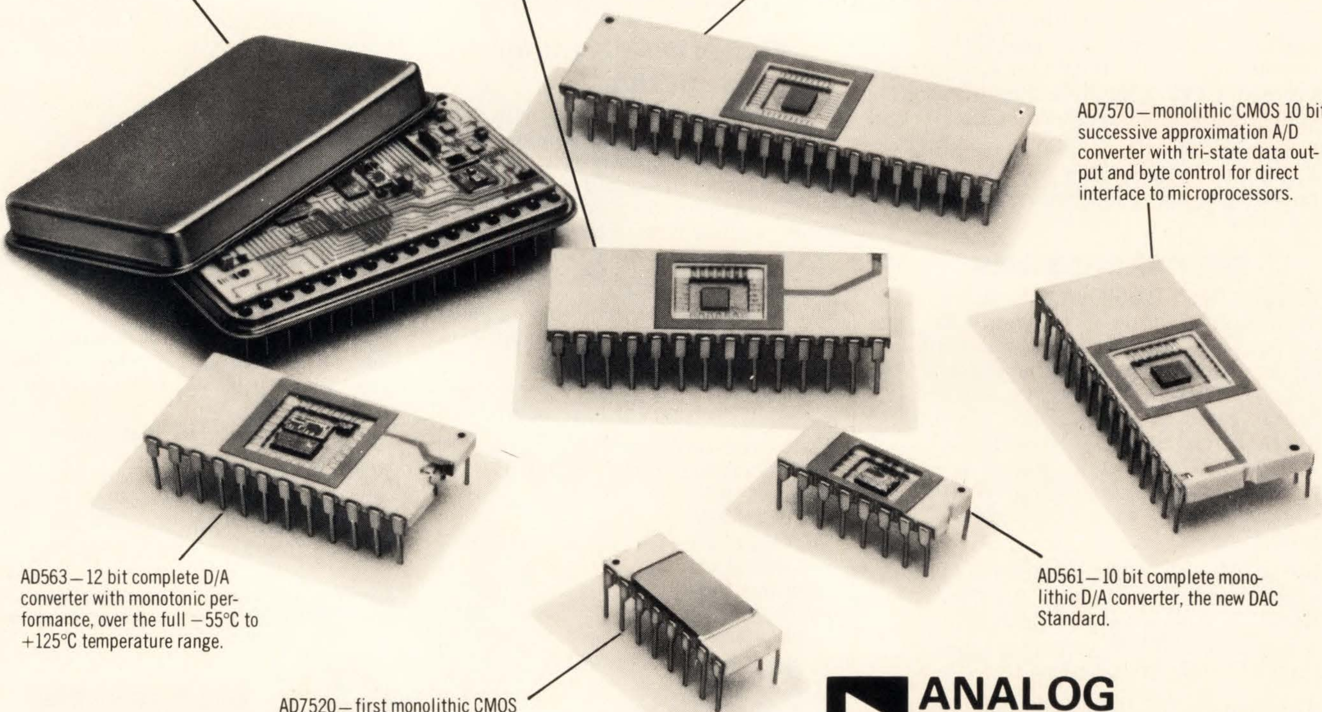

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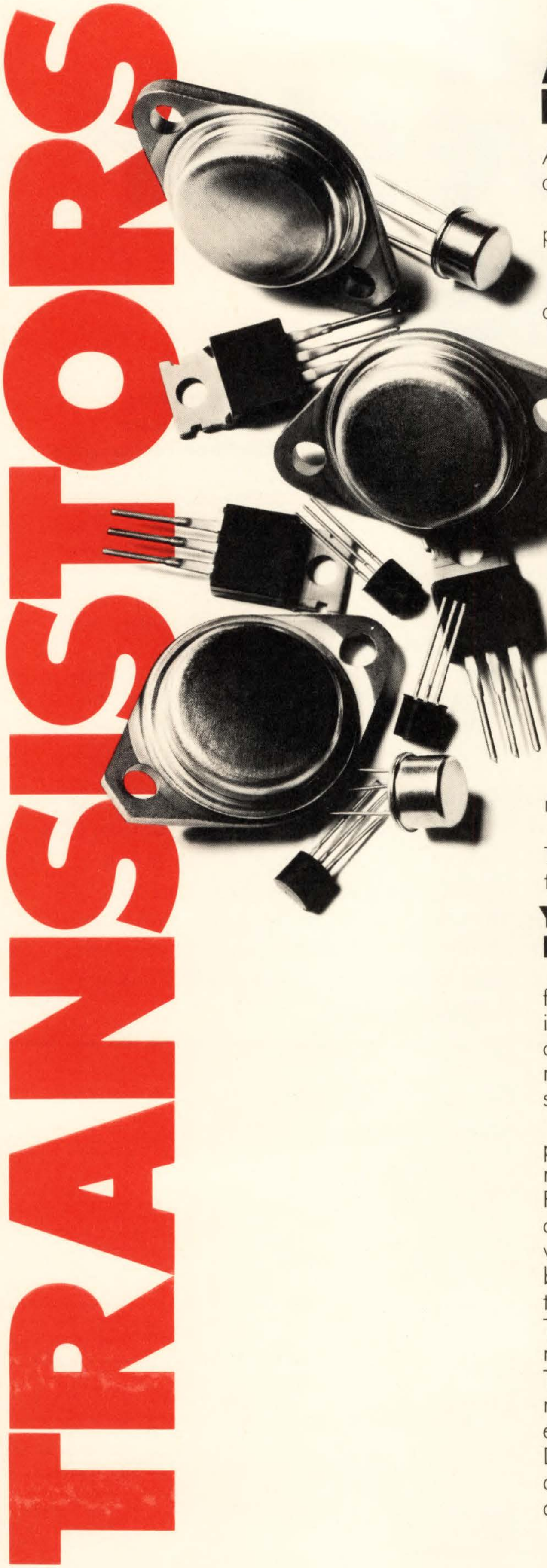

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FTR129	Low Noise RF Amplifier/Mixer	PG = 25 dB(TYP) @ 200 MHz; NF = 2.5 dB(TYP) @ 200 MHz; C_{cb} = .27 pF(TYP)
FTR129A	Common Base Oscillator to 1 GHz	f_T = 1000 MHz(TYP); $r_b'C_c$ = 4.5 ps(TYP); C_{rb} = 0.60 pF(MIN) — 0.90pF(MAX)
FTT158	Low Noise Forward AGC Amplifier	PG = 25 dB(TYP) @ 200 MHz, C_{cb} = 0.25 pF(TYP)
FTR168	Low Noise Common Base AGC Amplifier	PG = 18 dB(TYP) @ 200 MHz; NF = 2.8 dB(TYP) @ 200 MHz; C_{ce} = 0.12 pF(TYP)
FTR174	VHF/UHF Common Base Oscillator	f_T= 1000 MHz(TYP); C_{rb} = 0.35 pF(MIN) — 0.65 pF(MAX)

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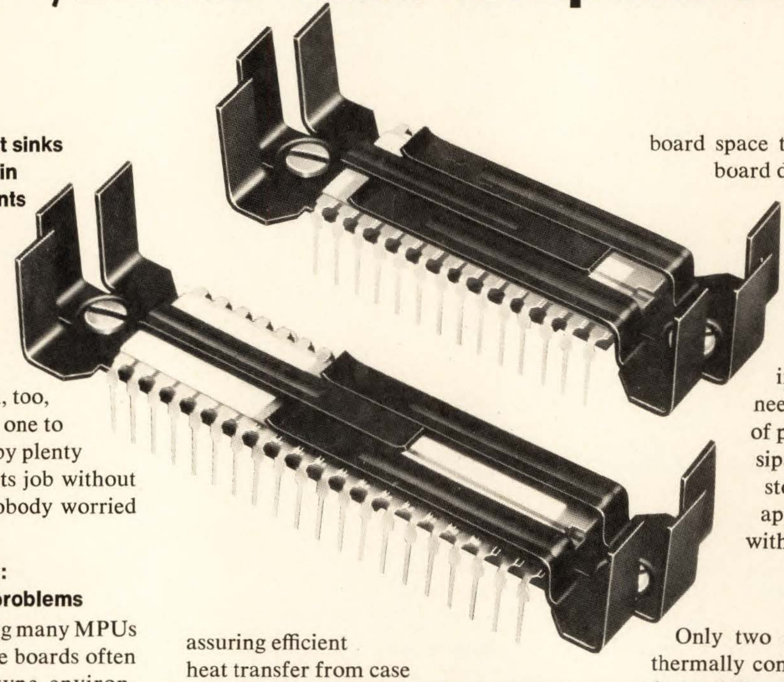


Unique new Micro-Clip heat sinks permit MPU operation in much hotter environments

Time was when microprocessors posed no thermal problems for designers. That's because earlier MPUs required very little power — up to 250 mw or maybe ½ watt at most. Then, too, designers usually spec'd only one to a circuit board. Surrounded by plenty of air, the lonely MPU did its job without generating much heat. So nobody worried much about heat dissipation.

Today's reality: serious MPU thermal problems

Today, designers are specing many MPUs on the same board. And these boards often must operate in military-type environments where ambient temperatures reach 71°C. Also, today's MPUs do more and, therefore, generate much more heat than earlier models. For example, they often function as both the arithmetic logic unit and the control section of a computer. These factors combine to cause serious thermal problems. Coping with these problems has become an increasingly important part of a circuit designer's job.

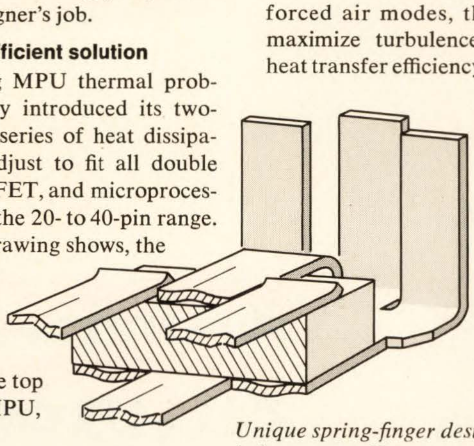
IERC finds efficient solution

To solve growing MPU thermal problems, IERC recently introduced its two-piece "Micro-Clip" series of heat dissipators. These units adjust to fit all double DIP, CMOS, MOS-FET, and microprocessor packages within the 20- to 40-pin range.

As the adjacent drawing shows, the Micro-Clip's unique spring-finger design lets the dissipator make good, solid contact with both the top and bottom of the MPU, assuring efficient heat transfer from case to dissipator. Tests show these units dissipate up to 100 percent more heat than conventional glued-down devices.

Staggered-finger design also assures more efficient heat dissipation

Micro-Clip series dissipators capitalize on IERC's patented staggered finger design. Heat radiates to the ambient, never transfers from one finger to another. In forced air modes, the staggered fingers maximize turbulence, further increasing heat transfer efficiency. Three finger heights are available — ¼ in., ½ in., and ¾ in. — to meet varying space and dissipation requirements. Micro-Clip dissipators weigh only 4 grams and require only .6 in.² more board space than the IC device itself. So board densities and spacing between rows of, for example, double DIPs and CMOSs are unaffected.



Unique spring-finger design helps assure efficient heat transfer.

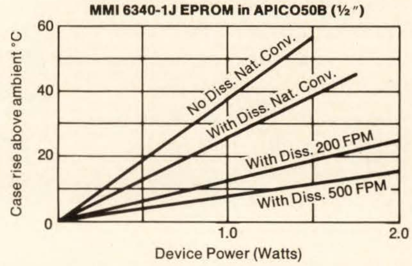
Stocking problems greatly reduced

Designed to (1) meet an infinite number of application needs and (2) fit an entire range of package sizes, Micro-Clip dissipators greatly simplify a user's stocking problems. This benefit appeals especially to companies with high-volume manufacturing operations.

Easy to attach

Only two screws or rivets or dots of thermally conductive epoxy are needed to fasten Micro-Clip dissipators securely into position. Mounting Micro-Clip units to MPUs already mounted to boards requires no disassembly.

MMI 6340-1J EPROM in APICO50B (½")



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Heat Sinks/Dissipators

Washington newsletter

U.S. CB makers weigh 'dumping' appeal against Japan . . .

Some domestic manufacturers of citizens' band radio are weighing an appeal to the U.S. International Trade Commission for increased tariffs and quotas on imports of CB radios from Japan. The proposal was the topic of corridor conversation at the Electronic Industries Association's Spring Conference in Washington. Following the success of domestic-TV producers before the commission (see p. 74), CB manufacturers saw promise in such an appeal.

Trade figures for 1976 show that Japan exported 9.9 million automobile CB transceivers—**88% of the 11.3-million units imported and valued at $557.5 million**—to the U.S. last year. Shipments from Taiwan of 1.1-million CB units constituted the bulk of the remaining imports. Transceiver imports of all types rose 220% from the 1975 level to 23.1 million, worth $881.4 million.

. . .but EDP trade sets record despite 83% import gain

U.S. exports of computers and related hardware rose 16% to $2,587 million in 1976, according to new figures from the Commerce Department's Census Bureau. Nevertheless, **the net U.S. computer trade balance of $2,352.8 million represents a record,** up 12% from the year before.

Computers and parts accounted for $1,339 million, up 15%, while input/output devices rose 20% to $645 million. Shipments of memories and other storage devices totaled $363 million, up 4%. The remaining $197 million, an 8% increase, was accounted for by computer-related machinery.

Canada continues to be America's biggest EDP equipment customer, buying $408 million in hardware last year, followed by the United Kingdom ($305 million), West Germany ($293 million), France ($273 million), and Japan ($239 million).

Boeing advantage seen as UMTA funds more people movers

Boeing Co. could finally make it big in the downtown people mover business with the Urban Mass Transit Administration's $220 million program for engineering and demonstration programs in Cleveland, Houston, Los Angeles, and St. Paul. The reason: UMTA has named Huntsville, Ala.'s N. D. Lea and Associates to conduct a $114,579 impact study of the Morgantown, W. Va., rapid transit system **on which Boeing was prime contractor.** Lea will use the resultant data "for preliminary engineering" of the four new programs.

After much difficulty, including large costs overruns [*Electronics*, May 1, 1975, p. 63], the 21-passenger, computer-controlled electric vehicles in Morgantown have logged 900,000 fleet miles, carrying 2 million passengers since revenue service began in the fall of 1975. UMTA granted $63.6 million more late last year to add another 2.1 miles of guideway to the dual-lane elevated system for a total of 4.6, build two more stations for the total of five originally planned, and buy as many as 33 new vehicles for a fleet of 78.

Army and RCA team to develop SOS processor

The U.S. Army Electronics Technology & Devices Laboratory at Fort Monmouth, N.J., has teamed with RCA Corp.'s Government Systems division in Camden, N.J., to develop a high-speed, low-power silicon-on-saphire microprocessor. Designated Atmac, the two-chip byte-slice device's architecture lends itself to pipeline processing—doing more than one thing at a time—and has a high clock rate.

Washington commentary

On Fukuda, Carter, trade and mismanagement

American color-television makers argue that they nearly drowned last year as a result of Japan's shipment of 2,530,000 receivers to the United States, more than 89% of the import total from all countries. They were particularly distressed by the concentration of U. S. color-set imports in screen sizes of 19 inches and larger—the most popular models. These rose to 1,578,000, an increase of 188% from 1975, to capture 56% of the total color-import market.

Thus American producers were not amused by Japanese prime minister Takeo Fukuda's likening of those imports to "a local thunderstorm in which the rain may be torrential" if you happen to be caught in it. But prime ministers, like presidents, prefer to look at the big picture, so to speak, and Fukuda clearly sees this problem as just one of many affecting relations between Japan and the United States.

Japan's compromise

Asked specifically if Japan would accept voluntary export controls on color-TV exports to America—in view of the U. S. International Trade Commission's recent recommendation of a 20% tariff boost (see p. 74)—Fukuda would say only that he expects 1977 shipments will decline from the 1976 peak. But he also hinted that Japan is seeking to offset its trade advantage with the U. S. in another way, by buying more American products—although these could be agricultural products or other commodities that would provide no relief for the electronics industries. Fukuda foresees "a substantial increase this year in Japan's imports," an increase that will exceed the growth rate of exports, "thus stimulating the economic recovery of our trading partners."

While Takeo Fukuda's words on trade in electronics offer little solace to U. S. electronics manufacturers, there was even less in his observations on Japan's plans to allot some of its "surplus resources" resulting from its minimal military outlays—less than 1% of the Japanese budget—to "the promotion of peace and prosperity in Asia." Specifically, Fukuda spoke of the Association of Southeast Asian Nations and the March 23 inaugural meeting in Jakarta, Indonesia, of the Japan-ASEAN Consultative Forum through which Japan will support "self-help programs of intraregional cooperation." Some U. S. Government and industry listeners immediately translated this into major new Japanese electronics production facilities across Southeast Asia—perhaps even Hanoi—to offset the burden on Taiwan and South Korea where employment is high, wages rising, and new factory space at a premium.

Prime minister Fukuda appeared to soften that image by calling for active U. S. participation "in the nation-building efforts of Asian peoples" as "indispensible" to the Japan-ASEAN goal. Nevertheless, he clearly warned that "the major trading nations must pledge never again to abandon free trade for self-destructive protectionism" that he believes led to "the social instability and extreme political nationalism" that produced World War II.

The prime minister's overview of global economic stability and the protectionist threats thereto is sound, but it does not contribute much to President Carter's domestic political problems with multiple industries where Japan has made major inroads and the demand for job protection is rising. A compromise on the issue of TV imports seems to be in the making, with Japan cutting back on shipments while the White House weighs the prospect of tariff increases—perhaps half of the 20% recommended by the ITC.

Protection for whom?

But President Carter must recognize that this or any other compromise with Japan on the issue of TV imports alone will not help solve the problems that are developing in other U. S. consumer-electronics products like citizens' band radios and the developing market for videotape players and recorders. These, too, are dominated by imports from Japan. In the case of citizens' band radios, Japan took the lead simply because it anticipated the American boom, committed to production, and was ready to ship before many U. S. producers were ready. In the case of video tape, American companies let their technology lead slip through their fingers while Japanese companies persisted in product development.

Whatever President Carter can do to protect American jobs, he should do at as little cost as possible to American consumers. But American consumer-electronics manufacturers have long had the advantages of nominal "value-added" tariffs under which to import their own products from offshore facilities in low-wage nations, and the President cannot protect them from themselves, from losing domestic markets as a consequence of their own market miscalculations and their own bad judgment in refusing to invest sufficiently in such areas as research, development, and plant automation that would have kept them competitive. **Ray Connolly**

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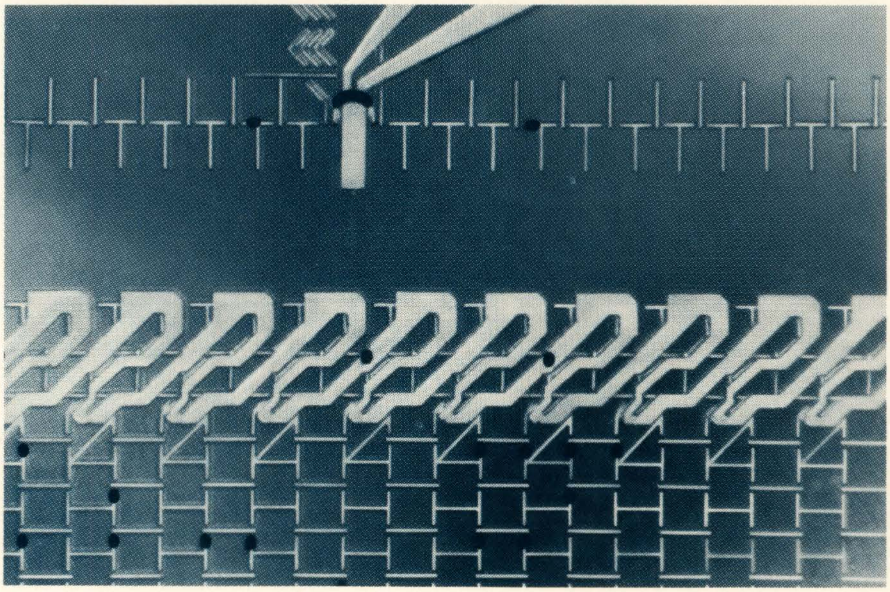

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Prototype quantities are available now. Coming soon: new interface peripherals, including an N-channel MOS controller.

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TI's new TMS 3064 is the first 65K charge-coupled device (CCD) memory on the market. Meets the need for a low-cost, high-performance memory between high-speed RAMs and low-speed, serial-access magnetic memories.

A new two-phase coplanar electrode CCD structure developed by TI, coupled with the standard double poly N-channel silicon gate process, is the key to the cost effectiveness of the TMS 3064.

Only two non-critical MOS-level clocks are required. Operating at 5 megabits per second, the TMS 3064 has a typical power dissipation of 300 mW.

In a 16-pin 400-mil ceramic DIP, the TMS 3064 will be available in May in sample quantities.

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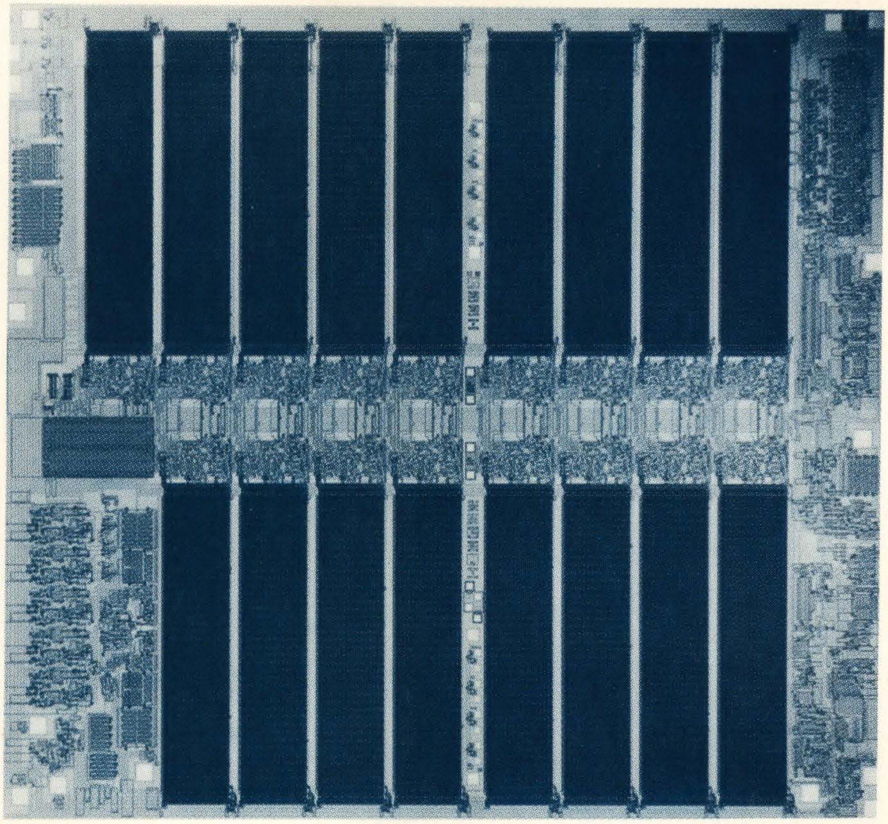

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These new 4K RAMs operate from single +5 volt supplies and are fully TTL compatible. A chip select and three-state output simplify memory expansion.

They come in four speeds: 450, 300, 200, and 150 ns maximum access times. And two organizations. The TMS 4044 and 4046 are organized as 4096 words of one bit; the 4045 and 4047 as 1024 words of four bits. Typical power dissipation at 200 ns is less than 325 mW.

All four new RAMs offer identical performance, with the TMS 4046 and 4047 series having the additional advantage of a unique power-down mode – less than 10 mW power consumption.

The TMS 4044 and 4045 come in a space-saving 18-pin ceramic or plastic package; the TMS 4046 and 4047 in a compatible 20-pin configuration. Sample quantities are available now.

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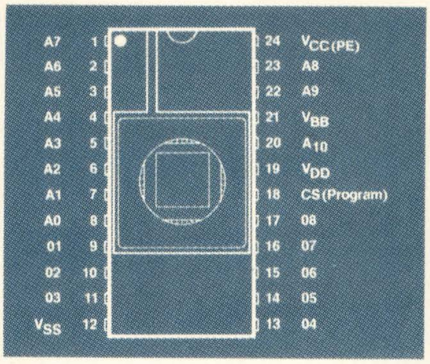
16K EPROM

. . . a 2708 times two

TI's new TMS 2716 is a 16,384 bit device that plugs into existing 2708 sockets. You get twice the EPROM memory in the same space. So it's ideal for upgrading present designs. Same basic chip design and circuitry as the TMS 2708. Same production-proven N-channel process. Same power supplies. At 375 mW typical, the TMS 2716 dissipates less total power than most 2708s that have half the memory.

The TMS 2716 is a natural addition to TI's 8K EPROMs – the standard TMS 2708 and the low-power TMS 27L08. All are available now.



Circle 248 on reader service card

16-pin 4K & 16K Dynamic RAMs

In addition to the industry standard 22 and 18-pin 4K RAMs from TI, a new high-performance 16-pin TMS 4027 is available in sample quantities.

A 16K dynamic RAM – the TMS 4070 (300 ns) – is available now. With an improved performance TMS 4071 (150, 200 and 250 ns) coming in the second quarter.

Circle 249 on reader service card

For more information on any of these new memories, call your nearest authorized Texas Instruments distributor or TI field sales office. Or write Texas Instruments Incorporated, P.O. Box 1443, M/S 669, Houston, Texas 77001. Please identify the memory you are interested in by giving its TI part number.

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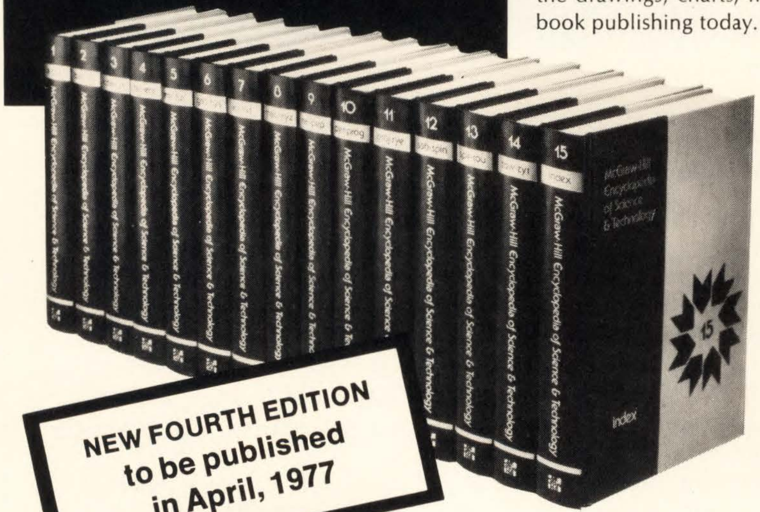

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Four Europeans get F-16 radar awards worth $54.7 million

Four electronics manufacturers in Belgium, Denmark, the Netherlands, and Norway will receive $54.7 million in contracts from **the Westinghouse Electric Corp. Defense and Electronic Systems Center, Baltimore, Md., for coproduction of the F-16 air combat fighter's multimode radar** [*Electronics*, July 10, 1975, p. 31].

As many as 800 of the F-16 radar digital computers will be produced under a $26.5 million contract by MBLE (Manufacture Belge de Lampes et de Matériel Electronique, SA) in Brussels. Hollandse Signaalapparaten BV, a Philips subsidiary, will get approximately $20.4 million for production of up to 500 planar-array antenna assemblies for the radar. Denmark's Dannebrog Electronik A/S will receive approximately $2.4 million for up to 800 cockpit radar-control panels, while Norway's Nera N/S will get approximately $5.4 million for up to 800 radar-equipment racks.

Cost drops to favor new serial memories, study predicts

It will be 1990 or so before the new breeds of serial memories become cheaper than floppy disks, cartridge units, or, for mass storage, moving-head disk files. **But because speed counts, too, charge-coupled devices, magnetic bubbles, and beam-accessed memories will have strong footholds in the U. S. and European markets by the mid-1980s.**

These are among the many likelihoods detailed in a just-out multi-client study of serial memories made by Mackintosh Consultants Co., a UK market-research company. Costs per bit for new-technology chips will plummet, the study predicts, as chip capacities bound upwards and production builds up. The cost of this year's 64-kilobit bubble-memory chips runs about 0.1 cent per bit, for example, but it is forecast to drop to 0.001 cent per bit for the million-bit chips that should be on the market by 1985. A sharp drop is in the offing, too, for CCDs—from 0.04 cent per bit for the current 64-k versions to 0.003 cent per bit for 265-k chips in 1985.

East Germans plan LSI microprocessor production soon

The East German electronics industry's first—and presumably the Soviet Bloc's second—large-scale-integrated microprocessor system is scheduled to enter volume production later this year. Its developer, VEB Funkgerätewerk, Erfurt, built the system, exhibited in March at the Leipzig Spring Fair, in fulfillment of a promise made early last year.

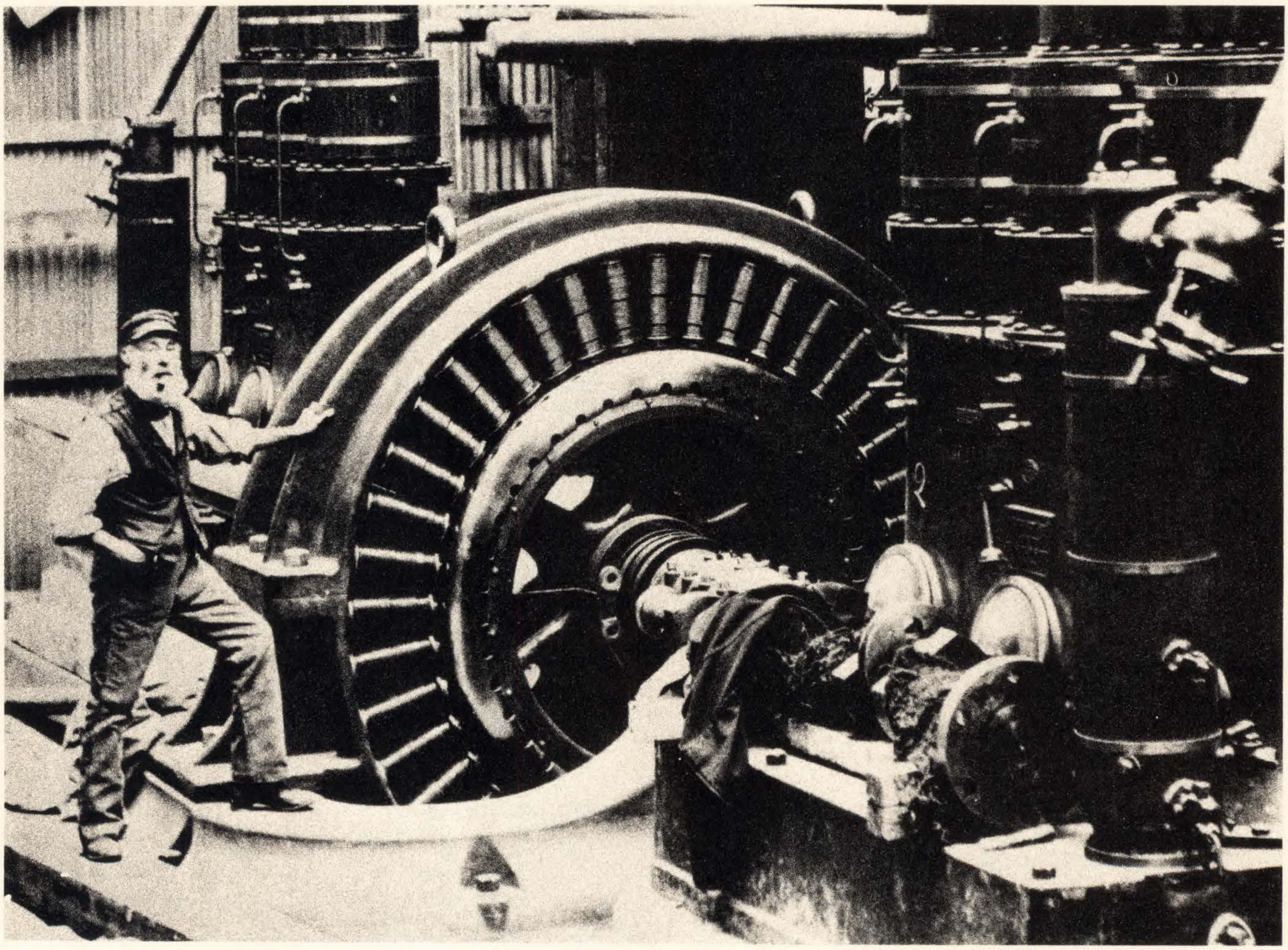
Heart of the microprocessor, which follows hard behind a Russian-designed system, is an 8-bit parallel p-channel MOS central processing unit. External to the chip are a static 2,048-bit read-only memory made with metal-nitride-oxide-semiconductor technology and a dynamic 1,024-bit random-access memory made with silicon-gate technology.

Chip-bonding scheme from French company attracts outsiders

Outsiders are taking a hard look at the tape-automated-bonding method developed by the "French" computer company, CII-Honeywell-Bull, in close cooperation with parent Honeywell Information Systems in the U. S. **Saab-Scania, the Swedish aerospace company, has bought a license for part of the process, and CII-HB is negotiating with watch makers and telecommunications-gear producers who like the film-carrier technique.**

HIS is using the French-made film-carrier machines to turn out hybrid modules containing the current-mode-logic chips for its recently announced series 66/85 computer, the most powerful in the Honeywell range [*Electronics*, March 17, p. 90]. CII-HB also plans to put the TAB modules in the Y 4/5 systems it plans to market in the 1980s.

If high start-up costs have delayed your expansion, contact Georgia.



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Georgia

Belgian firm introduces prototyper for developing microcomputer systems

Among the microprocessor-system prototypers exhibited at the Paris components show in early April will be a brand-new one from a 20-man Belgian company—Data Applications International. Claude Simpson, managing director and one of the founders of the Brussels-based firm, is convinced that his firm has one of the best one-card microcomputer designs going.

His development aid looks particularly attractive to people who build systems by the ones or tens, rather than by the hundreds or thousands. "We tried to see how parts from all the houses could fit together best in an 8080-based system," he says.

The firm had a solid fix on what parts to pick, since it had run training programs in microprocessors, first for Intel and later for other manufacturers, starting in the early 1970s. The result was the under-$500 DCE-1 microcomputer, packed onto a single Eurocard of 100 by 160 millimeters. Apart from its much smaller size, the DCE-1 differs from Intel's SBC 80/10 mainly in its timer, interrupt, and communications-control subsystem, implemented by a large-scale-integrated circuit from Texas Instruments. The interrupts and input/output ports are programmable.

Packaged in a seven-slot Eurorack, the development hardware can even become a working industrial prototype after the program has been debugged. It is mainly a matter of turning the plug-in Eurocards around, moving the back panel (which carries the DCE bus) to the front, and making system connections at the back side to the connectors on the Eurocards.

The complete development system, the DCE-DM, sells for roughly $1,850. Users get the rack wired with the system bus, a power supply, a DCE-2 microcomputer, a programmable read-only memory, programmer card, and a system-bus monitor that shows the bus states and simulated inputs as well. Along with this hardware comes a Teletype-oriented utility software package. An assembler and editor package costs another $260.

Memory. The DCE-2 microcomputer has 2 kilobytes of random-access memory, compared with 1 kilobyte of RAM for the DCE-1, and sockets for 4 kilobytes of erasable PROM for the system program. Development programs go into the RAM for checking and debugging. The final program can be stored on tape or put into an erasable PROM directly. If 2 kilobytes of RAM and 4 kilobytes of erasable PROM are not enough, a memory-expandable basic microcomputer card can be substituted for the DCE-2 and paired with memory modules carrying up to 64 kilobytes.

The input/output capability can be considerably enlarged, too. The basic microcomputer has 40 parallel

Around the world

Germany piggybacks TDM data on voice net

In less than two years, the West German post office plans to complete a nationwide digital data network that will be superimposed on its existing frequency-division-multiplex telephone system. Cost will be minimal because the time-division multiplexed system, the PCM30D, developed by the communications agency and Siemens AG, will use the phantom circuits derived from the symmetrical wire pairs that make up the FDM cables. To accommodate the piggyback network, which will link all major cities between Hamburg in the north and Munich in the south, the post office will merely add the appropriate equipment at the ends of the links and signal regenerators about 9 kilometers apart along the way. The technically autonomous network will not affect any of the 3,000 voice channels the FDM cable can simultaneoulsy transmit.

The first link of the data network is already operating between Frankfurt and Mannheim. The PCM30D system concentrates as many as 30 64-kilobit-per-second data channels into a 2-megabit/s signal stream before transmitting it over the phantom circuits.

Automatic dialers built around LSI chips

Britain's Pye TMC Ltd. has introduced two automatic-signaling push-button telephones built around its custom-MOS large-scale integrated circuits. For the home, Pye offers the Instafone, which can store up to 10 frequently used numbers and works anywhere in the world. It will be priced below $150. For the business office, it is making the 47-number Multicall. An export version, which can have 31 or 62 numbers, will sell for less than $400.

One of the first customers for the instruments is the British post office, which is ordering 1,500 Instafones and 2,000 Multicall units for user trials this year. Pye, aiming for export sales in Europe, Arabia, the Far East, and Latin America, expects to sell about $8 million of automatic dialers overseas.

The Instafone, contained in an ordinary-size push-button phone, stores 10 18-digit numbers, which the user can easily reprogram. The numbers can be "called" by pressing only two digits. A caller can "redial" a busy number by simply pressing the "try again" button.

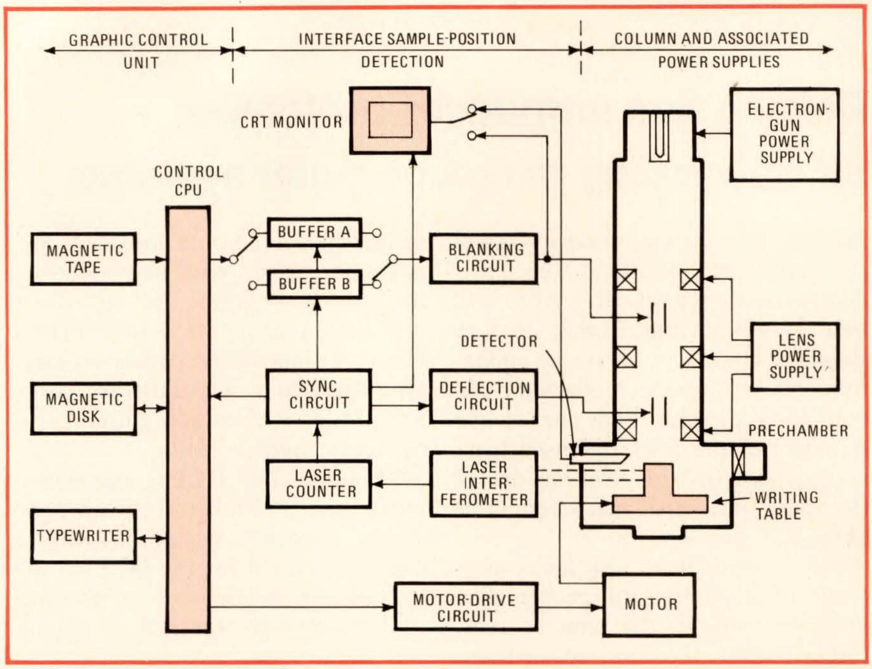
I/O ports, 24 of them programmable, and opto-isolated serial I/O with direct interface for Teletype and programmable baud rates. But that is not always enough to put the system in meaningful contact with the outside world, so the firm has developed a dozen "real-world" cards that can get all sorts of signals—analog or digital—into the system.

These cards plug into the bus, and the input/output flow through them is controlled by programming interface I/O ports that match up with those of the microcomputer card.

Going the other way, there are bare-bone versions of the DCE development system that sell for around $800 as kits. All the DCE hardware and software are fully compatible, Simpson points out. "A software house can become a system supplier through DCE," he maintains. "All the hardware can come from plug-in modules." □

Japan

Electron beams make precise LSI masks



A Japanese prototype electron-beam system exposes large-scale-integrated circuits with higher resolution than optical systems can provide. Built by researchers at Toshiba's Research & Development Laboratory, this unit will evolve into a product that its developers say can produce more precise chrome masks for ICs faster and at lower cost than other technologies. Moreover, future equipment will be designed to expose silicon wafers directly.

The beam can scan an area 50 millimeters square in one hour, a rate that makes possible generation of a complete set of master masks in one or two days. Its developers predict that raster scan, rather than step-and-repeat equipment, will be required for developing devices within the next four or five years. The system can combine various components made with the same process.

Unlike many previous developmental electron-beam exposure units, this one was built from scratch. One reason Toshiba fabricated the system was to accelerate development of its own LSI masks.

With a nominal beam spot size of 0.3 micrometer, the system exposes line widths and feature dimensions as small as 2 μm on master masks. However, the spot can be made larger if desired. As with other systems of this kind, the detector and cathode-ray-tube monitor are of the type used in scanning electron microscopes and cathode-ray-tube monitors. The scan writes 250 points along a 119-μm-long line in 50 microseconds. Another 12.5 μs is reserved in the prototype for beam return.

During this 62.5 μs, the table advances 0.4746 μm, a rate of almost 0.76 centimeter per second. After writing one line, the table is moved laterally to position it for writing the adjacent line until the entire mask is exposed.

Aiming. Electron-beam deflection guides the horizontal scan, and table motion directs the perpendicular scan. Table motion of up to 75 millimeters in the X and Y axes enables exposure of wafer masks as large as 3 inches in diameter, but later models will handle larger masks.

Laser interferometers measure table positions within 0.0791 μm along both axes and serve as a reference scale for servo motors that position the table. They also provide data that enables beam deflection to compensate for errors in position. At least four lines or picture elements must be written with 2-μm lines to prevent rounding of corners.

To minimize the size of the main memory in the minicomputer control system, the researchers designed it to accept data directly from a disk. Provision for the disk file to accept data from a tape deck also keeps down costs. The continuous flow of data from the disk makes it possible for a single chip to handle patterns for a number of devices.

Repetition. Six control bits can direct the unit to repeat a given line up to 64 times when needed, rather than repeating the same data for each line. Another 250 data bits govern the 250 points in each line. For this small number of points, a relatively simple digital-to-analog converter can provide the deflection voltage, while the short scan helps obtain linearity and precision in the deflection mechanism.

The system compensates for table motion so that scanning lines can join those of adjacent strips. The electron-beam column is 700 mm high and 200 mm in diameter. □

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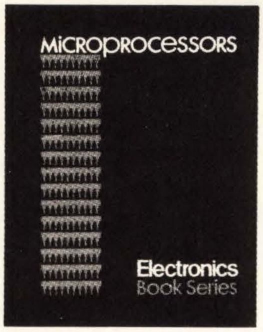

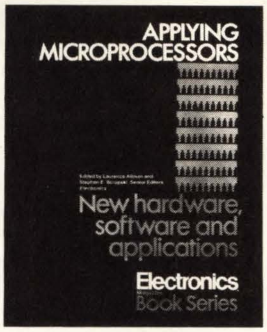

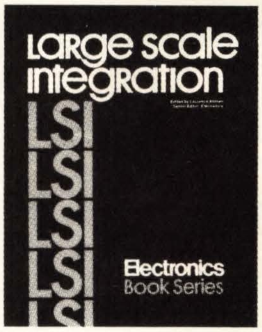

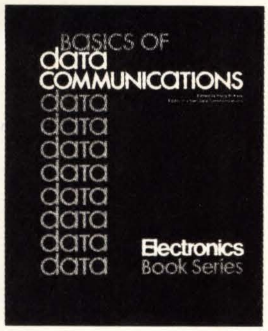

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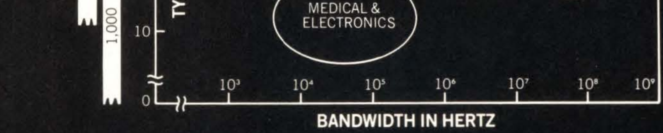

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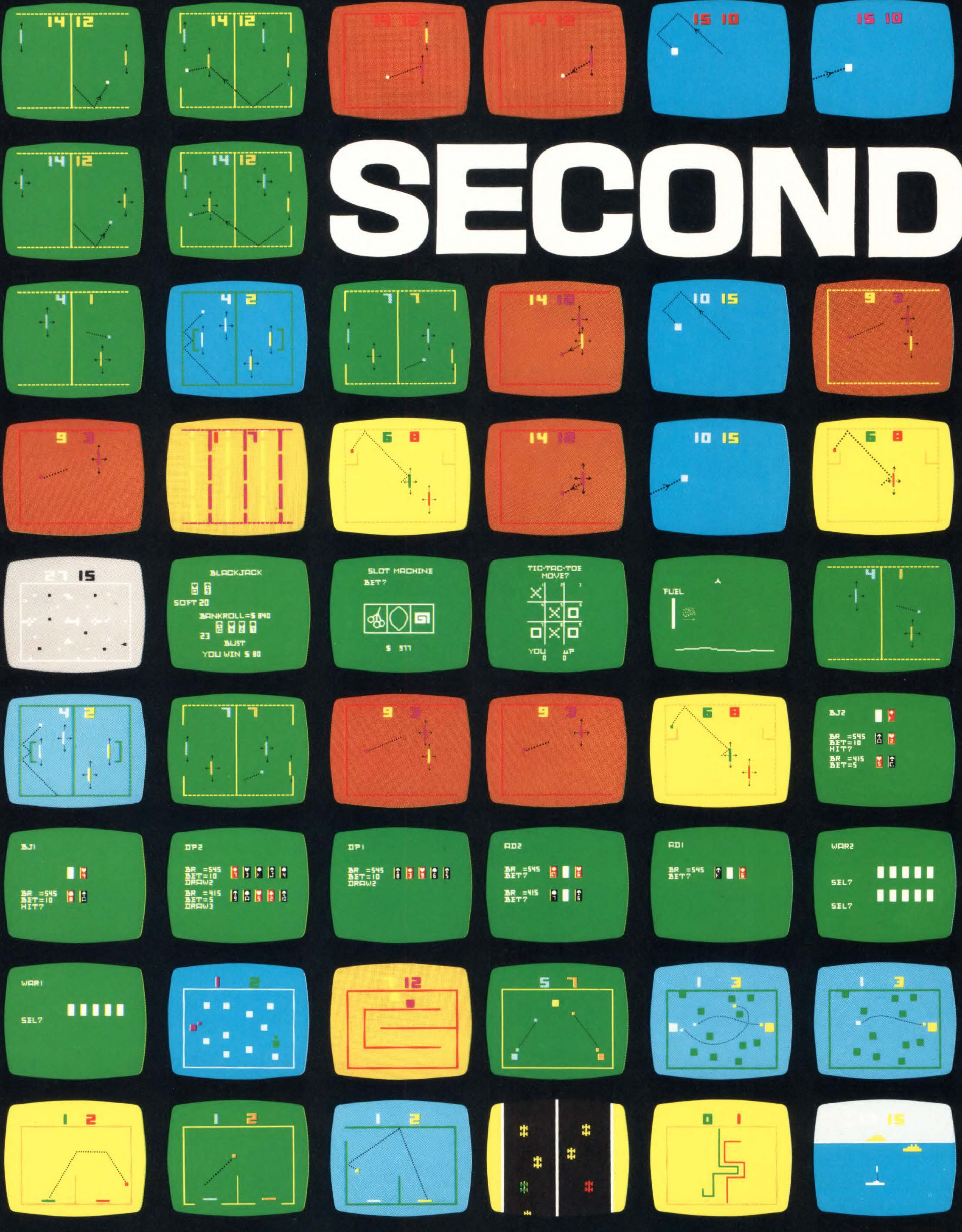
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BUST
SLOT MACHINE
BET?
TIC-TAC-TOE
MOVE?
FUEL
BJ2
BJ1
DP2
DP1
AD2
AD1
WAR2
WAR1
SEL?

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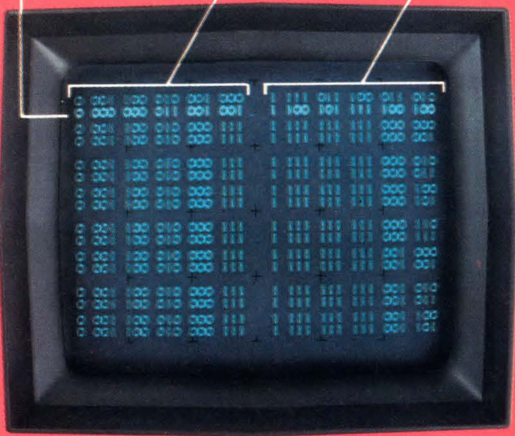

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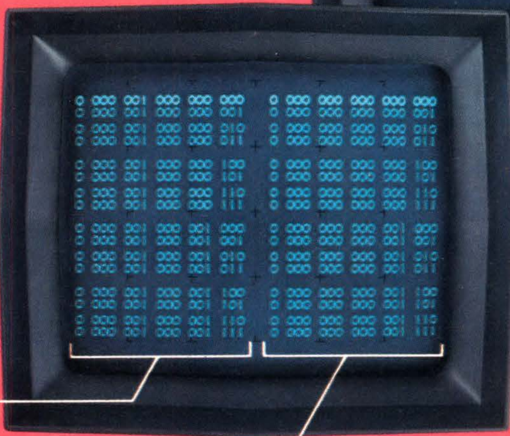

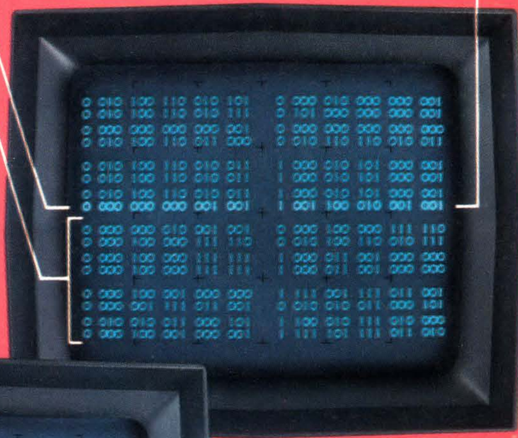

Verify that interrupt linkages are correct by observing program flow prior to the request for interrupt and seeing that the proper subroutine is being executed following interrupt. You can also use digital delay or word triggering to watch I/O driver subroutine activity in real time.

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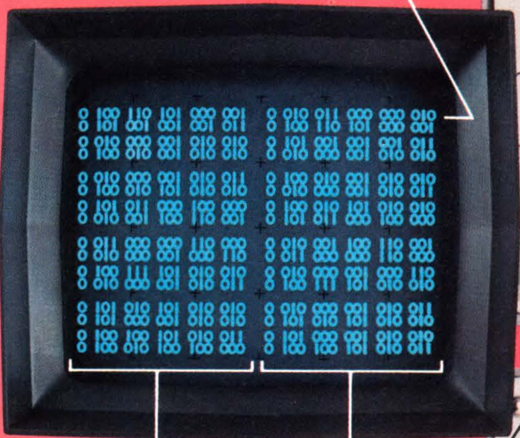

Parallel data inside computer *Serial data from 10254A* *ASCII code*

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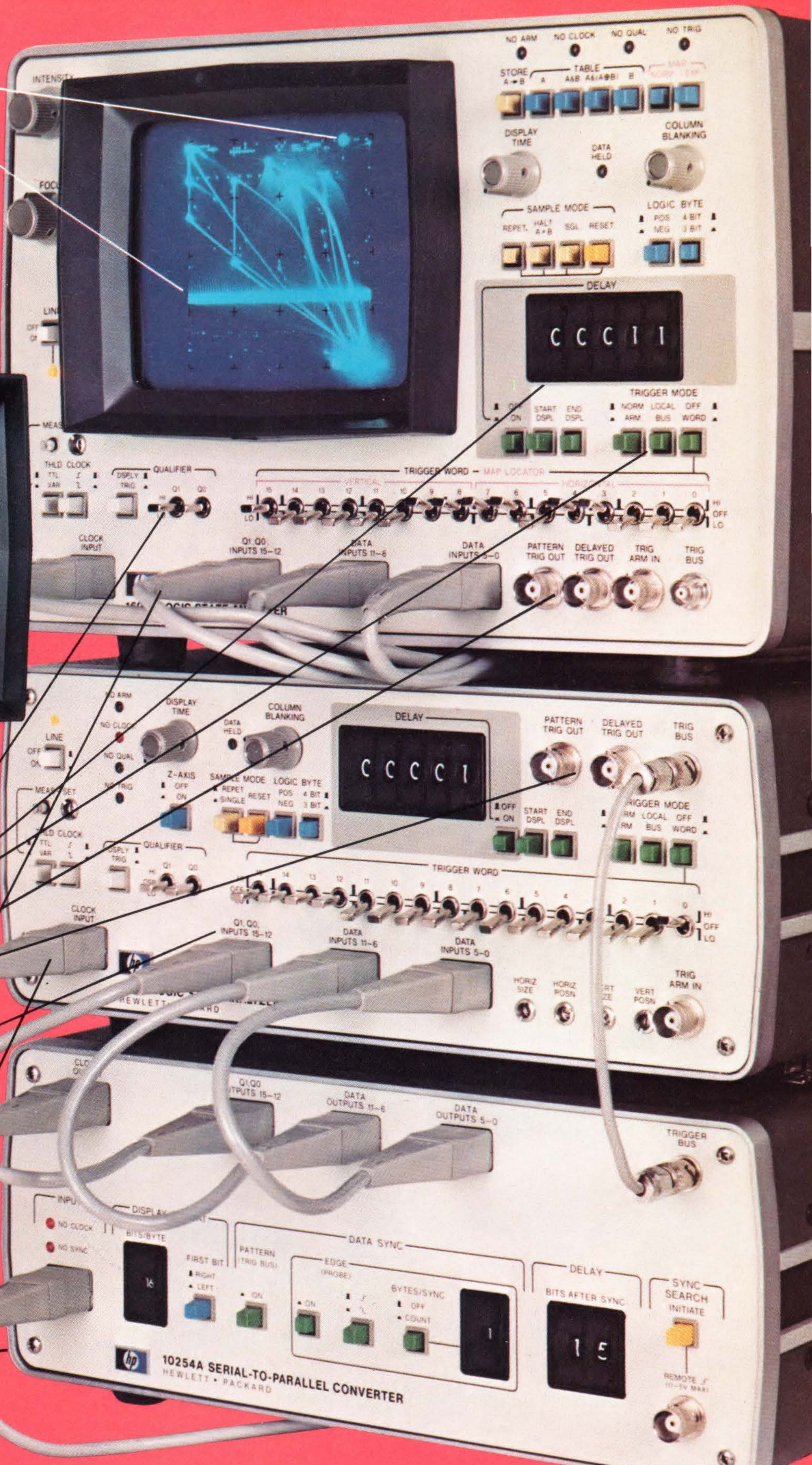

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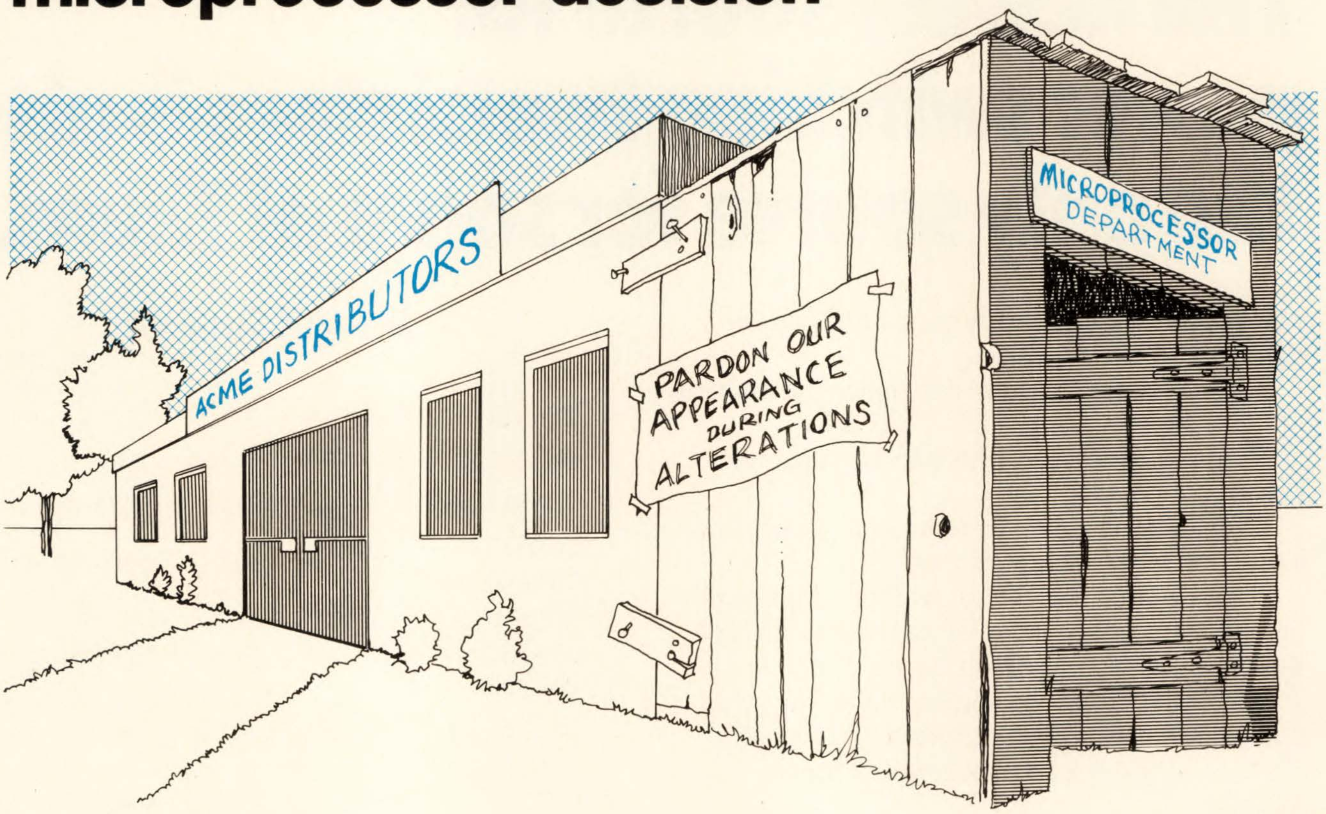
UNITRODE

Distributors face year of microprocessor decision



by Larry Waller, Los Angeles bureau manager

One of the few things that all distributors agree on is that microprocessors are having a profound impact on electronic-component distribution. But after four years, few distributors are making any money by selling the little marvels—and 1977 is shaping up as the year when the matter of profits comes to a head, a make-or-break time for distributors and their microprocessor operations.

There are several reasons for the splashes of red ink that have marked microprocessor ledger books. For one, high-priced engineering and programming talent are needed for sales to customers, who also are feeling their way; for another, manufacturers do not provide definitive marketing plans.

The view that the industry is now poised at the crossroads *vis-à-vis* microprocessors is subscribed to by William C. Cacciatore, senior vice president of Hamilton/Avnet, the largest firm ($231 million sales in 1976) in the business. "Suppliers will present programs that require major commitments from distributors," he predicts. What kinds of programs these turn out to be is less important than forcing distributors to make decisions about microprocessor involvement. "They'll either go with it," Cacciatore says, "or they'll be out of it"—likely forever.

Other distributors say that such a development cannot come soon enough because its absence has been responsible for much of the microprocessor muddle. "The whole microprocessor area hasn't been clearly defined on either the manufacturers' or the distributors' level," observes Edwin A. Trapp Jr., president of Dallas-based Hall-Mark Electronics Corp. Clear guidelines are necessary, he feels, before investments in additional staff and hardware can be made. "When we see the definition, we'll make the investment." Trapp agrees these programs will be coming by year-end.

Backing up Cacciatore is another Texas distributor, Frank Castle, president of Sterling Industrial Marketing, Houston. "A basic set of parameters hasn't emerged yet, so each transaction is almost a customer transaction," he says. The goal is higher microprocessor volume and a more standardized system. "When customers' needs start falling into an established framework of programs, it will become a real business, instead of a zoo," Castle says.

Despite the uncertainty, several firms already have made substantial start-up investments in microprocessors and are making money. Leading the pack, as might be expected, is Hamilton/Avnet, with microprocessor-oriented engineering sales personnel in all its 33 domestic locations. Cacciatore says the clear requirement is to supply a "vehicle for customers to play around with, and software-knowledgeable people for demonstrations." With an "early start 18 months ago and an investment that topped $1 million a year ago," Hamilton/Avnet is building profitable volume on a pay-as-you-go basis. Cacciatore vows to spend more to generate momentum.

Another active firm is Wyle Laboratories/Distribution Group, with up to 20% of its $80 million 1976 sales coming from microcomputer and related peripherals and memory components. Furthermore, Larry Pond, vice president and general manager of Wyle's Elmar division, expects it to reach 35% this year. For both Wyle and the industry, the split could be 50-50 as soon as 1979, he thinks. Wyle maintains technology centers with applications engineers, complete library, and seminars.

On the other end of distributor microprocessor efforts are such firms as Jaco Electronics Inc. of Hauppauge, N.Y., and Powell Electronics Inc. of Philadelphia. Jaco is not a leader in the microprocessor marketplace, admits Joel Girsky, secretary and treasurer, but has invested "prudently and judiciously," especially in educating nonelectronics-type customers. Powell has chosen to pass up this market. Somewhere between are the majority of distributors, many of whom are biding their time, waiting for the microprocessor sales outlook to settle before deciding.

Going up. Wyle's Spiegel considers a 20% growth in 1977 sales "not unreasonable."

Growth. Aside from the focus on microprocessors (whose glamour tends to divert attention from prosaic economics), the distribution field unquestionably is in another of its strong growth phases. Indeed, as a business, distribution sales and profits seem closely tied to the overall U.S. business-activity cycle. In 1976, for example, distributor sales jumped 20% to 25%, as estimated by industry officials whose own firms often enjoyed even better growth.

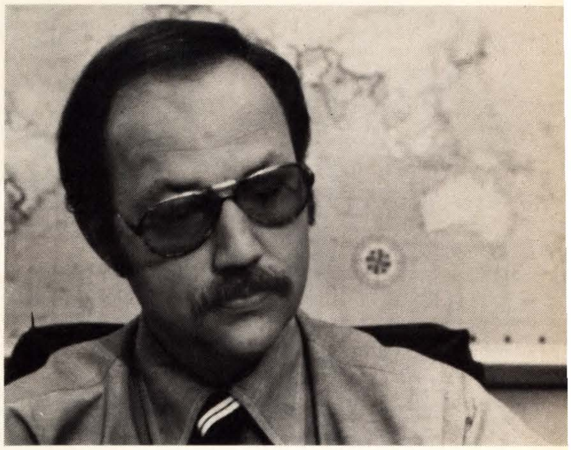
Wyle group vice president Sidney L. Spiegel and his counterparts estimate for 1977 a growth range of 15% to 20%, with most of the estimates from the big firms clustering on the high side. The Wyle boss himself, who was glum on the year's prospects as recently as last December [*Electronics*, Dec. 23, p. 82], considers "20% not unreasonable."

Citing a "strong pickup from flat sales in 1976's second half, Hamilton/Avnet's Cacciatore says he "likes the 15% to 17% numbers," and W.L. Harrison, marketing manager of Chicago-based Semiconductor Specialists Inc., seconds this view. "We feel we'll be up between 15% and 20%—probably closer to 20%—and that's probably close to the figure for the distributor in industry, as well," he says.

Art Nannos, executive vice president at Powell, does not hazard a prediction, but reports record billings in February, with no sign of a slowdown. Seymour Schweber also holds back on projections, saying, "too many things are happening in the world that could affect those forecasts."

Conservative. On the low side is Sterling's Castle, who expects a 12% increase for his firm and the industry. Girsky of Jaco, while granting the possibility of a 10% jump, sees dark clouds forming. "I think we'll have a recession toward the end of the year—certainly by 1978—and we're planning our business that way."

Whether or not this occurs, electronics distributors know their business is benefiting from a long-term trend that supports steady growth, despite fluctuations now and then. Simply, distributors each year are selling a higher percentage of the total sales of electronic components. "This amounts to no less than 25% and no more than 30%," Cacciatore says, "and is still going up." By contrast, this number was only about 9% in 1959.



Expensive cash. Hamilton/Avnet's JuDay points to high cost of obtaining capital.

Stabilization. This stems from the "small-account nature" of the typical distributor customer, whose cumulative effect is to balance the very large orders sold directly by the manufacturer. "We're a vehicle for suppliers to get at a broad base, so they're not swung by a few big customers," as Cacciatore puts it.

Even with long-term improvement and a positive business cycle, distributors do not lack worries, however. All mention ever-present inflation, and skyrocketing operation costs. Even highly successful Hamilton/Avnet keeps a wary eye on some components makers' attempts to dilute the value of an exclusive-area sales franchise, or "saturation." "More mature managers recognize they must help strengthen distributors," president Tony Hamilton says. In his book, this means preserving franchise integrity.

Also, growth takes additional capital, which some thinly profitable distributors reportedly have trouble raising. Each additional $1 million in sales, for instance, requires $300,000, estimates Hamilton/Avnet's Vance C. JuDay, vice president of sales and marketing. Although not a problem to strong firms, it could cause weaker ones to lose market share. □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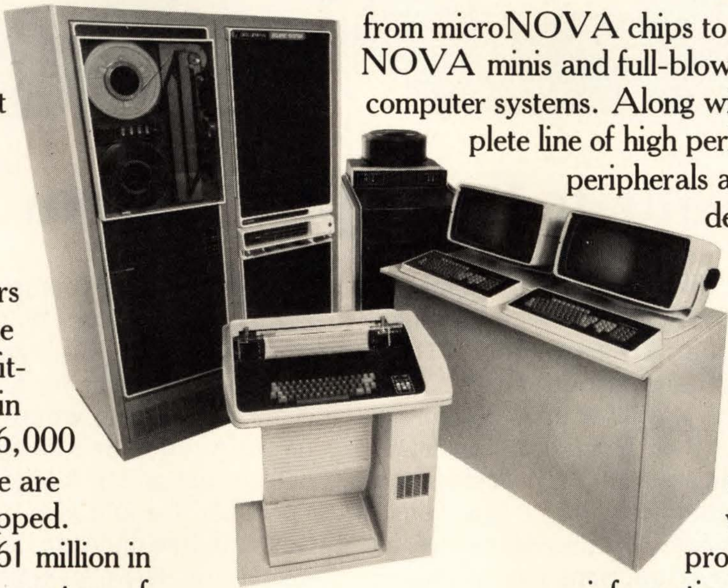

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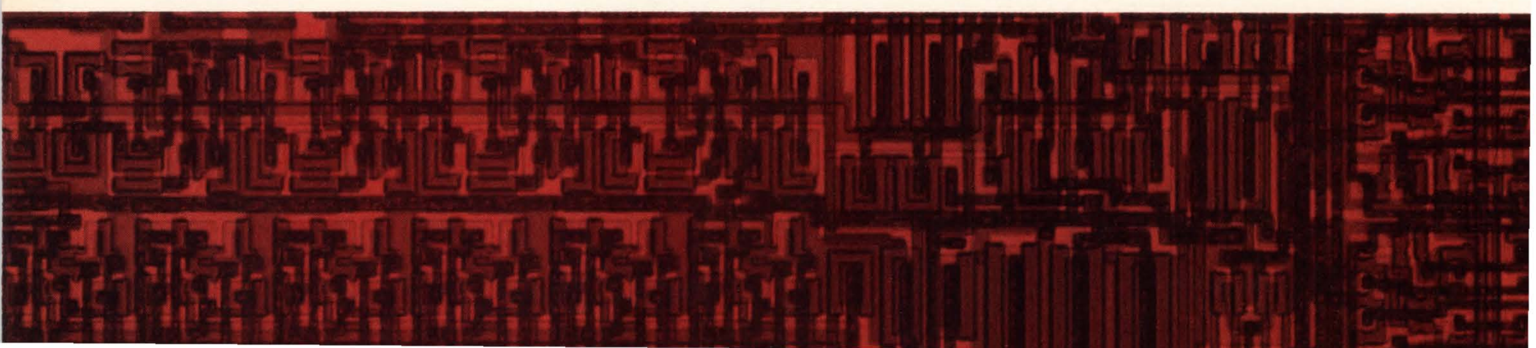


Automotive electronics

Fuel management is stepping stone

Beginning next year, car makers expect to incorporate that function with digital controls that also supervise other engine parameters

by Larry Armstrong, Midwest bureau manager

Driving relentlessly toward the microprocessor-based engine controls that will be standard on most cars in the 1980s, Detroit's Big Three automakers will add electronic fuel-management systems to a few 1978 model cars. But fuel management probably will be short-lived as a separate electronic module: as early as next year, that task will be swallowed by more capable digital electronics that combine it with control of other engine functions, such as spark-timing and exhaust-gas recirculation.

General Motors Corp. has a jump on the competition. It has shipped more than 105,000 copies of an electronic fuel-injection system built by Bendix Corp.'s Electronics and Engine Control Systems group in Troy, Mich. Standard on Sevilles and optional on other Cadillacs since 1975, the Bendix system will be used on 1978 models but possibly not 1979s. For future fuel controls, Cadillac reportedly is shifting to GM subsidiary Delco Electronics.

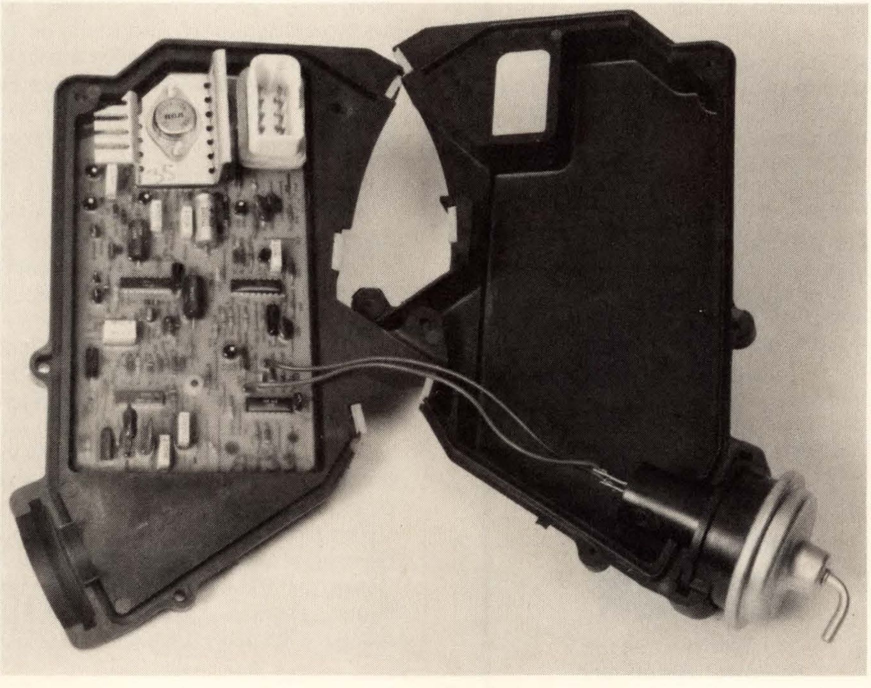
At other GM car divisions, "there are other things being considered for 1978," says John T. Auman, executive engineer at GM's Technical Center in Warren, Mich. He will divulge no more than that, but any new system that GM implements is likely to use its zirconium-dioxide sensor, under development for years, in the exhaust pipe. The voltage output of that sensor is fed back to the electronics that controls the fuel schedule, for the first time giving the closed-loop control of the air/fuel ratio needed to attain optimum combustion. The industry expects to see such a system offered on a few 1978 GM cars.

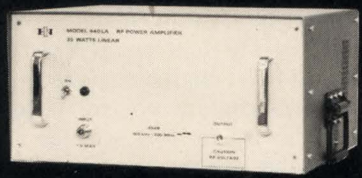
Rather than use electronic fuel-injection techniques like Cadillac's, the Ford Motor Co. has opted for a conventional carburetor with electronic feedback controls. It will ship some 30,000 1978 cars equipped with the system to California, where emission standards are more demanding than Federal requirements.

Doing much what GM plans to do, Ford couples an exhaust air/fuel-ratio sensor from Robert Bosch Corp. to analog electronics built by Motorola's Automotive Products division in Schaumburg, Ill., as well as by Ford's own Electrical and Electronics division. But while the Bosch sensor allows some closed-loop operation, keeping combustion at its stoichiometric point, the Ford system "also provides some open-loop control functions over the carburetor," says Robert S. Oswald, manager of electronic engine controls at Ford's Dearborn, Mich., engine-engineering office. Fixed-program control takes over for the 20 to 150 seconds it takes for the exhaust system and sensor to warm up, he explains, "and a second open-loop mode, determined by a throttle-position sensor, specifies operation while the system is at idle and during deceleration."

But Ford plans to bundle the electronic carburetor controls with other engine electronics in 1979 cars, says Jerome G. Rivard, assistant chief engineer at Ford's Electrical and

Thinking thin. Chrysler plans to place analog system for programmed fuel metering alongside its "lean burn" engine computer, shown here. Room was made by use of ICs.





Engineering division. Control of spark timing and exhaust-gas recirculation will be handled in another 30,000 1978 cars by a nine-chip Toshiba system. For 1979, it will be replaced by a six-chip set that will handle fuel management, as well [*Electronics*, March 3, p. 40]. Already named as semiconductor suppliers for those chips are Tokyo Shibaura Electric Co. (Toshiba), Intel Corp., Texas Instruments Inc., and the Essex Group of United Technologies Corp. "They are all working on the six-chip system," Oswald says, "but we will not allow more than one design for 1979."

Chrysler Corp., too, is planning to package its fuel-management system with other engine controls. Next month, it will start shipping cars with a new version of the analog spark-control computer it has been using with its "lean burn" engine. By replacing more than half the components in the original system with three custom integrated circuits—from National, TI, and RCA—the firm has managed to free up half the spark-computer module, into which, later this year, it will drop a second analog system for programmed fuel metering.

"But we'll replace the whole module with another version, perhaps as early as 1979," says John L. Webster, manager of advanced-product development at Chrysler's Huntsville, Ala., Electronics division. Next year's digital versions, based on TI and RCA microprocessors, are designed to work interchangeably [*Electronics*, Sept. 2, 1976, p. 70], but as each vendor develops its own alternate sources, Chrysler is expected to drop one.

For the 1979 Chryslers, TI is developing a three-chip system, a pair of custom input/output chips that works with the firm's TMS9940 one-chip microcomputer. The same engine chore is handled at RCA with its new 1803 microprocessor, a 28-pin version of its standard 40-pin C-MOS 1802 that, at least initially, probably uses the same die. RCA's C-MOS approach, less dense than TI's n-channel MOS technique, requires a larger chip count: the processor, two custom input/output chips, and two read-only memories are needed to perform the spark timing and fuel-metering tasks. Chrysler does not now need exhaust-gas recirculation to meet U. S. emission standards. □

Bendix, Motorola fight the squeeze

What with GM steering to Delco for 1979-model fuel controls and Ford adding carburetor electronics to its 1979 engine-control package, it looks as if two first-tier auto suppliers are being edged out of the engine-electronics business. They are Bendix Corp.'s Electronics and Engine Control Systems group and Motorola's Automotive Products division. But neither is about to concede anything; they are both working frantically on upgraded systems to handle all three engine-control functions—systems that they hope to sell to automakers in the 1980s.

Although Bendix' current fuel-injection system is analog, the group has demonstrated a two-board digital module, built around a standard 6800 microprocessor, that manages spark timing, exhaust-gas recirculation, and fuel control. It is also showing around a three-chip mockup on a ceramic substrate.

"We're apt to spread some functions around to get three chips of comparable size, but Motorola's 6802 [*Electronics*, March 3, p. 34] is central to our plans," says William S. Haagen, director of advanced development at the Troy, Mich., group. The 6802, with on-board processor, random-access memory, and clock, will be used with a custom input/output and a custom read-only memory that contains engine and emission parameters likely to change in production.

The Motorola division, still playing its hand close to the vest, is known to be developing a modification of the 6800 specifically for auto applications. Called the 6700, it has an 8-bit data word and 10-bit control word, can handle all three engine-control functions, and pairs n-channel MOS technology with integrated injection logic in a two-chip system.

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Consumer electronics

Carter word awaited on TV tariff

Recommendation for increased imposts on all imported TV sets poses ticklish international problem, leaves producers with mixed feelings

by Ray Connolly, Washington bureau manager, and Gerald M. Walker, Consumer Electronics Editor

Now that the U.S. International Trade Commission has dropped the other shoe regarding television imports, the next move is President Carter's. Having found that imports, primarily from Japan, have hurt U.S. TV manufacturers, the commission has recommended that the White House sharply increase import duties on both color and monochrome sets.

The ITC's plan calls for tariff boosts from the present 5% to 25% of value for the first two years. The duty would then drop to 20% in the third and fourth years before settling at 15% in the fifth year. But by lumping color receivers with black-and-white sets, including those made offshore by U.S. companies, the commission has come up with a plan that pleases nobody in the industry—U.S. or foreign. It certainly does not satisfy the petitioning coalition of four manufacturers and 11 labor unions, called Compact, which wanted import quotas slapped on color sets only.

The White House has 60 days from March 22, the date of ITC's formal recommendation, to accept, modify, or reject the proposals. If the ITC plan is turned down, Congress has another 90 days in which to override the decision and implement the higher tariffs. If the President fails to act, the recommendation goes into effect automatically.

Ticklish. The issue is quite ticklish because of the impact of a decision either way on domestic and international economic recovery, diplomatic relations with Japan, and political relations with the labor unions. In addition, Article 19 of the General Agreement on Tariffs and Trade, which the U.S. and Japan have signed, authorizes Japan to demand that the U.S. make "equivalent concessions" on other trade items.

With the new tariff, the ITC estimates that prices paid by U.S. consumers for television sets would increase—another political hot potato for the Carter Administration. If enacted and passed on to TV buyers, the initial 20% tariff increase would mean a price hike of about $60 on the present average retail price of $350 for a 19-inch color receiver, the most popular size.

Split. However, the American industry is not unified in its stance, nor in its reaction to the ITC's action. A U.S. television-company veteran offers one view: "It's very close to closing the barn door after the horses are out. The only thing that's left in this country is color—there's only a little black-and-white. Of some 16 manufacturers in the '60s, only four or five that are left are truly American manufacturers. It's very much like what happened in radio."

Yet, the U.S. firms with offshore monochrome facilities in Taiwan—that includes Zenith Radio Corp., RCA, Admiral, and GTE Sylvania—are none too happy. "It looks like all we've managed to do is foul our own nests," growls one corporate official privately after learning of the ITC's decision. On the other hand, Zenith and Sylvania have expressed satisfaction publicly over the color-TV side of the recommendation.

George Konkol, president of the GTE Sylvania Consumer Business group, applauds the move, saying that the proposal is a "meaningful remedy" that should give the U.S. TV industry "the time and the atmosphere" it needs to get a "stable and normal working environment." Among the most outspoken critics of the business practices of some Japanese producers, Zenith president and chairman John J. Nevin concedes that tariffs would provide immediate relief, but he calls for a continuing investigation into "unfair and unlawful competition from overseas."

Silent. RCA and General Electric have been generally quiet during the current episode. RCA not only has

SUMMARY OF 1976 U.S. IMPORTS OF TELEVISION SETS

	4th Quarter (units only)			Year to date (units only)		
	1976	1975	% change	1976	1975	% change
Color	890,475	448,743	+ 98.4	2,833,738	1,214,664	+ 133.3
Monochrome	1,249,810	799,497	+ 56.3	4,327,022	2,974,622	+ 45.5
Total	**2,140,285**	**1,248,240**	**+ 71.5**	**7,160,760**	**4,189,286**	**+ 70.9**

Source: U.S. Commerce Dept.

monochrome and color production offshore, but it also collects large annual royalties from some Japanese color-TV licensees. GE, which is said to have a net trade advantage, has no offshore TV commitments, but does not necessarily want to rock the overseas-trade boat.

On the whole, as one U.S. manufacturer sums it up, "The tariff will put the lower-priced brands in a reasonable spread with the U.S.-made sets. I'd expect that the private-sourcing will start moving back to the U.S. and that much of the black-and-white production will come back to the U.S.—components and all. [This move has already begun.] The reason for the big surge in imports has been purchase of private labels by Sears, Ward, and Penney. Sears kicked out Warwick, which was then bought by Sanyo; Ward kicked out Admiral. This has made the difference—not the brand-name Japanese sets."

For their part, the Japanese are dismayed, but not floored, by the decision. Privately, most Japanese television makers hope that President Carter will reduce the ITC recommendations to a plan they can live with. At the same time, these companies are generally relieved that the decision was for increased tariffs, rather than quotas.

Consultations. Meanwhile, officials at the Ministry of International Trade and Industry in Tokyo say that Japan will shortly "start consultation with the U.S. to work out an effective solution to the problems." The inference is that Japan could demand the equivalent concessions allowed by the GATT treaty.

Sony and Matsushita, which have production facilities in the U.S., could increase output in this country to avoid the tariff, although these plants have been turning out only large-screen receivers. Hitachi has a rather small TV-export business. Perhaps worst hit would be Sanyo, Toshiba, and Sharp, which depend on major OEM private-label sales. Although Sanyo has a new plant in the U.S. and now controls Warwick, it could not increase production quickly here. Moreover, if exports are decreased drastically, it will have excess capacity in Japan, regardless of sales from U.S. plants. □

Meetings

The panel game: larger displays

That is one conclusion from papers due at upcoming symposium; CRT and LCD technology also to receive attention

by Stephen E. Scrupski, Instrumentation Editor

The annual symposium of the Society for Information Display has earned a reputation among technology watchers as a "hot" meeting, one that pays close attention to the latest developments in the art and science of display. An advance look at the 1977 edition, set for Boston from April 19 to 21, indicates the customary breadth of coverage. Topics to be examined range from military displays through large liquid-crystal and plasma panels, to the problems of standardization of today's industrial-type cathode-ray tubes. This article previews some of the papers.

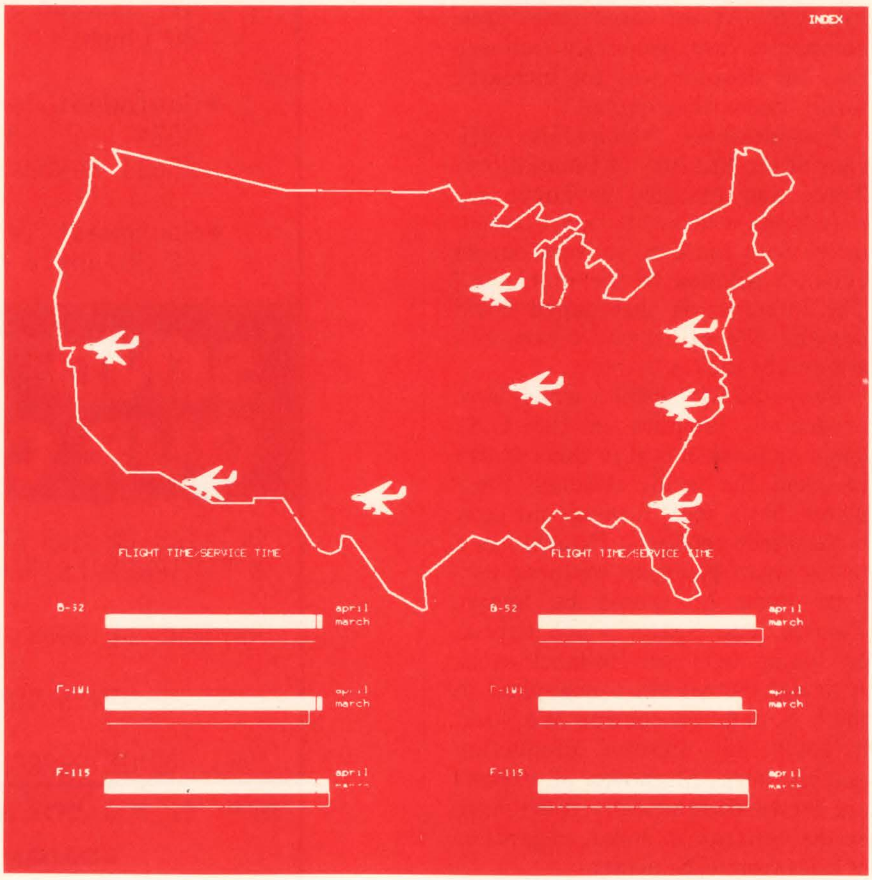
For liquid-crystal displays, today's emphasis is on the practical problems of drive circuitry and manufacturing. As overall program chairman, John Flannery of Xerox Corp. in Webster, N.Y., points out, "The field has moved away from the stage of constant, novel discoveries to the point where hardware is real; the field now seems to be getting down to the hard stuff."

Liquid-crystal panels play an important role in the session on projection displays. Hughes Aircraft's Alexander Jacobson will discuss a color-television projection system that uses a liquid-crystal panel as a light valve, while Anthony Dewey of the IBM Research division, San Jose, Calif., will describe a 2,000-character projection display.

Dewey's panel is thermally written with a gallium-arsenide laser. He credits workers at Bell Laboratories and Western Electric with some early work in which a neodymium YAG laser was used, but says that to be practical, a room-temperature GaAs laser proved necessary. The laser beam is scanned across the 10-millimeter-square liquid crystal with a galvanometer-type mirror, and the image is projected onto a screen 25 times as large—about 10 inches square. At present, he says, he can display 40 rows of 50 characters each, writing 20 characters or so per second.

As for plasma displays, H. Joseph Hoehn of Owens-Illinois Inc., Toledo, Ohio, will discuss manufacturing improvements in the company's 512-by-512-bit plasma panels, which display 60 lines per inch and have been in production since 1972. In that year, Owens-Illinois also developed a 1,024-by-1,024-bit display that showed 83 lines per inch. Built for Rome Air Development Center, it was 12 in. square.

Now the million-bit panel is being built into a computer terminal by Science Applications Inc., San Diego, Calif., where William Coates says the latest effort has been to



Million bits. A million bits are driven for display on plasma panel produced by computer terminal at Science Applications Inc. It will be described at SID meeting.

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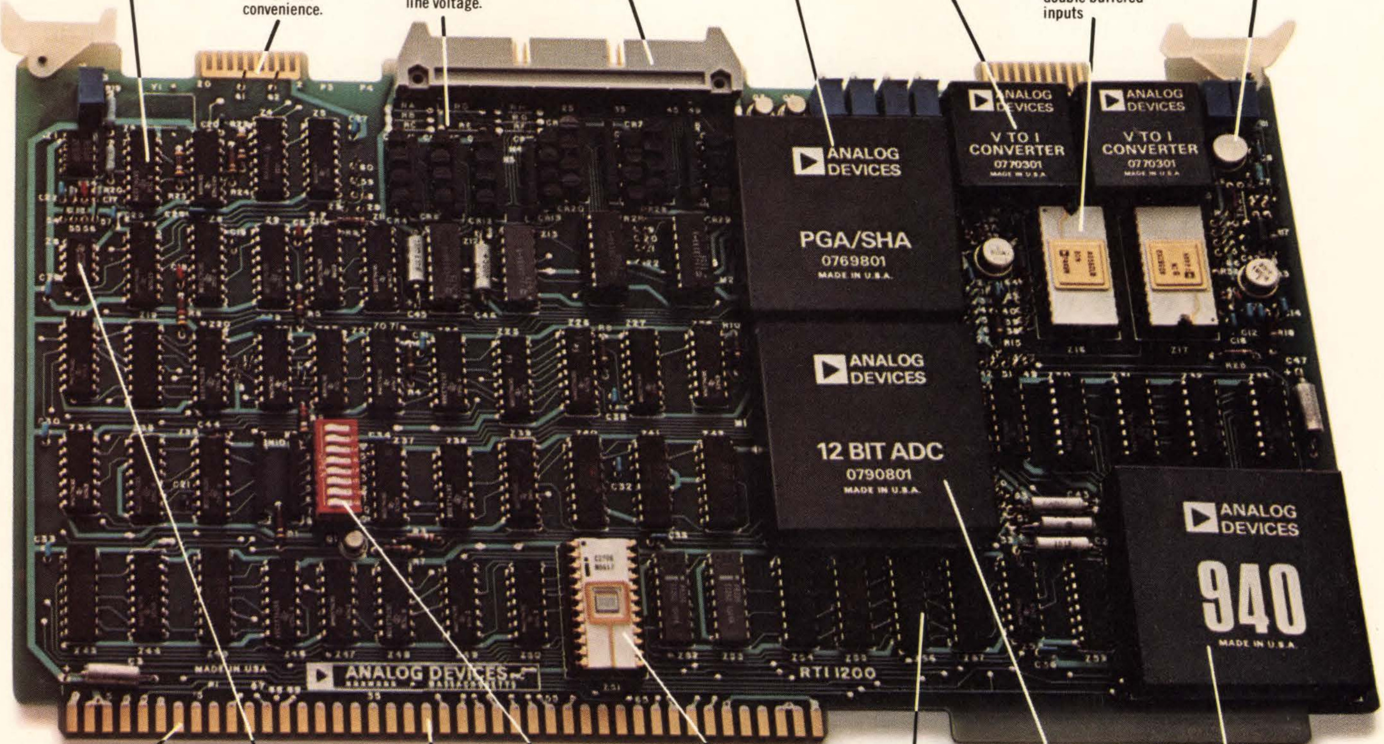

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Probing the news

install it in a terminal based on a Digital Equipment Corp. LSI-11. Until now, only 16-by-16-bit portions of the panel had been tested, but Coates says his system is driving the complete million-bit panel. The panel draws the display information directly from the LSI-11 memory via a direct-memory-access interface, and 16 bits are written in parallel. One of the problems is to overcome line high-voltage inductance problems, since rise times are in the range of 100 to 200 nanoseconds, while currents can range up to 8 amperes.

William Johnson of Owens-Illinois will describe a custom MOS chip that drives 32 lines of the company's panels. The chip is packaged in tape carrier and bonded to the glass of the plasma panel.

A couple of unusual though similar displays using tiny magnetic spheres will be described. Lawrence Lee of Magnavox Co., Fort Wayne, Ind., will tell about a matrix-addressed display formed from magnetic microspheres, white on one side and black on the other [*Electronics*, April 29, 1976, p. 41], while Nicholas Sheridon of Xerox Research Center, Palo Alto, Calif., will describe a display based on dielectric microspheres, also half black and half white, activated by dc voltages.

In Lee's display, each sphere is suspended in an oil-filled cavity. It can be turned to present either the black or white side by a magnetic field developed by the coincidence of currents in a matrix behind the panel. The present display comprises 10 rows by 15 columns, with about 0.5-mm spacing between the dots.

Sheridon's display also places each sphere in an oil-filled cavity. When a dc voltage is applied to the assembly, the sphere rotates to show either the white or the black side, so that a display can be formed. The spheres are between 2 and 4 mils in diameter (50 to 100 micrometers), and a black material is deposited on the basically white sphere to give it different dielectric characteristics. The present display measures only a few inches, but was built primarily for demonstration purposes. □

Consumer electronics

TI to offer wide range of courses to public

by Larry Armstrong, Midwest bureau manager

As one of the country's largest users of videotaped self-training courses, Texas Instruments Inc. has long been committed to education for its employees. But now it has taken the first steps toward the establishment of a nationwide network of "learning centers" similar to those in all its plants, except that they will be open to the general public.

Possibly one of the primary purposes of the network is to expand the market for TI consumer products. Roy Varner, the former manager of TI's internal learning centers who is serving as a consultant on the new project, concedes as much.

He says, "Our long-range goal in this area is toward consumer products, and it doesn't take much imagination to come up with a list of future consumer products derived from integrated circuits." He adds, too, that "the media-oriented educational market is one that TI wants to get involved in quite heavily."

The first facility, officially called the Texas Instruments Electronics Learning Resource Center, opened in Houston early this year. Though the Dallas-based firm emphasizes that the Houston center is strictly an experiment, it plans to open one more each quarter this year. They will probably be tied to its offices in Los Angeles, Chicago, and New York.

Wide range. The Houston center focuses principally on TI's existing repertoire of videotape-and-workbook self-study courses. The eight 12-hour courses have titles ranging from "Basic Electricity and dc Circuits" to "Digital Subsystems," and each is to cost $65.

"We're trying to open up to small companies the electronics training that's only been available to large companies," Varner says. TI has been selling those more elaborate videotape courses for an average of $3,500 a copy.

But TI's eventual direction is indicated by the series of low-cost videotape courses that it is introducing this month for users and potential owners of TI programmable calculators. The company has spent the last few Saturdays training sales clerks from six Foley's department stores in Houston on the basics of programming TI's SR-52 and SR-56 magnetic-card and key-programmable calculators. "They'll now be able to demonstrate sample programs—such as income-tax preparation—to customers on the calculators," Varner points out.

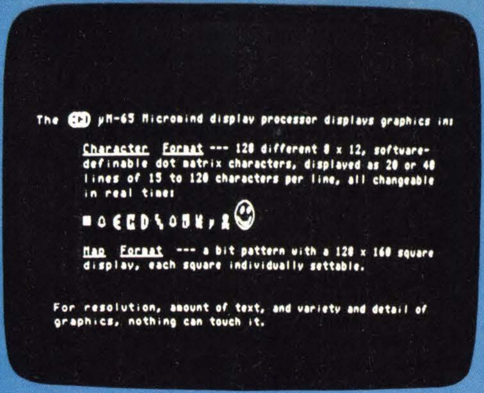
Foley's, in turn, is kicking off the program this week with lunchtime brown-bag and evening seminars on calculator programming, open to the public and taught by TI staff. Beginning next month, each programmable calculator purchased at Foley's comes with a coupon redeemable for a $10 or $15 videotape-and-workbook course at TI's learning center. "And skeptics can take the course first and then deduct its cost from the price of the calculator," Varner adds.

The courses—one for each TI programmable calculator—take the user through programming basics, calculator features, applications programs, and writing programs for personal use. Besides the videotaped courses, TI will have an on-site tutor and direct phone lines to Dallas engineers for question-and-answer sessions.

Looking at Europe. "If these four centers work out the way we plan, we hope to open up to 16 more in 1978," Varner says, "and we may have one operating in Europe by the end of this year."

Besides videotape courses, TI has added one- and two-day seminars with stand-up lectures to teach nonelectronic courses, such as time management, and fundamental supervisory training. The firm is also working with producers of educational videotapes to offer other managerial courses. "We're trying out the nonelectronic material to pay the overhead of the center until we get up to speed, and to get managers into the center to show them what's available," Varner says. □

Calculating answers. Students at a TI Learning Resource Center buckle down to their books and CRTs. The Texas semiconductor maker plans to add several more centers during 1977.



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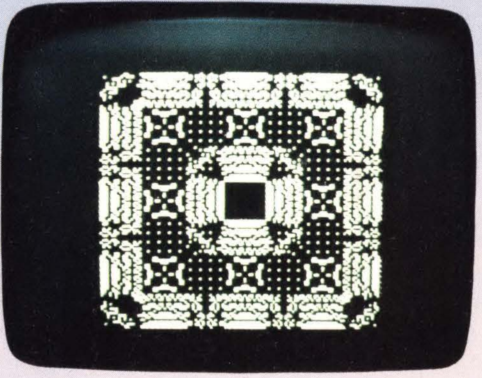

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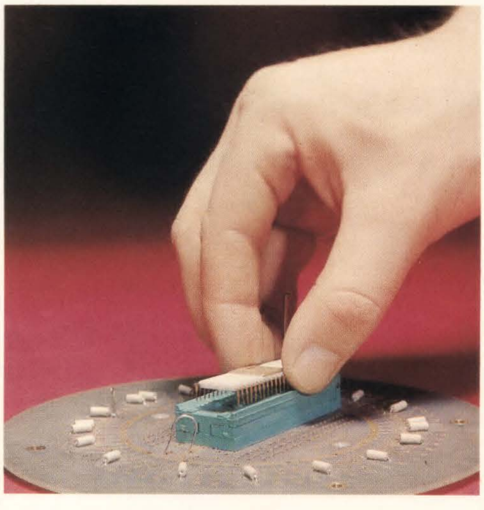

At Tektronix, new product designers team up with specialists in IC technology and testing known as Component Evaluation Engineers. Using their combined expertise, the team compiles information on the devices that seem to fit the application and then narrow the list to a few good candidates. Now, Component Evaluation Engineers begin their most important function; thoroughly evaluating the performance and reliability of each candidate device.

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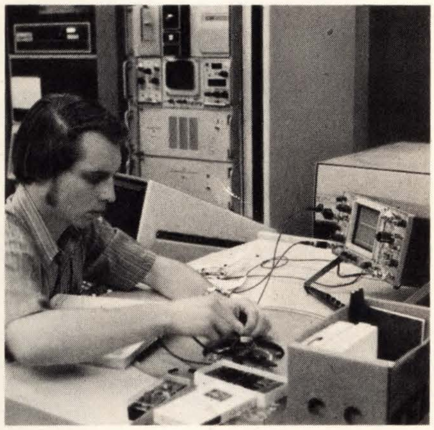

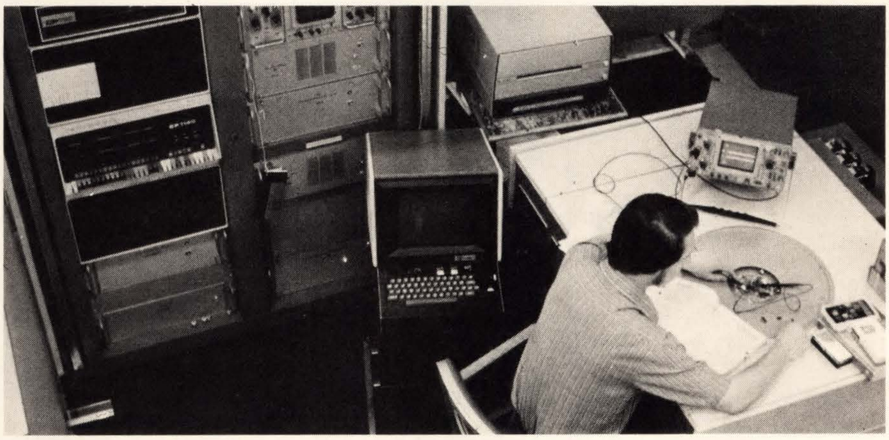

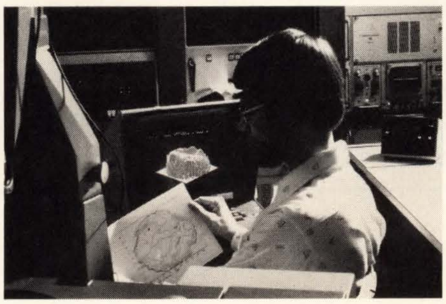

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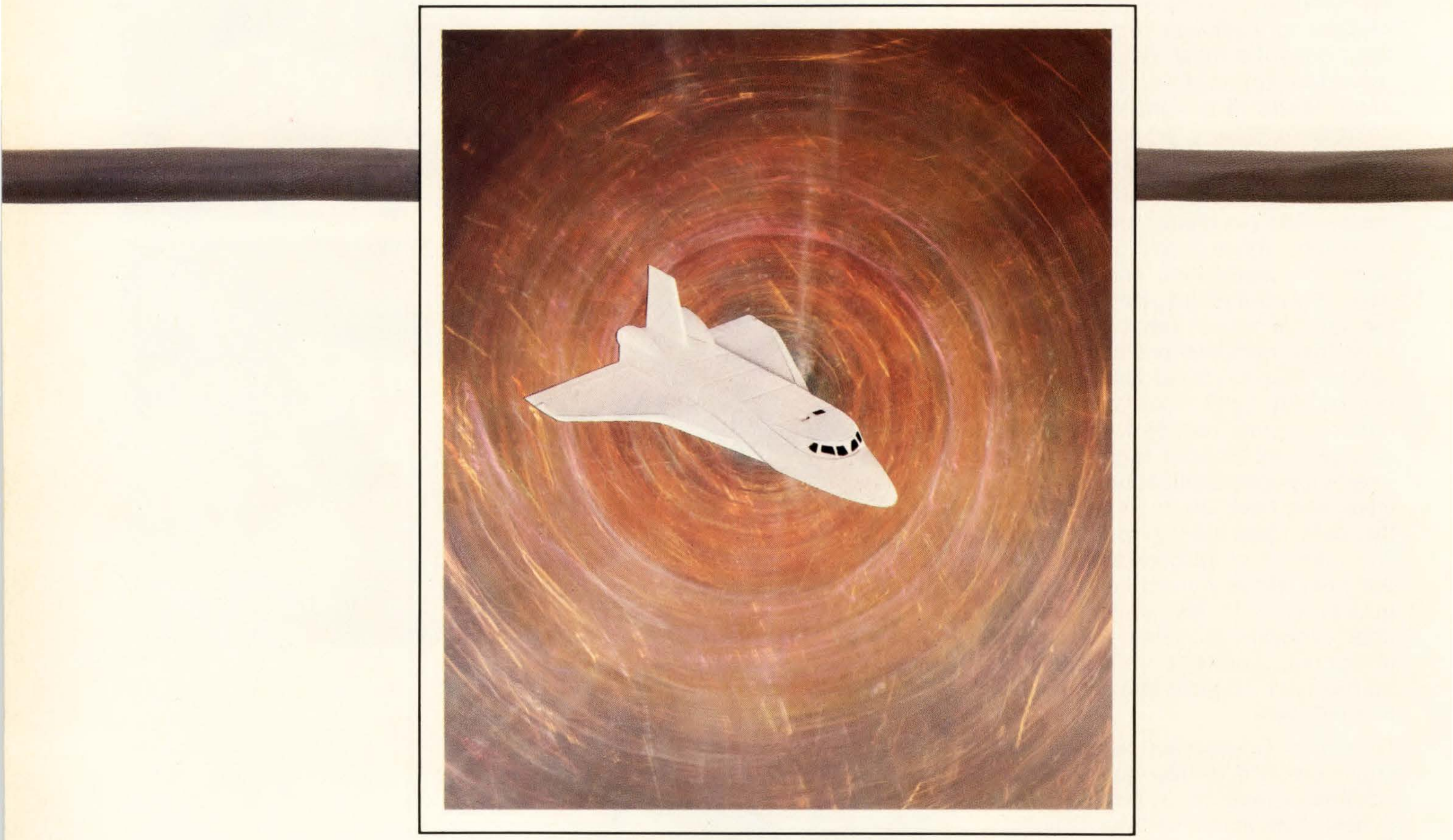

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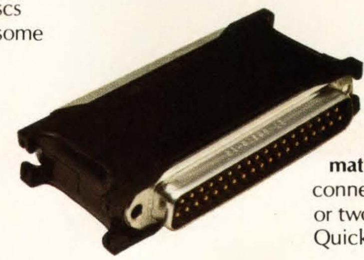

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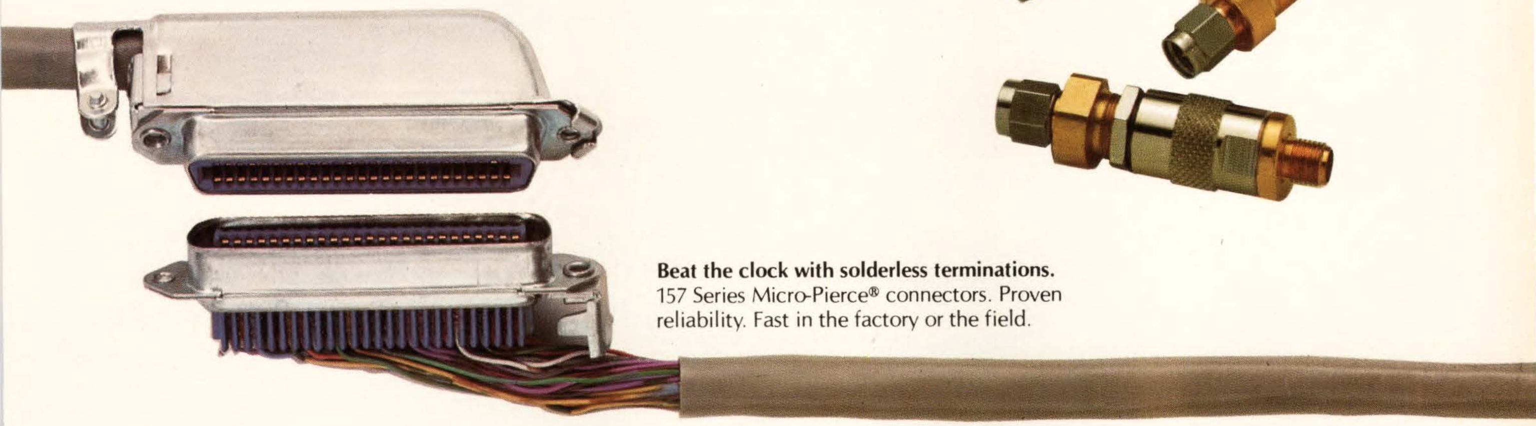

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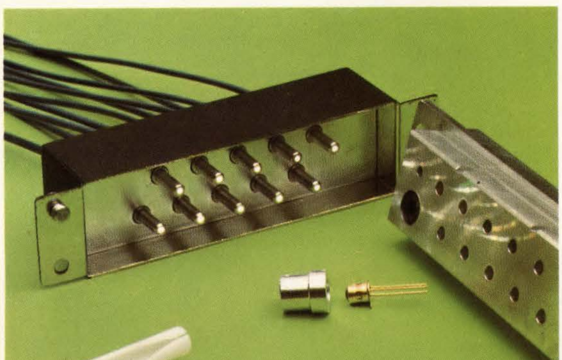

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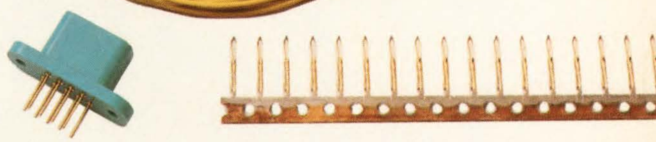

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Automatic standby	X		X
Low power dissipation	X		X
High performance speeds	X	X	X
Direct TTL compatibility		X	X
On chip latches	X		X
Minimal support circuitry		X	X
Battery back-up mode		X	X

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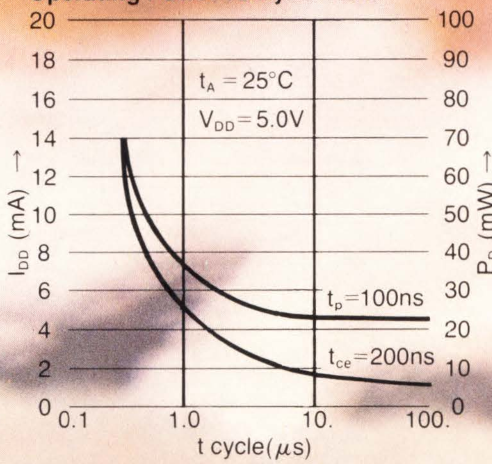

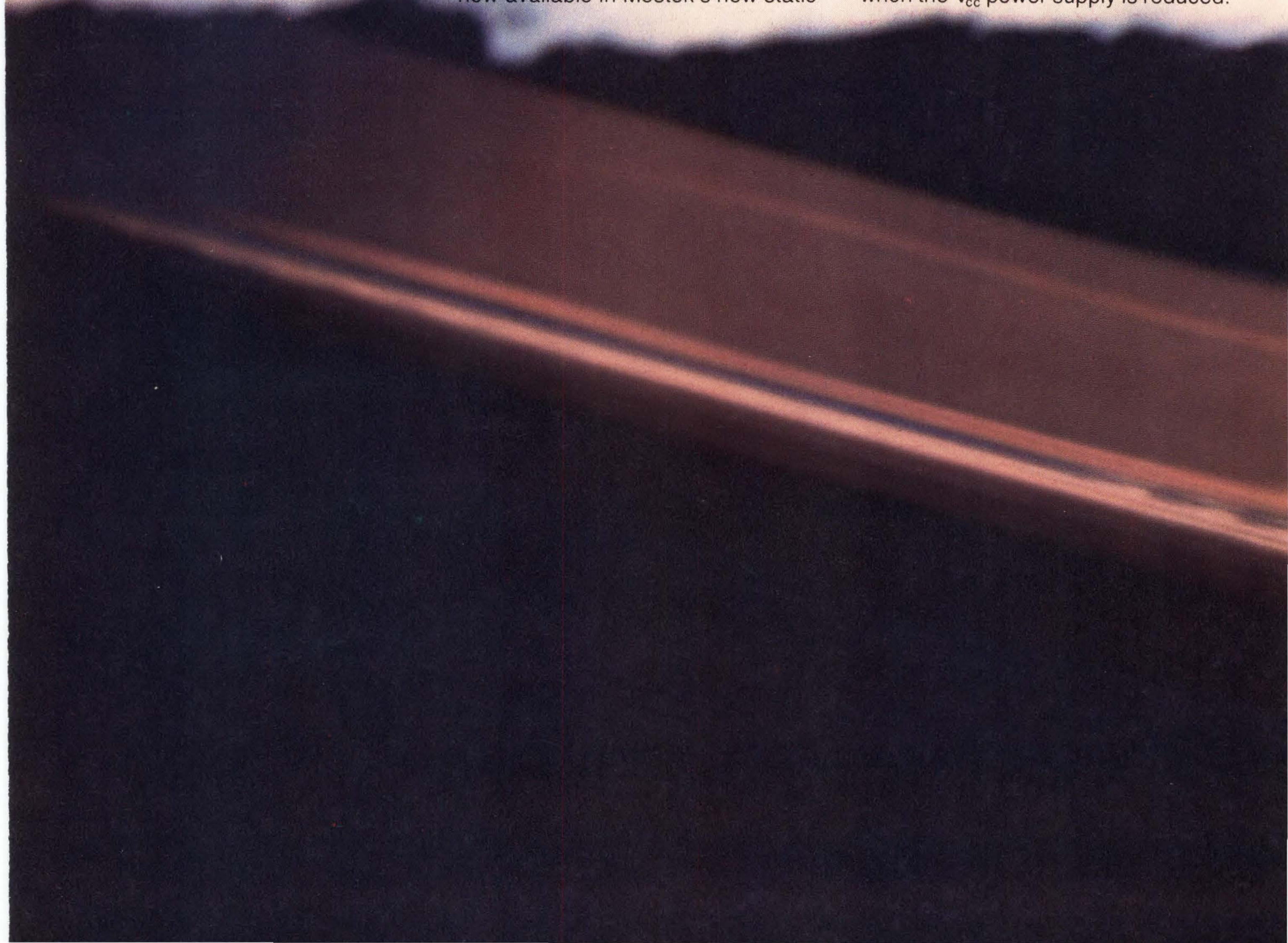

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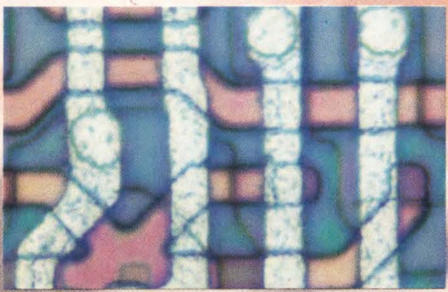

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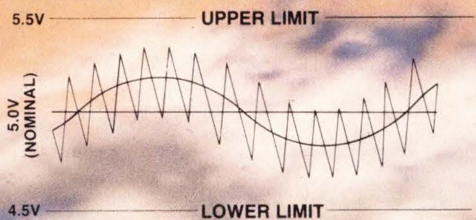

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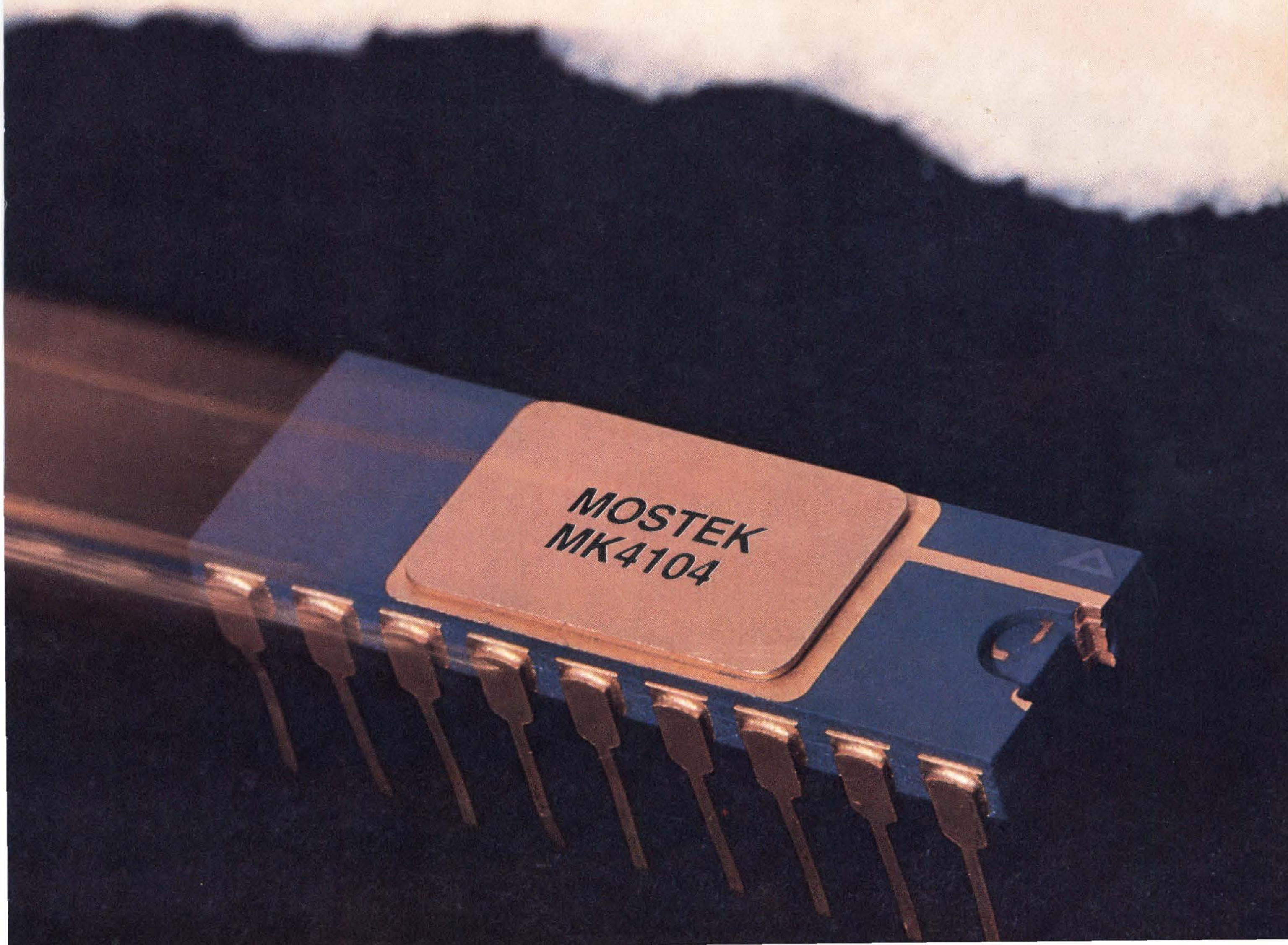

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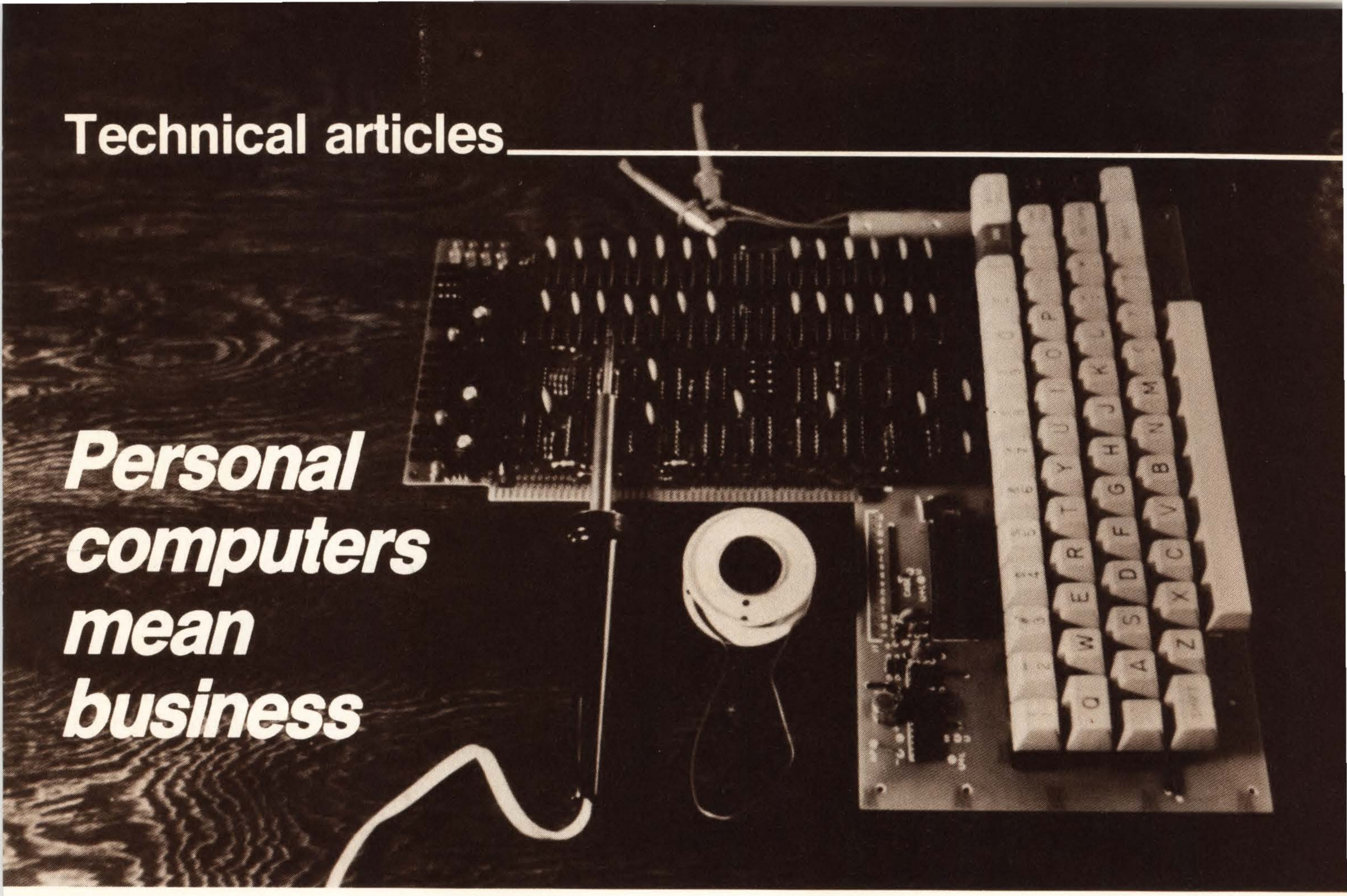


by Lawrence Curran, *Senior Editor*

More and more homes and even small businesses are putting out a welcome mat for the personal computer. The first computer designed specifically for the hobbyist emerged little more than two years ago and to everyone's surprise triggered the development of an entire new industry, complete with a crop of new small companies, retail outlets, trade shows, and magazines.

Just where the appeal of the personal computer lies is still something of a mystery. Some believe it caters mainly to the desire for more sophisticated video games, others stress its educational uses or its utility for handling financial and domestic chores. Already a few observers are speculating on the eventual rise of a mass market, with \$300 black boxes reaching tens of millions of consumers through department stores.

Present products, though, appeal mainly to the technically minded who are prepared to make a larger initial outlay: \$1,500 to \$3,000 for a utilitarian machine or something under \$1,000 for a hobby computer. Total sales last year neared \$10 million—a figure that by 1981 could approach \$60 million for mainframes alone, according to consulting company Venture Development Corp. of Wellesley, Mass.

Technological origin of all the excitement is of course the microprocessor. Some of the systems in private use are general-purpose microprocessor-based machines aimed at industrial or commercial users but low enough in cost—a few thousands of dollars—to appeal to some home users as well. Others are the usually one-board evaluation kits sold by microprocessor manufacturers for a basic \$100 to \$400 to promote their product among system designers but also being grabbed for private use through distributors. But many are kits made up of several circuit boards (and maybe a chassis, motherboard, cabinet, and terminal gear, too). These are sold, assembled or unassembled, mainly through computer-hobbyist stores.

In most kits, the microprocessor on the central processing board is an 8-bit device. Often the read-only memory that holds the computer's microcoded instructions also includes a monitor, to help with information input. The random-access memory varies from less than 1 to 8 kilobytes in size, though systems can generally be expanded to address 65 kilobytes (contrast the megabyte capacity of minicomputers).

As for programming, the simpler systems must be set up with machine language. Others include assemblers. But most suppliers are pushing Basic or some variant of that higher-level language. Program entry may be very simple, through switches or a 16-key keypad, or from a paper-tape unit or cassette recorder. Output is often on a light-emitting-diode display of hexadecimal digits or on a specially adapted television set.

Computer kits and evaluation boards appeal to two categories of user—the inveterate kit builder, for whom the assembly step is half the fun and utility a secondary consideration, and the electronics engineer or software sophisticate, who wants the system to do useful work and is willing to do some soldering, wire-wrapping, or extensive programming, though he may prefer an already assembled kit. Then there is a third category—the layman, who just wants a machine that will let him play more and better video games, keep track of personal financial records, or help him run a small business.

Whether, how soon, and how fast this last group will really grow is anybody's guess. A plausible parallel is with citizens' band radio, which boomed only after ham radio had been around for years. Doubt about the outcome is probably what is protecting the small companies that manufacture personal computers from serious onslaught by established microprocessor manufacturers, video-games suppliers, and even minicomputer makers. Even so, the threat is enough to have produced undoubtedly accurate predictions of shakeouts or consolidations among the newcomers, who are often underfinanced.

Others who stand to profit from the new industry are peripheral manufacturers, software suppliers, semiconductor distributors, and the host of new hobby-computer stores, which sometimes assemble and service equipment as well as sell it. Also available through these stores is a mushrooming library of technical books, which their readers may supplement with "how to" information gleaned from some two dozen specialized magazines and newsletters or through attendance at one of nearly 100 computer clubs.

Trade shows are springing up, too, and in June the National Computer Conference will give official recognition to the phenomenon. Its 1977 program will include a personal computing exposition, two whole days of sessions, and a computer-club congress.

Learning system. Seated at terminal of a Baby! I computer from STM Systems Inc., a teacher changes a Basic program to help a child learn multiplication tables. Computer is portable.

Hobby-computer makers supply a widening public

The company that really got the personal-computer business going is MITS Inc., Albuquerque, N.M. Computers had been put together at home before, of course, with microprocessor chip sets or single-board computers. But MITS' introduction of its Altair 8800 computer kit in January 1975 is the watershed from which a definable market flowed—$6 million of it last year in sales to MITS alone.

By now at least 50 more companies have started supplying hardware—both central processors and peripherals—to the private individual. Scattered throughout the country, they have names like Apple Computer Co., the Digital Group, Logical Services Inc., and Ohio Scientific Instruments. Significantly, Heath Co., the biggest kitmaker of all, is not yet among them, though there are unconfirmed but strong rumors that later this year it will offer kits based on the LSI-11 chip set made by minicomputer manufacturer Digital Equipment Corp.

But that may be the closest a minicomputer maker may come for some time to tangling with personal machines. Eventually, of course, this kind of firm might become very interested in attracting users like small businessmen with a small computer that they could upgrade later to a $20,000 minicomputer.

Closer competition

More immediate pressure on the young companies is being felt from the big semiconductor manufacturers, whose microprocessor evaluation kits are widely available from distributors. The possibility here is that as personal computers take off, firms like Intel or Motorola or Fairchild will integrate upwards, preventing the kit companies from expanding out of the hobbyist area into the commercial and consumer world. Indeed a move in this direction may already have been made by Commodore International Ltd., which could be planning to combine its merchandising expertise in the consumer calculator field with the microprocessor know-how of its recent acquisition, MOS Technology.

Awareness of this pressure is widespread among the personal-computer companies, but reactions vary. "We know the ultimate market will be a packaged, high-volume, low-cost consumer product," says Kerry Berland, marketing vice president of kit-maker Martin Research Inc. in Chicago, "and we'd like some of that market, but we have serious doubts that anyone who doesn't control the semiconductor process will make it there. So to survive we'll go to the hobbyist." Also among those aiming just at hobbyists are California companies IMS Associates Inc. of San Leandro, Polymorphic Systems of Goleta, and Processor Technology of Emeryville.

Others are broadening their base into the gap between personal systems and minicomputers, producing kits that can add enough extra memory, peripherals, and software to cope with small commercial and industrial applications. MITS is doing this, as are California's Cromemco in Mountain View and Gnat Computers of San Diego and New Jersey's Quay Corp. in Freehold and Technical Design Laboratories in Princeton, not to mention STM Systems in Mont Vernon, N.H. Moving in the reverse direction are Wave Mate Corp., Gardena, Calif., and Electronic Tool Co. in nearby Hawthorne, both of which started out in low-cost general-purpose industrial computers and are now attracting home users as well.

One or two are even daring to approach the nontechnical consumer. A Cambridge, Mass., firm, ECD Corp., sells a home computer called MicroMind that among its other talents can run games on a home television set.

Strictly for pleasure

The basic hardware offered to each of these three categories of customers is not so very different. In fact, the only difference Arnold Karush, IMS Associates director of marketing, sees between home computers and commercial/industrial models is that "the former is low-cost enough to be personally affordable."

IMS Associates, believed to be MITS' nearest competitor, is not yet taking MITS' public stance that it is interested in the small-business market. Instead, Karush believes home computers will be mainly devoted to video games, at least for the near future. The company began as a consulting firm five years ago, got a contract to design a computer, and decided to market its own, which it did with the first IMSAI 8080 a little more than a year ago. The machine, incidentally, uses the S-100 bus designed by MITS for its Altair 8800 and emerging now as the standard bus system in its field.

The $699 basic kit ($931 assembled) includes a logic and central-processing-unit board, 1,024 bytes of random-access memory, a front panel, and a 22-slot metal chassis. But Karush says a total system will cost well over $1,000, probably requiring another board with 4 kilobytes of memory ($139), a multiple input/output board ($195), and either the Lear-Siegler ADM-3 black-and-white video display with keyboard ($1,295) or a video interface board ($200) that connects to a home television set.

IMS Associates has also begun a franchised retail outlet chain—called Computer Shack—which Karush hopes will grow to 100 stores by October, probably selling 80% kits and 20% assembled hardware. According to Kilobaud, a publication serving the hobby field, more than 1,200 IMSAI machines have been shipped to hobbyists alone, and the formidable grapevine tuned in to personal computers has the company tabbed as an aggressive competitor with a quality product.

Processor Technology, Emeryville, Calif., introduced its 8080-based Sol line in April 1975. President Gary Ingram says the company plans to stay with the hobbyist, confident that smaller firms like his will be the only ones able to meet the after-sale needs of the user. Dealers say the Sol-20 kit is one of their popular sellers, providing just about everything but a display. It sells for $995 ($1,495 assembled), and its Basic 5 software is free, along with a lunar landing game.

Service is important. "Computer doctor" George Tate checks out ailing system at hobbyist store Computer Mart. His fee ranges from $75 for a board diagnosis to $500 for a system "cure."

Also still dedicated to the personal or hobby user is Polymorphic Systems, which sold only component boards for microcomputers before introducing its Poly-88 last summer. The 8080-based kit, which also uses the S-100 bus carries a $595 price tag.

Martin Research Inc., too, is after "the guy who wants to get his hands on," says Berland. His company's more recent machines are the MIKE 3, an 8080-based system that is sold in three-board ($395) and four-board ($495) versions, and a Z-80-based three-board system, the MIKE 8, introduced earlier this year. The latter sells for $495 and includes the CPU board, a console board with a calculator-type keyboard and six decoded LED digits and a programmable-ROM programming board. Additional memory and peripheral-interface boards are optional extras. Martin Research sells only a minimal amount of programming.

Also for profit

In contrast to this group, MITS is talking now about going after small businesses with systems carrying price tags as high as $14,000, which would put it in competition with such portable computers as IBM's 5100. About 80% of the 8,000-plus Altairs shipped through late 1976 went to hobbyists, but a MITS source says that portion of the business is leveling off as the company focuses more attention on small businesses. "We see the small-business market as the biggest," this source says, defining the personal-computer market as "people who never dreamed they could own a computer."

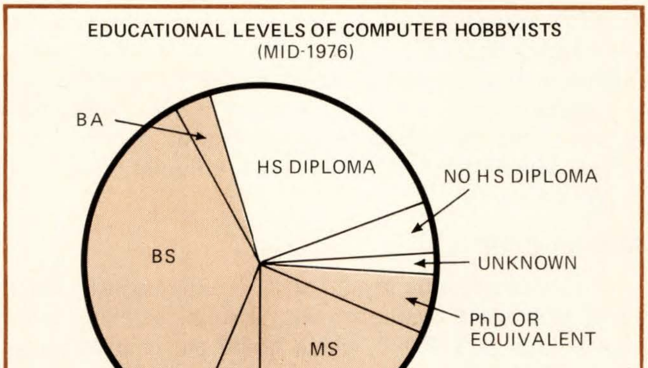
MITS has established a subsidiary to supply Altair users with software initially directed to the small-business-system applications. The first of these range in price from $1,200 to $2,500 and include a general ledger package, payroll, receivables and payables, inventory management, and word-processing package. As a result, the company is projecting a sales jump to $12.8 million this year. It is to be acquired next month by Pertec Computer Corp., the Los Angeles-based company, which will presumably provide financial stability and manufacturing expertise.

Cromemco, too, is beginning to develop software for business applications, though till recently, according to marketing manager Alice Ahlgren, the firm has been largely hardware-oriented. The company sells two microcomputers and a variety of peripherals. The older Z-1 system, built with Zilog Microcomputer's 8-bit Z-80 microprocessor, is a fully assembled $2,496 development system; the newer Z-2, at $595 in kit form or $995 assembled and tested, also uses the Z-80 board. About 60% of Cromemco's systems go to hobby stores, the rest to industrial users.

Quay Corp. in New Jersey is working both sides of the street by offering kits and finished hardware for hobbyist and OEM microcomputer systems. The 80AI Z-80-based personal system is compatible with the S-100 bus "because of the many peripherals and memories available to play on that bus," says Dick Maly, marketing vice president. But the company also has a system called 80MPS, which offers the OEM more memory than the personal computer and sells for $695 assembled and tested. Quay's personal computer is priced in kit form at $450, or $600 assembled.

New Jersey's Technical Design Laboratories also sells a Z-80-based microcomputer, the ZPU, for $269 as a kit or $325 assembled. The company is planning several peripherals, and the ZPU is sold to home as well as commercial users. The only difference is in the software.

An educated public. Educational levels of users of personal computers are high. Of the group canvassed by Venture Development Corp., almost 70% had bachelor degrees or higher, with a third of their number holding masters' degrees.



The Baby! I from the very new STM Systems Inc. is still in its infancy. STM has sold some of its Baby units, but is only now gearing up for production runs and soliciting dealers. Housed in an attaché case, Baby! I includes a 62-key typewriter-like keyboard, the 6502 microprocessor board and 4 kilobytes of memory, a 1,024-byte ROM monitor, and an audio-cassette interface. With the 9-inch-screen Panasonic monitor, that basic package sells for $1,170. Don Gunter, STM's vice president for marketing, says a total of 32 kilobytes of memory can be put in the 6502 set for less than $1,000. The Shugart minifloppy-disk drive, soon to be added, will provide 90 more kilobytes of formatted storage for a price of $850.

For profit and pleasure

The expansion in personal computers is in the other direction as well—from the industrial market to the consumer. California's Wave Mate got started in business to address the industrial market with a small computer, then took advantage of the Motorola 6800 in a wire-wrapped industrial-quality system—the $2,850 Jupiter IIC—that it is selling to home users as well.

Nearby, Electronic Tool Co. has experienced something similar. The company entered the small-computer business with general-purpose, low-cost systems for commercial-industrial use in the summer of 1975, only to find home users buying their hardware, too. Not only will ETC's Etcetera system accommodate the Intel's 8080A, Motorola's 6800, MOS Technology's 6502, or Fairchild's F8 as the main processor, but it also lets one operate as subordinate to the other. The company has four standard ETC-1000 system configurations, all assembled. They range in price from $830 for the beginner to a small-business system at $7,197.

As for products with direct consumer appeal, ECD Corp.'s MicroMind, the home computer that plugs into a TV set's antenna leads, loads its game programs into a MOS Technology 6512A microprocessor from a cassette recorder [*Electronics*, Feb. 17, p. 38]. Its $987 price for a fully assembled, encased unit includes an 80-key ASCII keyboard, the CPU board with 8 kilobytes of memory, and an I/O board that holds the power supply.

MicroMind's Basic language allows it to be used as an intelligent terminal, for computation, remote job entry or to run games, three of which are offered with the system. ECD already has more than 200 orders for it.

Possibly unaware of MicroMind's existence, Apple Computer Inc.'s Steven Jobs sees the hobbyist as "a latent home user, but no product exists for him to plop into his living room." Jobs is product manager at the Palo Alto, Calif., firm which last year sold 150 of its Apple I microcomputer boards built around the 6502 from MOS Technology. The $666 board also includes a PROM monitor, 4 kilobytes of dynamic RAM, video interface and power supply.

Apple II, which has the home-user grapevine buzzing, is scheduled for introduction next month. It will have up to 48 kilobytes of RAM on the same board and will be the first personal computer to include the Mostek 16,384-bit

RAM. An assembled but unencased board version will sell for $600. The company is at work on a music synthesizer to sell for about $200 as a peripheral for Apple II.

Focus on programmability

A good many hardware companies appear to bother little about the ease of programming their products—though users worry about it a lot. One of the exceptions is 12-year-old Southwest Technical Products of San Antonio, Texas. Before November 1975 the company sold kits of parts to be used in projects published in Popular Electronics magazine. It attributes much of its growth since then—to $4 million sales—to its introduction of the SWTPC 6800 computer system.

Motorola's 6800 8-bit microprocessor was chosen for this system, says Southwest president Daniel Meyer, because it eases software writing for the user. But recognizing that entering programs in machine code "is a little tedious," says Meyer, and that Basic has become the most widely used personal-computer language, Southwest also provides Basic as a high-level language. The $345 hardware kit for the SWTPC 6800 includes everything required for a system except an ASCII terminal.

Semiconductor manufacturers hesitate to commit themselves

Not yet competing directly with all these small systems companies, only one of which (MITS) expects to do more than $10 million of business this year, are all the multimillion-dollar semiconductor biggies. Still, National, RCA, MOS Technology, and GI, as well as Fairchild, Motorola, Signetics, AMI, TI, and Intel, have sales of single-board microcomputers that are of some consequence in the personal computer market. But it is difficult to get a handle on numbers. Sales are often through distributors, with the chief among them being Cramer Electronics, Hamilton/Avnet, and Semiconductor Specialists. Cramer itself offers "Cramerkits," specially tailored as single-board evaluation kits using the 8080, 6800, RCA's Cosmac unit, and TI's 9900.

National Semiconductor Corp. is addressing the personal computer market downward via the microcomputer path and upward through its consumer operation's programmable video games.

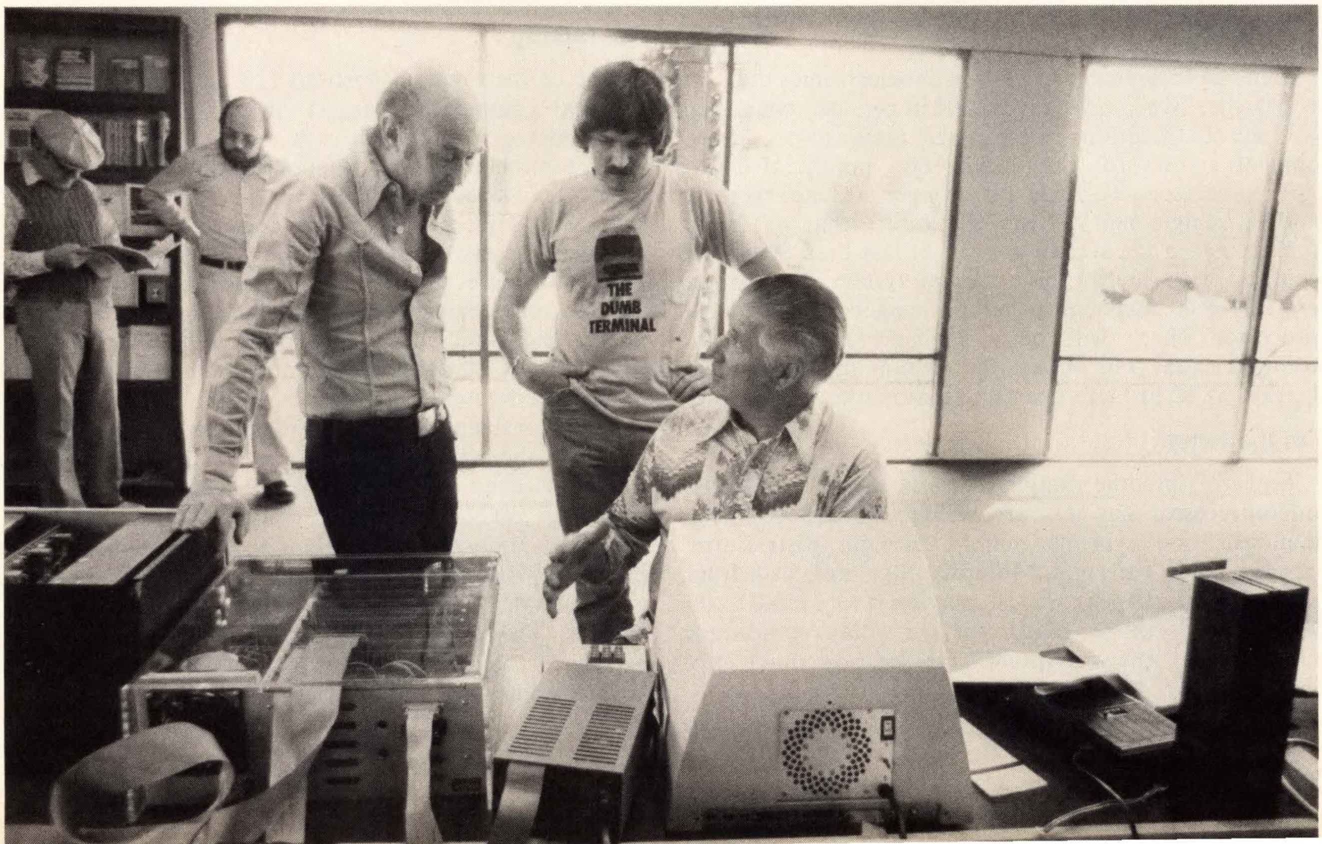
"I think the personal-computing market caught many of us flatfooted," says Phil Roybal, microprocessor marketing manager at National. "We've seen the numbers, made a few projections of our own, and we like what we see, but we're not quite sure how to approach it, and when. Be sure of one thing, all of us, all the semiconductor houses and microprocessor makers, will be in it one way or another."

A double thrust

National has also been making a serious effort to reach the non-electronics engineers with its 8-bit SC/MP microprocessors. The company has designed a high-level computer language specifically for SC/MP called NIBL, for national industrial basic language. Consisting of a simple, limited vocabulary of written English words in a rigidly defined grammar, NIBL has been placed in the public domain and is available free of charge. "We want to make SC/MP as easy as is imaginable to use," says Roybal.

While National's microprocessor group is focusing its

On display. A complete personal-computer system built around an IMS Associates 8080 machine is being shown here to a customer by Alan Tarsky at his store, Computer Mart, in Orange, Calif.



efforts on the hobbyist, the Santa Clara, Calif., company's consumer products division is looking at the consumer who wants a completely packaged low-cost personal computer, oriented toward entertainment, education, and simple bookkeeping tasks. Right now, National is bringing out an 8080-based programmable game terminal with many of the elements of full computer architecture, with options for add-on keyboards and game software in tape cassettes.

RCA Corp.'s Solid State division in Somerville, N.J., has two products using Basic language that are applicable to the home-computer market, although both are primarily design aids for the industrial market, where RCA's CDP 1802 microprocessor finds application. There is a $249 evaluation kit that includes 256 bytes of RAM on a board that will handle up to 4 kilobytes. The unit also offers terminal interfacing, which is handy because RCA plans to come out in May or June with a handheld terminal with a $150 teletypewriter-like interface, says William Dennehy, microprocessor product line manager.

RCA also offers the Microtutor, a completely assembled elementary computer that is programmed with switches. Priced at $349, it comes with a self-teaching manual and is "truly a beginner's microcomputer," says Dennehy. Coming shortly is Microtutor II, a new version that will do more but cost less.

MOS Technology's KIM-1 is a complete one-board evaluation system for the 6502. It sells for $245 and though Rick Simpson, manager of product support, claims KIM-1 is easy for a hobbyist to start with, he expects only 20% of the more than 9,000 units ordered to end up as personal computers.

The picture will change, though, with the introduction of a system, called PET for personal electronic transactions, packaged in a plastic case and looking like a conventional TV terminal. "Since it's aimed at the consumer market," notes Simpson, it will have a typewriter-style keyboard and a place to plug in audio cassettes. PET will be distributed at retail stores for a price of $495.

General Instrument Corp.'s Microelectronics division, Hicksville, N.Y., also found itself in personal computers through its Gimini microcomputer, designed as a development system for the firm's 1600 family of 16-bit microprocessors. To achieve a stronger presence there, GI is developing a new system, Gimini Jr., that will be on the market in the second quarter at less than $1,000, in contrast with $3,000 for a Gimini system. The Gimini Jr., says Ron Stephens, general manager for GI's microprocessor line, "will be a high-performance home computer that will outsell the Gimini in the hobbyist market by 10 to 1. It's geared to that market."

On the fence

Some of the other major forces in the semiconductor microprocessor business are selling evaluation kits or demonstration systems mainly through distributors. These include Fairchild, Motorola, Signetics, AMI, Intel, and TI. Some of them are also playing it very close to the vest about future plans for personal computers. Undoubtedly, they're watching to see how much of a market evolves—and when.

Fairchild Semiconductor sells its assembled kit 1-A for $185 through distributors. The F8-based computer is being acquired by engineers for their personal use. "To that extent," says Donald D. Winstead, director of marketing for the Microsystems division, "we're in the hobbyist market."

Motorola Semiconductor is participating in personal computing with two kits, in addition to selling its 6800 processor and other chips to what it regards as a growing market in these systems. The MEK6800D-2, which the company introduced in February, is a two-board kit selling through distributors for $235 in quantity. The Educator 2 is just out this month and sells for $169.95 through retail computer outlets. Both kits are upwardly expandable and compatible with Motorola's Exorcisor development system.

At Signetics, in Sunnyvale, Calif., George Vaschel, manager of product support, sees the hobby-computer market alone reaching $15 million to $20 million by 1980 and says the company is "keeping a keen eye" on that part of the market. The Signetics 2650 kit, which includes RAM, PROM and interface circuits in its $155 price, is used in some video games. Those games are the vehicle Vaschel sees "for getting computers into the home," envisioning the day when the owner of a microprocessor-based game will buy a cassette that will also let him program the system for bookkeeping or for recipe storage.

Nearby in Santa Clara, AMI has recently completed an internal evaluation of whether to enter the hobbyist or home-computer fray. One of the conclusions, says Rob Pawsner, product manager for development systems, is that the hobbyist market is risky. Another is that the home market will be split into microprocessor-controlled appliances and general-purpose control systems. Meanwhile, AMI's 6800 MPS evaluation boards drift into use as personal computers through distributor sales. There are five such kits, ranging in price from $133 to $765.

Not talking

One of the biggest questions is what Intel will do in personal computers. Rumors abound that the Santa Clara microprocessor pioneer is about to enter the hobby market in a big way, but Intel officials are not commenting. "Obviously we're interested in home computers," says Don Bryson, strategic marketing manager in the microcomputer division. "We're interested in any market that uses Intel parts," he adds, but will amplify on that only enough to say it plans to expand in the hobby field. Intel is already involved in home computers with its SDK-80 design development kits and the MDS-80 microcomputer development system.

Texas Instruments, while it has nothing directed clearly at the personal-computer market, will announce a single-board microcomputer in the second quarter that could find use among do-it-yourselfers. Called the EVM-9900, it is an assembled evaluation board using the 16-bit TMS-9900 microprocessor that also includes erasable PROM, RAM, and RS-232 and teletypewriter interface circuits. The price will be about $400, with optional extras including a low-cost keyboard and display, keyboard interface and resident assembler.

Personal-computer owners brim with ideas for applications

Personal computers appeal to farmers, educators, music lovers, fuel-bill trimmers, household-chore haters, video-game players, but above all to people interested in learning more about programming. According to a survey taken by hobby-computer magazine BYTE, software development ranks first among the applications for which its readers use their machines, with interactive keyboard games second and interactive graphics third.

Swartz: software 'junkie'

"I'm a class-A software junkie—I collect code," acknowledges 26-year-old Robert Swartz. "Whenever a new piece of software comes out, I'll enter it, get it up and running, and fiddle with it." He works for Embosograph Co., his family's firm that manufactures point-of-sale displays in Chicago.

Swartz got hooked in college. He says, "There's nothing more engrossing than an interactive computer, and until now, that's only been available to people who get on time-sharing systems." Getting started three years ago was hard, he admits. "I first built a couple of clocks and a power supply, then I started a Mod-8," a development system from the now-defunct Microsystems International Ltd., he says. "At that time there was only one way to get parts, and that was to lie to distributors." Microsystems International promised that the 8008-based Mod-8 would be convertible upward to an 8080, "but MIL went broke, and I had to build my own conversion board," Swartz explains.

After building his Mod-8 system, Swartz put together a package on how to build, debug, and program it and sold copies for $20 each. With the proceeds he bought his present system, an 8080 CPU with dual floppy-disk drives, disk operating system, Diablo printer, teletypewriter, and CRT. It's worth "in the neighborhood of $10,000 today."

Chamberlain: farmer

Calculating the return on investment per acre on a farm: that job makes Thomas Chamberlain's Altair 8800 a small-business system. Besides being scheduling officer for the University of Massachusetts, Amherst, Mass., Chamberlain operates a farm in Ohio, which he owns with a brother and sister. Having a degree in systems analysis from New York University, the 60-year-old retired Army colonel decided to apply his knowledge to running the farm.

His computer is an Altair 8800. With it, he uses 32 kilobytes of memory, a floppy disk, teletypewriter and teletypewriter controller, plus a hardware disk loader and Basic as the language. Chamberlain taught himself how to program the machine, with the goal of improving the farm's profits by 20%.

Chamberlain estimates he has $6,500 in the Altair system, "and while I consider running the farm an avocation, I bought the computer as an investment." He is developing a data base that could include such things as what fertilizer to use to give the best yield per acre for a given crop. The system would also contain cyclical weather data and price histories on the commodities of interest from planting time to market time. He puts his true costs into the computer, along with commodities and weather histories, and the computer helps him decide when to sell or not sell.

Blaney: music-maker

It was to generate synthesized music that Robin Blaney two years ago decided to build a low-cost computer system—though as a 21-year-old college student, he has not yet been able to buy a synthesizer. "The $500 computer is a beautiful sell, but you have to buy so much more to have anything that works," he comments. "I have $2,000 to $3,000 invested, and I have scrounged for used equipment and bargains."

Blaney bought his IMSAI kit from Computer Mart, Orange, Calif., after shopping most computer-hobbyist outlets in the Los Angeles area. Its pledge of after-sale service was the convincer, he recalls.

At his home in Woodland Hills, Calif., Blaney also has a Lear Seigler "Dumb Terminal" built from a kit, Cromemco analog-to-digital interfaces and PROM board, a Tarbell audio cassette, approximately 30 kilobytes of memory, and Polymorphic I/O devices for computer-generated music. The software Blaney wrote in Basic.

To write a song, he punches notes into a plugged-in electronic organ keyboard, which are reproduced by an amplifier and read out on the terminal in real time, while also being stored in memory. Through an electronic synthesizer, however, his system could simulate sounds for any instrument.

Dilks: games player and teacher

For John Dilks, "the computer will be more important in education than the blackboard in a few years." He uses his system at home with his three children ranging in age from 5 to 12, to play games such as Hangman. He

Music man. Preparing to run a program on his system for generating electronic music, Robin Blaney flips control switches on his IMSAI computer and punches instructions into his Lear-Siegler terminal.

used a variation of Hangman to improve one of the children's spelling radically.

Dilks estimates he has about $2,000 invested in his IMSAI-8080-based system, which includes 14 kilobytes of RAM, 4 kilobytes of PROM, a tape-cassette interface board, and I/O board with two bidirectional ports. There is also a serial port that he uses with an 80-character-by-2-inch video terminal "picked up as junk," and a model 28 teletypewriter used as printer.

A Western Electric installer of electronic switching systems, Dilks also teaches adult educational courses at a Mays Landing, N.J., high school, using an E&L Instrument MMD-1 8080-based system.

Lavallee: fuel-saver

Ron Lavallee insists, "I'm not a computer hobbyist. I put my system together out of necessity." His personal solution to the national energy crisis is a vintage-1920 wood-burning stove—plus a heat-regulating system built around the $99 SC/MP kit from National Semiconductor Corp.

In January, when his neighbors in Hudson, N.H., lowered their thermostats to avoid a second month's gas bill of well over $100, he kept his six-room home at a toasty 75°. His December gas bill for heating, cooking, and hot water was only $29.

"The microprocessor increases the efficiency of a very inefficient stove," says Lavallee, who hauled the wood burner down from the Maine woods and installed it in November, just before the winter cold wave began. "When wood is loaded into the belly of the stove," he explains, "the fire flares up for a short time, then slowly burns down to embers until another log is thrown in. If the air from the stove's flue is regulated, the wood will burn evenly, generating more heat over a longer period."

A thermal sensor in the stove's stack pipe monitors the heat. To maintain the stack temperature within a specified range, the microcomputer periodically checks it, then opens or closes the flue damper via a stepper motor. "When the temperature does not rise to the control range after a certain number of openings, a low-wood alarm is activated," Lavalle continues. "The signal beeps once a minute until the stove is loaded again." He estimates that the computerized wood burner is 10% more efficient on very cold days and about 30% more efficient in above-freezing weather.

An electronics engineer who designs machine control systems for Nashua Corp., Nashua, N.H., Lavallee built his system with odds and ends and a used motor.

Raskin: model-home owner

But the potential of the personal computer is perhaps spelled out most clearly by Jef Raskin. When he finishes building his 1,700-square-foot house in Brisbane, Calif., every room will have an RS-232 port, a parallel bus and coaxial cable strung behind the walls so Raskin can move his Poly-88 system into any room. The house is "designed from the ground up for music and computers," says the 34-year-old bachelor.

A writer, electronics consultant, professional musician, hobby-airplane manufacturer, and photographer, Raskin holds both a master's degree in computer science, which he taught at the university level, and a philosophy degree. His living room creates a feeling of time warp: a 100-year-old organ, used by missionaries on door-to-door recruiting trips, sits next to a computer. In other parts of the room are another organ, a harpischord, an electric piano, bass cello, and a rack of recorders. Raskin plays them all.

Energy saver. By heating his six-room New Hampshire house with a wood-burning stove raised to maximum efficiency by a SC/MP-based controller, Ron Lavallee has cut his monthly gas bill by $100.

Not that the computer controls his life. On the contrary, Raskin uses it to liberate him from mundane duties such as letter writing. The basic machine is a $150 Poly-88 with 48 kilobytes of memory. To it he has added a $3,700 printer, a $50 typewriter keyboard he uses for programming in Basic, an RS-232 interface, a cassette interface, and an interface that allows him to play programs on his home TV set.

Raskin plans to use 4 kilobytes of the memory to control a large $90,000 pipe organ (but which cost him much less after bargaining at a local convent). The concerts he holds there will be "computer-controlled:" the theater-type lighting he is installing will be run by computer; his coffee machine will automatically perk in time for intermission. He is currently developing a program to run his microwave oven. The solar-energy system that will run his house will also power the computer. □

Contributions to this special report came from field editors Bernard Cole, Judith Curtis, Bruce LeBoss, Pamela Leven, and Larry Waller.

A new role for charge-coupled devices: digital signal processing

Operations suited to pipelining are naturals for inherent low-power and high-density attributes of CCDs

by Thomas A. Zimmerman, *TRW Systems Group, Redondo Beach, Calif.*
and David F. Barbe, *Naval Research Laboratory, Washington, D.C.*

□ Charge-coupled devices won their spurs in such analog applications as low-light-level imaging and signal-processing functions. Then they moved on to show the flag in digital memories, with commercial random-access chips boasting capacities as large as 65,536 bits. Now CCDs are ready to advance into an exceptionally promising field: digital signal processing.

This application of charge coupling combines all the desirable features of the digital world—design flexibility, a choice in the degree of accuracy attainable, and potentially low cost—with the inherent low-power and high-density attributes of the CCD. It offers the possibility of combining dense memory arrays and complex digital signal processing on the same chip. This combination can provide greater computing power than is achievable in other technologies.

The table shows why charge coupling is a strong challenger of the other major large-scale-integration technologies. However, there are speed limitations imposed by the charge-transfer principle, which dictate that special techniques such as pipelining must be used to permit a faster speed of operation.

Because of this limitation, CCD technology lends itself better to some functions than others. Functions that are inherently of a streaming nature, such as the fast Fourier transform, are well suited to the pipeline approach. In other digital operations, where the result of one computation must be obtained before the next operation may proceed, a serious penalty in speed must be paid if charge coupling is used.

Nevertheless, digital arrays of charge-coupled devices are now being designed and tested in the laboratory. So far, only 2-word 8-bit adders and 2-word 3-bit multipliers have been fabricated and tested. But under consideration is a single chip containing four 16-by-16 multipliers, three 16-bit adders, and the necessary control gates, inverters, and timing functions to perform the "kernel" operation of the fast Fourier transform. Given the potential advantages of digital CCD chips, the future surely holds promise for LSI processing chips of extraordinary power.

CCD technology

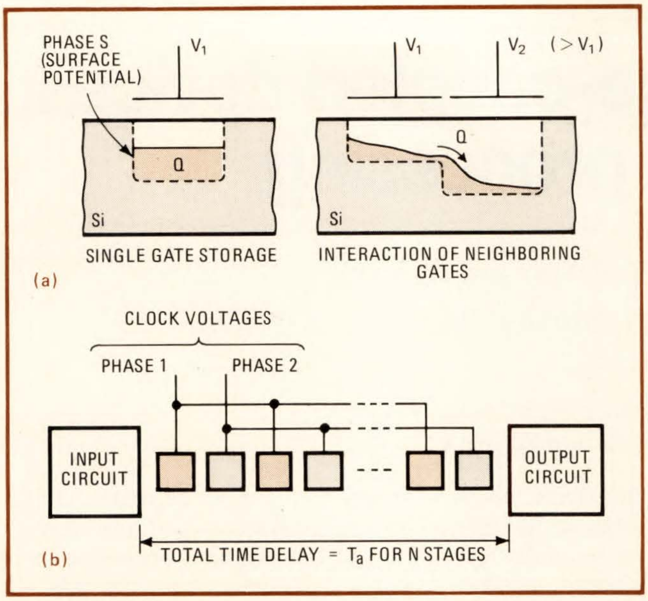
Charge-coupled devices are arrays of metal-oxide-semiconductor capacitors along which charge is transferred. An electrical field creates a region in the semiconductor substrate that acts as a localized potential minimum for mobile carriers of the charge (Fig. 1a). By applying proper voltages to neighboring electrodes, mobile carriers held in a given potential minimum can be

A TECHNOLOGY COMPARISON OF ARRAYS

Technology (1980)	Logic gate		Shift register stage			Type of logic	Chip size (20% yield)
	Speed-power (pJ)	Area (mil²)	Power/bit @ 1 MHz	Area/bit (mil²)	Max. speed (MHz)		
Charge-coupled-device	0.2	2	1 μW	0.5	50	dynamic	250
Triple-diffused VLSI	3	10	100 μW	30	100	static	400
Integrated injection logic	2	10	50 μW	30	5	static	200
Silicon on sapphire CMOS	5	20	100 μW	75	50	static	175

Conclusions

1. For mix of repetitive 80% logic + 20% pipeline memory, CCD advantage at 5 MHz is
   power x18
   area x16
   compared to next best technology (I^2L).
2. Interconnectibility (power, area) degrades more rapidly for CCD than any other technology as circuitry departs from pure arrays to pure random networks.



1. Natural extension. By applying the proper voltages to neighboring electrodes, mobile charge carriers will be transferred to adjacent sites (a). This forms the basic of shift-register operation (b), in which individual charge packets are transferred from input to output.

transferred to an adjacent site. This property lends itself naturally to a shift-register organization (Fig. 1b), where, for example, two-phase clocks can be used to transfer each individual charge packet from the input circuit to the output circuit.

In practice, however, the transfer of charge from one CCD storage site to the next is not 100% efficient. The small amount of charge lost from a packet at each transfer introduces an amplitude and phase effect that depends on the total number of transfers, N, in a given shift register and on the charge-transfer efficiency. These effects are conveniently expressed as a function of N and the fractional charge lost per transfer, ϵ. In most practical shift registers, the $N\epsilon$ product is kept to less than 0.1. In such cases, the overall CCD insertion loss is less than 2 decibels, and phase deviation is less than 3°.

Basic building block

The linear shift register is the simplest CCD. Several useful digital memory structures and organizations have evolved from that basic form.

An early geometry used to increase the density of charge storage is the serpentine channel organization. The CCD channel snakes back and forth across the silicon to maximize the number of memory sites in a given area. Although this type of structure utilizes the silicon better, it is still quite long. Also, transfer inefficiency means that these long shift registers must include signal-charge regenerator circuits to reconstruct the input before it is sent on to the next section of the memory. Use of these circuits poses two problems: the power they require becomes a significant factor in the overall power budget, and their area becomes a significant part of the total chip area.

As the technology has matured, other structures have developed to overcome such limitations. A series-parallel-series (SPS) organization capitalizes on the ability of charge packets to move along two axes, depending on the gate structure controlling them.

This organization accepts data in a serial fashion until the input register is filled. Then one of the controlling electrodes is turned on, and the data shifts in parallel to a set of parallel registers. This shifting occurs within one serial-bit time, and the serial register fills uninterruptedly. After the proper interval, the control electrode again allows the data to pass from the serial register into the set of parallel registers.

This process is repeated, with data shifted along the parallel registers, but at a much lower frequency than in the serial register. The parallel registers operate at a frequency equal to the serial shift frequency divided by the number of bits in the serial register.

To the outside world, the memory appears to run at the faster serial data rate, but internally most of the bits are shifting at the lower parallel rate. Because the power consumed by a CCD is proportional to this shifting frequency, a reduction in power results. This is one of the main advantages of the SPS organization.

Another important plus is the high capacity-to-transfer ratio. The storage capacity is approximately equal to the product of the number of bits in the serial register times the number of bits in any of the parallel registers. However, the number of transfers that any given bit must accomplish as it passes through the register is simply the sum of the number of serial bits and the number of bits in any parallel register. This represents a much higher capacity-to-transfer ratio than the simple shift register of Fig. 1b, where the capacity is equal to the number of transfers.

The larger commercial memory chips to be offered for sale later this year by Fairchild Camera and Instruments Corp., Texas Instruments Inc., and Intel Corp. most likely will be built from series-parallel-series structures. For example, a 65-K chip may well comprise 16 4,096-bit SPS units.

Future systems will need substantial amounts of memory with wide-ranging characteristics reaching beyond existing capabilities, and CCDs appear to fulfill many of the anticipated needs. They are better suited to serial-memory applications requiring large amounts of bulk delay, rather than to random-access applications. Thus high-density digital charge-coupled memories are more suitable for systems requiring large memories.

Logical extension

Memory chips are only the beginning of the CCD foray into the digital world. Simple CCD binary adders and multiplier arrays already exist, and they are the key to implementing LSI chips that can perform much of the local processing on chip.

Performing digital-logic functions with the charge-transfer principle requires interaction with the information contained in charge-coupled shift registers. Such interaction can be accomplished in two ways. One is termed bit-destructive because in the process the original bits lose their individual identities. The other, designated bit-preserving, detects the presence or absence of charge without disturbing the bit stream. This detection controls charge flow in another register.

Generally speaking, any of the schemes used to provide weighted tap points in analog charge-coupled filters can be adapted for use as a nondestructive charge-sensing operation, suitable for bit-preserving logic circuits. In such digital applications, tapping and weighting schemes are relatively easy to implement since the tap values need only be the equivalent of a one or zero.

Although both methods find many applications, there is a significant difference. The bit-preserving method allows many repeated operations on the original data stream, since it is always preserved. But the bit-destructive method can operate only once on any bit stream.

In the basic AND gate implemented with CCD logic in Fig. 2a, the two shift registers A and B are connected to two series-transfer gates. Both gates must be on for minority mobile carriers to reach the gate marked C. In logic symbols:

$$C = A \cdot B = \text{AND}.$$

An OR function can be similarly implemented (Fig. 2b). The controlled transfer gates are in parallel. With the same reasoning, the equation is:

$$C = A + B = \text{OR}.$$

Both schemes are bit-preserving and do not disturb the controlling bit patterns. Bits are simply sensed nondestructively and used as controllers for other registers.

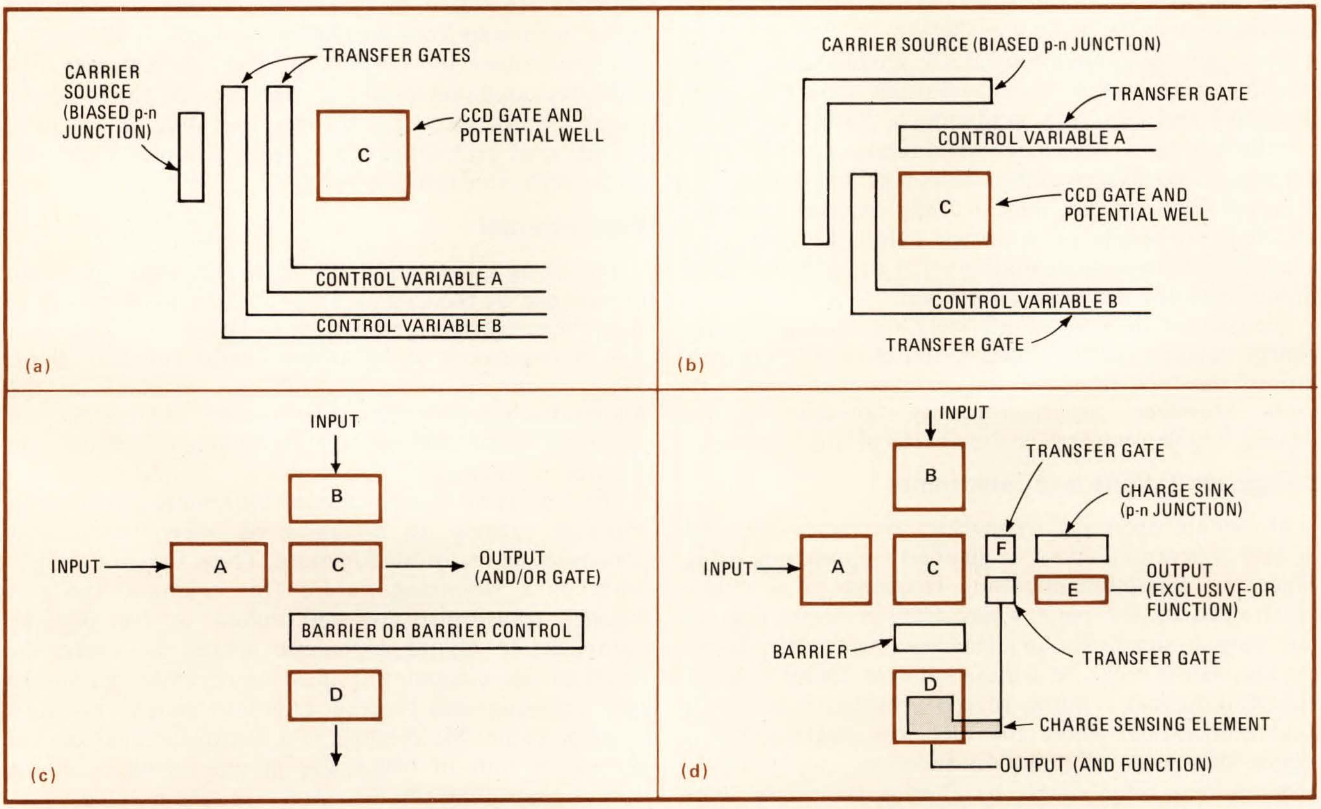
However, there are some useful bit-destructive logic circuits. Providing OR and exclusive-OR gates requires a configuration only slightly more complex. In Fig. 2c, shift registers A and B dump their charge packets directly into the potential well under gate C. Another gate, D, is biased in a mode capable of accepting charge, but it is separated from gate C by a potential barrier that is created by ion implantation or controlled by a separate gate voltage.

In either case, the capacity of the potential wells under gates A, B, C, and D are all equal; therefore, if A and B are filled to capacity, their combined charge packets are more than can be contained under C. The barrier then allows this surplus of charge to flow under D. If only A or B is full of charge, C will be filled exactly and D will remain empty. So C represents an OR function and D an AND function:

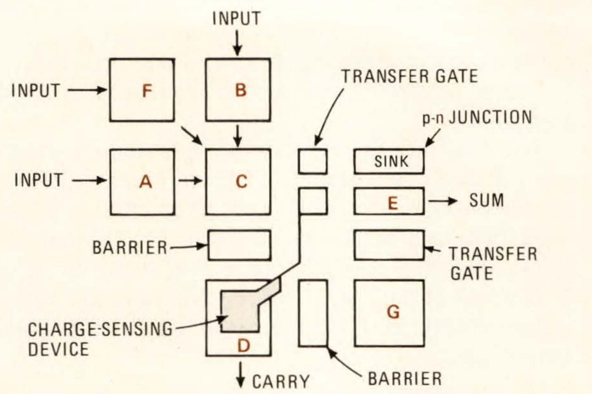
$$C = A + B = \text{OR}$$
$$D = A \cdot B = \text{AND}$$

Carrying the implementation one step further produces an exclusive-OR gate. Fig. 2d shows that gate D contains a charge-sensing element and drives one of two parallel-transfer gates that control the flow of charge from gate C. The charge-sensing element will allow the charge under gate C to flow to gate E only if there is no charge under gate D. The purpose of transfer gate F is to clear out charge under C if it has not been moved under E. Not only does E provide an exclusive-OR function and D an AND function, but the two gates together provide a complete 2-bit half adder with a sum and a carry.

This half-adder circuit can be expanded to a full-adder with additional gates (Fig. 3). These gates allow another storage location and, of course, a third input. Circuit operation is based on the fact that gate D will have charge under it only if at least two of the three inputs A,



2. Gate configurations. Arranging transfer gates, carrier source, and potential wells provides the following logic functions: AND gate (a), OR gate (b), AND/OR gate (c), and exclusive-OR gate (d) where exclusive-OR and AND functions are realized simultaneously.



LOGIC EQUATIONS

$$C = A + B + F$$
$$D = AB + AF + BF + ABF$$
$$G = ABF$$
$$E = G + C\overline{D}$$

TRUTH TABLE

A	B	F	C	G	E	D
0	0	0	0	0	0	0
0	0	1	1	0	1	0
0	1	0	1	0	1	0
0	1	1	1	0	0	1
1	0	0	1	0	1	0
1	0	1	1	0	0	1
1	1	0	1	0	0	1
1	1	1	1	1	1	1

3. Full adder. Adding a few gates to the exclusive-OR function of Fig. 2(d) results in a complete adder with sum and carry outputs. This layout corresponds to the truth table and logic function shown.

B, and F contain charge. Gate G will receive charge only if all three inputs contain charge. The logic equations and corresponding truth table for the various gate locations are included in the figure.

Gates E and D represent the sum and carry functions of the full adder. Such a circuit has led to devices performing more complex arithmetic functions, such as binary adder and multiplier arrays.

Large-scale digital functions

With shift registers and basic logic functions, along with digital adders (or subtracters) and multipliers, any desired digital function can be synthesized. Yet some of these functions are better suited to CCD implementation because they fit the technology best.

Since charge coupling generally produces very dense functional structures, implementations that are highly repetitive and require a minimum of busing are ideal. Similarly, designs that make maximum use of the characteristics of charge-coupled shift-registers will be the most efficient. Because the full adder requires a number of events to occur in sequence before the output is available, those implementations that can use data pipelining and avoid feedback will be best.

In addition, the present relatively low shifting speed of charge-coupled registers means that parallel implementations must be designed for systems with high data rates. However, the high-density capability of the devices largely removes the drawbacks of this approach.

Design limitations and constraints

Maximum operating frequencies are increasing, and, in fact, operation above 1 gigahertz appears feasible. Since the maximum operating frequency of a CCD is determined by the point where transfer losses degrade the output signal to an unacceptable level, useable digital operation can be achieved at even higher frequencies. Charge loss is not as severe a limitation as it is in analog operation, where any such loss means a loss in signal. Moreover, digital CCD functions can easily be programmed, often simply by altering the digital word representing the multiplier coefficient.

Pipelining is a necessary evil because, while it solves the speed problem, it is the biggest limitation on the types of functions that the devices can implement. Its use stems from the workings of the charge-transfer principle. To form a digital adder, several charge transfers must occur before the carry from the least significant bit is available as an input to the next most significant bit. In a 16-bit charge-coupled adder, this operation must be repeated 16 times, thus inserting a throughput delay. In transistor-transistor-logic 16-bit adder circuits, the carry propagates through 16 stages in 30 or 40 nanoseconds.

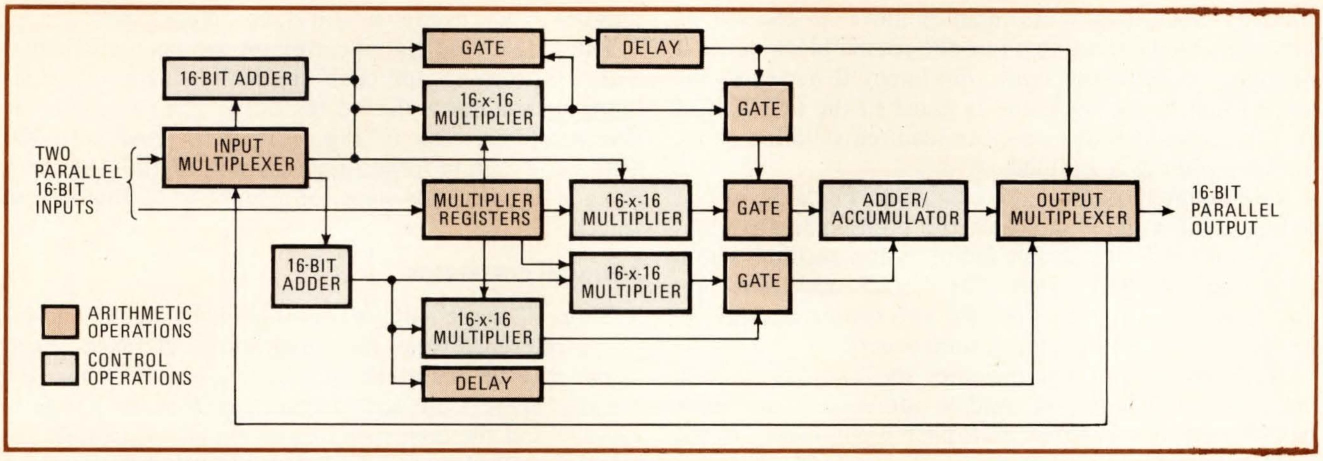
Rather than accept the long delay while charge packets are being manipulated, designers can use pipelining to provide an acceptable speed of operation. The addends are stored in parallel shift registers with the delay increasing from the LSB to the most significant bit. To synchronize the outputs, making the LSB and MSB available simultaneously, a number of shift-register stages are necessary. Fortunately, they require very little of the total real estate of a charge-coupled chip that implements an entire algorithm.

Faster format

Pipelining allows additions to be performed at a rate determined by the delay through 1 bit of addition rather than the delay through the total 16 bits, which could be a few microseconds in a 16-bit charge-coupled adder. With pipelining, addition results are available at the highest clock rate of the received signal. Summations are obtained every 200 ns in existing binary adders and multiplier arrays.

But operating charge-coupled arithmetic circuits in a pipeline fashion to attain good speed imposes a constraint on realizable functions. Those functions inherently of a streaming nature (for example, the fast Fourier transform) are best suited to the pipeline approach. In digital arithmetic operations where the result of one computation must be obtained before the next operation can proceed, a serious penalty in speed must be paid. One example is a charge-coupled central processing unit in which the program-arithmetic-unit output controlling the next program step may be unacceptably low.

The maximum achievable size of the LSI chip



4. Electronically alterable. Although the arithmetic chip's primary use is to perform FFT calculations, its arithmetic functions can be used in selectable sequences to perform other algorithms, thus providing the user with a single chip capable of diverse applications. The color blocks indicate arithmetic operations performed on the chip, and the gray blocks define the control operations.

represents a fundamental limitation to the CCD configuration. Not only must the amount of chip area needed for each functional element be considered, but additional area must be allowed for interconnecting the functional blocks and for pads for input/output connections. However, CCD chips can be made as large as the fabrication limit, while bipolar chips reach their power-dissipation limits before their chip-area limits.

Another important constraint in configuring CCD chips is the limited number of package pins available. As pointed out, the characteristic high component density and moderate speed of CCDs suggest a parallel organiztion of arithmetic functions. Present standard packages are limited to 64 pins, with more available only with expensive nonstandard packages. One solution is to time-multiplex the I/O signals onto the same set of pins. This approach does cut throughput speed in half.

Chip configurations

The best way to examine the level of performance and functional complexity attainable with present technology is to describe some LSI charge-coupled digital-signal-processing chips. Although these configurations have not been fabricated, component functions have been tested in the laboratory, and the designs comply with the constraints just outlined. These three examples are based on 5-micrometer photolithography, two-level metal interconnection, and standard two-phase CCD design.

A charge-coupled arithmetic chip is the basic device, so it should be configured so as to be useful in many applications. As pointed out, the fast Fourier transform is well suited to CCDs, and it finds wide use in such applications as sonar, radar, and communications and voice processing. With its high component density, a single charge-coupled arithmetic chip can provide a powerful computation capability. Moreover, organizing the arithmetic function carefully and including control functions permit the chip to perform more signal-processing operations than just FFTs.

The heart of the FFT arithmetic is the kernel operation, or "butterfly" as it is sometimes called because of its double-triangle appearance in a flow diagram. The hardware for the kernel operation must perform six addition/subtraction operations and four multiplications. However, the addition and subtraction circuits are identical, since only a logical complement and a carry distinguish the two.

For maximum speed, the four multiplications are performed in parallel. A single adder/subtracter circuit can be time-shared to perform two operations during the time of one multiply. Thus all of the arithmetic operations can be accomplished with four multipliers and three adder/subtracters.

The arithmetic chip in Fig. 4 can perform the basic FFT kernel operation. In addition, the powerful arithmetic capability can be modified by user-generated control signals, gates, and timing sequences to perform a variety of digital filtering functions:

- FFT and inverse FFT.
- Two-pole recursive digital filter.
- Two single-pole time-multiplexed recursive digital filters for cascading.
- Single-zero digital filter.
- Serial correlator.
- Analyzer section of a lattice digital filter.
- Synthesizer section of a lattice digital filter.
- Sum and difference for combining charge-coupled correlator-chip outputs.

To complement the arithmetic chip, an FFT memory chip was configured to provide both memory and control. With only these two charge-coupled chips, a basic FFT operation can be implemented. The number of points in the transform is directly proportional to memory size. Additional chips for input buffering, clocking, and read-only memory are all that are required to complete the operation.

FFT memory chip

The principle of charge-coupled-memory organization is illustrated in Fig. 5. Memory access is not random, but follows a regular pattern. This is important for CCD implementation, because a serial memory (a shift register) is easy to implement, while a truly random-access memory is difficult.

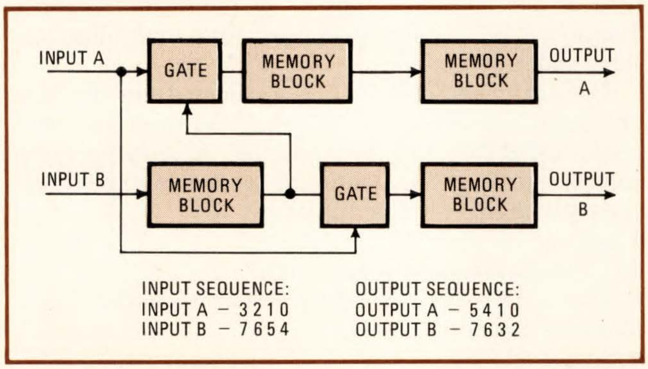
The two data sequences, A and B, are read into the serial memories, each input occupying half of its total memory-block length. As input A moves to the second half of its block, it is gated into the second block in the B memory, while at the same time input B moves to the second half of its block and is gated to the first half of the A memory. In this way, the required shuffling of the output sequence is attained.

Two counters control the operation. For a 256-point FFT, a 3-bit counter indicates the position in the eight steps, and an 8-bit counter indicates the position within each step. Actually, only 128 kernel operations are performed during each step, but two counts are used to designate real and imaginary components.

An 8-bit accumulator indicates the complex rotation coefficients. This may be used to address a ROM, which can provide the required multiplier input values to the arithmetic chip.

Including a divide-by-5 circuit provides synchronization for the five clock phases of the multipliers on the arithmetic chip. This assures that the arithmetic operations are timed properly. The organization of the memory chip is shown in Fig. 6.

For high-speed operation, several arithmetic and memory chips can operate in parallel. External multiplexing gates are needed to gate the memory output between two arithmetic chips. It is not possible to include these gates on the chips, because of the limited number of pins available with standard packages.



5. FFT memory makeup. This memory organization performs the reordering required for the FFT algorithm after each pass through the "kernel" operation. Assuming that each memory can hold two samples, the proper gate toggling produces the data reordering.

The widely used digital correlator can be implemented with a streaming approach compatible with the pipelining techniques preferred for CCDs. The correlator, or matched-filter, chip in Fig. 7 may be used with the arithmetic chip to form a nonrecursive digital filter or a cascade of correlator chips for a function of any desired length.

A digital correlator

Three 32-stage shift registers hold the signal, the in-phase reference, and the quadrature reference. Each signal may be quantized to 4 bits, so the chip has 384 bits of storage. Connected between each of the 32 signal samples and the corresponding in-phase and quadrature reference samples are 4-by-4 multipliers.

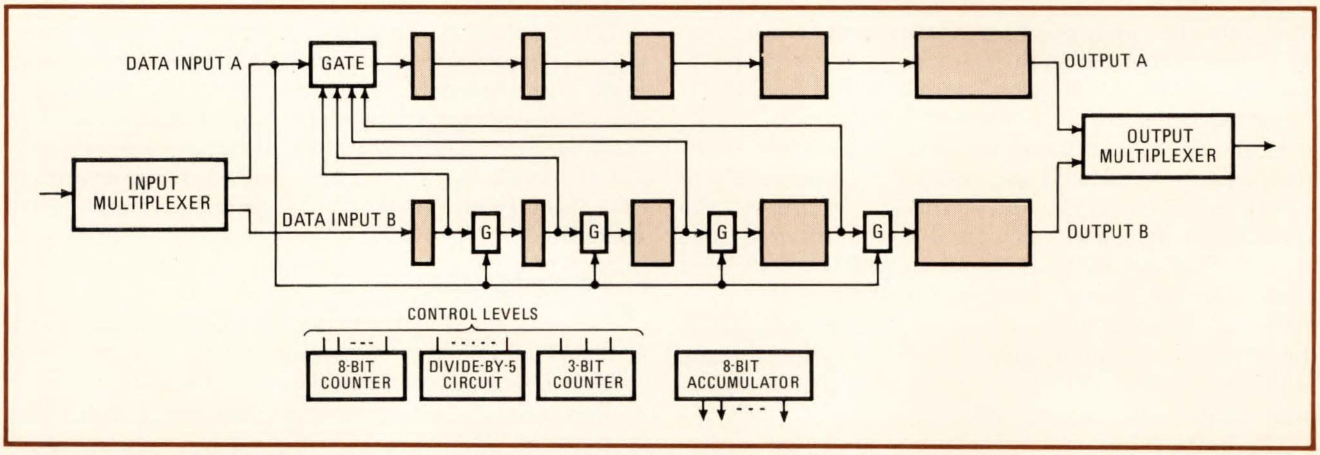
A tree-like structure of full adders either sums or integrates over the 32 products. This approach, sometimes called a unison counter, simultaneously sums all 32 products and provides a digital number, accurate to 13 bits, representing the correlation. To obtain the sum simultaneously, it is necessary to accept a delay, since the summation propagates through the tree of pipelined adders.

In the cascaded digital correlator, a single parallel adder connected to a pair of correlator outputs is required for adding the outputs of the 32-stage sections in order to obtain the total correlation value. The outputs of the first two such adders are applied to the third, and so on, until the trial correlation is summed. The basic FFT arithmetic chip already described can form parallel adders of as many as 16 bits.

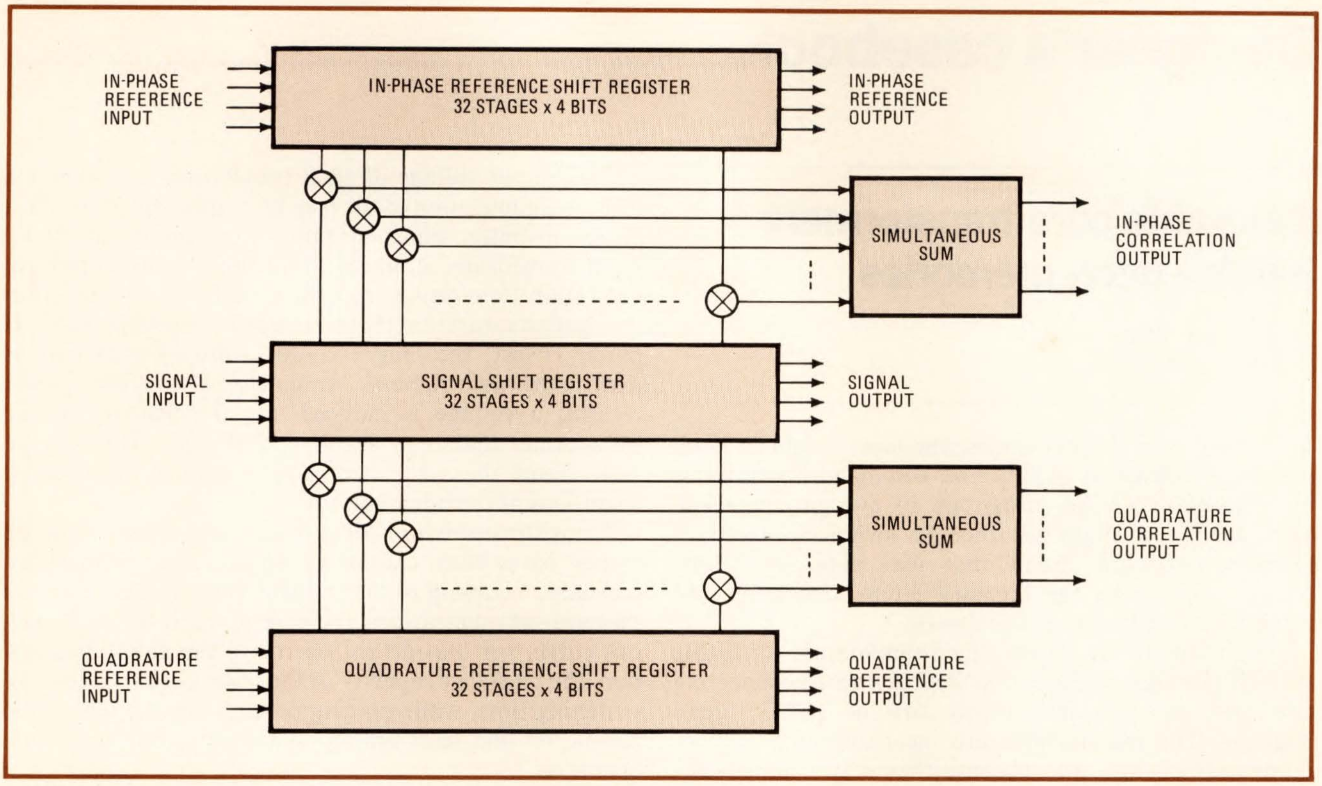
For the future

Experimental results on existing CCDs show that typical surface-channel units operate in the 3-to-15-megahertz frequency range, while experimental buried-channel devices have been shown to work at hundreds of megahertz. Experimental shift-register operation at frequencies on the order of 1 GHz demonstrates that CCD technology is not limited to the low-megahertz range.

Memory densities of about 10 bits per square mil of silicon have been achieved so far, but densities will



6. Memory chip configuration. Increasing the delay by a factor of two in each of the blocks permits proper data reordering for large-scale FFTs. Additional counters, a divide-by-5 circuit, and accumulators provide the proper timing and control functions for the companion FFT arithmetic chip. The colored blocks of varying sizes indicate increasingly longer delays.



7. Digital correlator. Correlating an unknown signal against an in-phase and quadrature reference, each quantized to 4 bits, is achieved by using 4-by-4 multipliers at each of the 32 stages and then taking the simultaneous sum of the multiplications.

increase as more sophisticated photolithographic techniques such as electron-beam and X-ray photolithography are used. And a concurrent increase in bit density and useable frequency range should result. Such an advance in processing technology will move the use of CCDs into areas not now feasible. For example, charge-coupled filters could well move into the higher frequency range now reserved for surface-acoustic-wave devices.

Memory-logic combinations

As the sophistication of signal-processing systems increases, combining charge-coupled memory and digital-logic functions on a single monolithic integrated circuit begins to look more promising. The high accuracy with such word lengths as 16 or 32 bits and high-noise immunity of CCDs for such functions, along with the attendant high density, low-power advantage over other technologies, is indeed attractive. However, such a memory-logic combination requires an increase in circuit complexity, the cost of which is prohibitive unless a high degree of integration is realized at the individual-chip level.

Of course, such chips would be some 300 to 400 mils on a side. Chips on the order of 300 mils are available now, with 400-mil chips likely in two to three years.

Chips that would contain all circuitry necessary to implement a significant portion of some signal processing systems might require thousands of bits of memory and a large number of such computational functions as addition and multiplication. These functions may be permanently interconnected in the case of a chip that performs only one or two basic functions. The interconnection would be reprogrammable in the more likely case of a nondedicated system with several functions.

There are some obvious advantages with such complex chips. The interconnection scheme required for the entire signal-processing system would be significantly reduced. This will affect system construction, reliability, and general physical size, as well as reducing the number of pins per IC package.

Since the chips would contain entire functions, input data would be completely processed before leaving the chip, thus reducing the number of accesses to an individual chip. With less interaction off chip, the computational rates maintained on the chips may be increased. Moreover, power requirements per chip function will drop because of a decrease in clock drive power and the power required to get on and off the chip.

There is another, less obvious advantage. With such computational power available on single chips, new, more efficient algorithms will perform signal-processing functions. Different and potentially better ways of performing complex system functions will certainly be investigated, and system architectures are likely to change to organizations that handle blocks of data and fit into a streaming format. Such organizations will better use the additional computational power available in LSI memory-logic chips.

The highly complex military systems will be the first benefactors of such simplifications. However, it is obvious that the general trend in all systems is toward complex data analysis and more complete data processing. The increased computational power of CCDs will lead to new algorithms, implementations, and formulations for standard procedures. This, in itself, may well create a new application for the technology. □

Saturable core transformers harden latch memories

by Gordon E. Bloom
IRT Corp., San Diego, Calif.

In certain critical applications, the loss of data in latch memories caused by supply and command-line failures or transients can be disastrous to system operation. However, at a slight sacrifice in switching speed, a memory-hardening circuit that uses saturable transformers can make the memory latch nonvolatile and insensitive to false command signals.

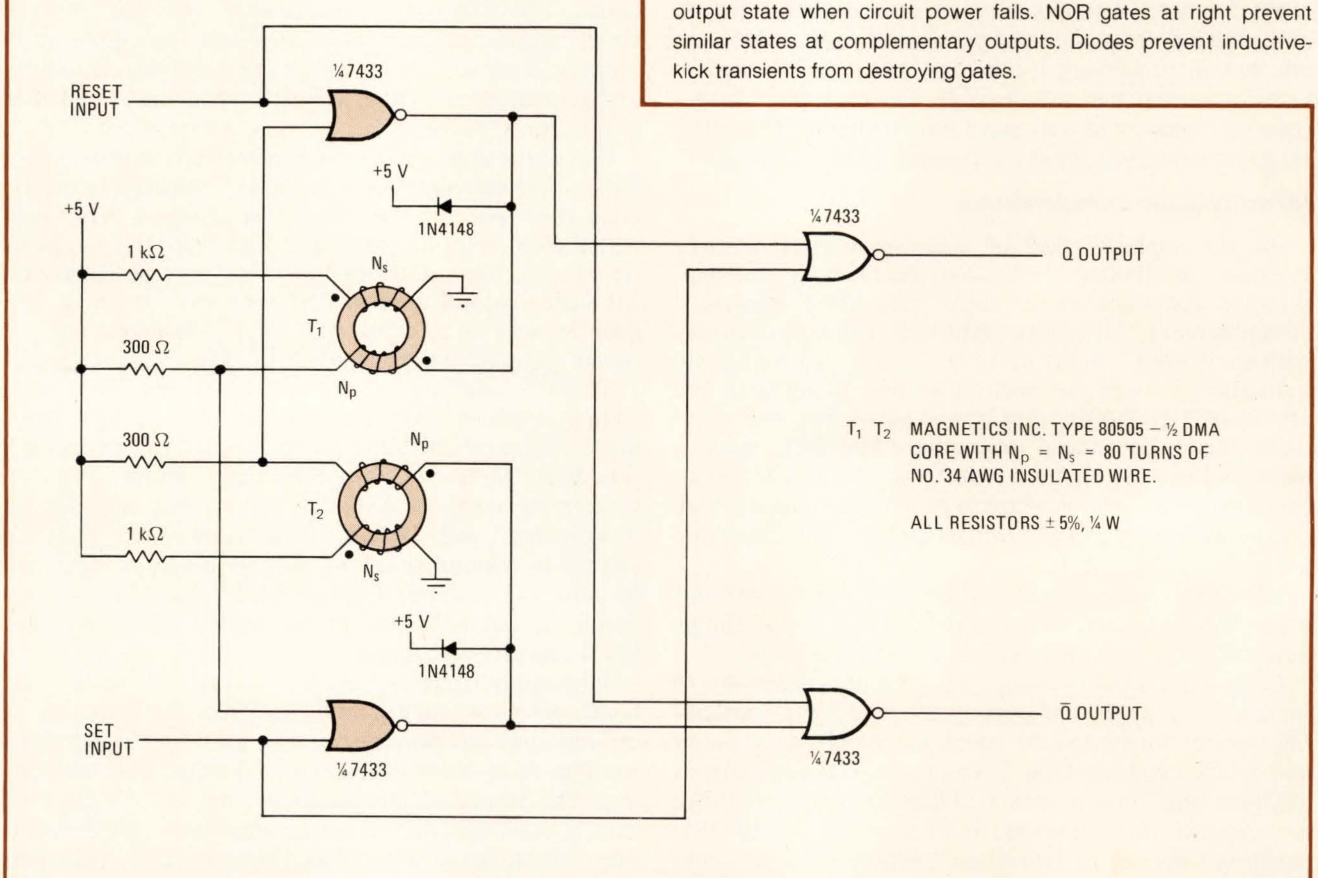
As shown in the figure, the subminiature saturable transformers are placed in the feedback paths connecting two NOR gates, which occupy half of a 7433 quad package. The transformers are incapable of an immediate state change, and because they stay magnetically biased without a voltage supply, they provide a reference state to which the memory latch returns when the power is reapplied.

The output voltage of each transformer is a function of its magnetization state (set by a gate output) and a power-up pulse, which attempts to examine this state. Each transformer is biased at all times—one in positive saturation (low-resistance core condition) and the other in negative saturation (high-resistance core condition). If power is lost, the magnetization state of each core is unchanged and remains so indefinitely. When power returns, a voltage is induced into the primary of the transformer that is in negative saturation. This voltage then drives the associated gate, restoring the original conditions at the latch outputs.

Transistor-transistor-logic gates are used. Resistor values have been chosen to ensure that primary-to-secondary coupling of the transformers produce currents that are sufficient to bias the core properly on its hysteresis curve, yet that do not overdrive the gates. In addition, the total flux capacity of the cores permits adequate switching time, while placing no undue restiction on the normal set and reset timing relationships during normal operation.

When a bit is initially stored in this circuit, the set or reset pulse must have a minimum width of 35 microseconds, and pulses must be separated by a minimum of

Nonvolatile memory. Saturable transformers remember previous output state when circuit power fails. NOR gates at right prevent similar states at complementary outputs. Diodes prevent inductive-kick transients from destroying gates.



65 μs. Should power fail during operation, the power-supply fall time must be much less than 35 μs; otherwise, the latch may lose its contents. The same rise-time constraints accompany power-up.

The circuit may be implemented with other logic families, but choice of component values must take into consideration the family's impedance and switching characteristics. □

Special PROM mode effects binary-to-BCD converter

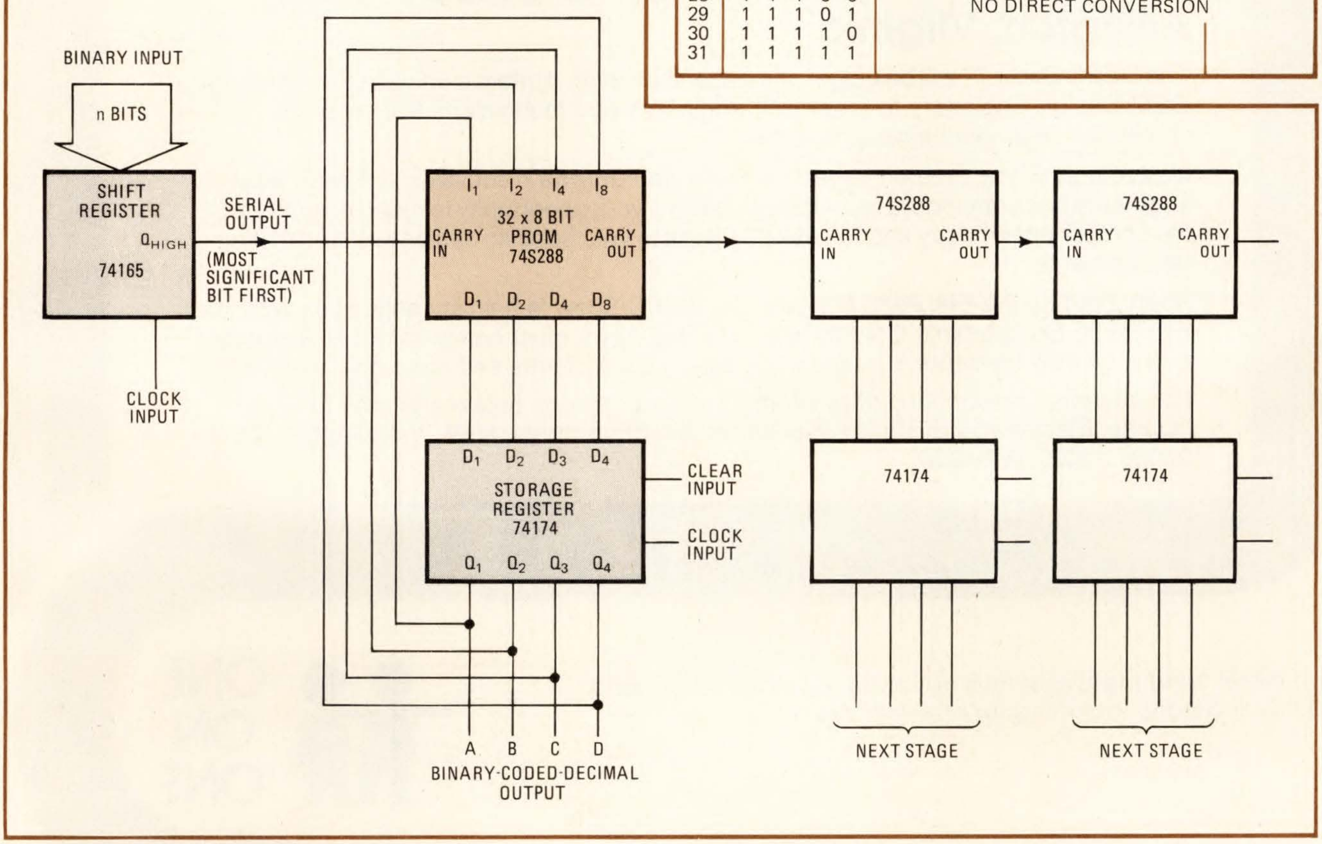
by D. M. Brockman
The Boeing Co., Seattle, Wash.

Computer software converts a binary number to its binary-coded-decimal equivalent by algebraically summing each bit, starting with the most significant bit, and doubling the result of each addition. The method is the equivalent of a binary shift register where a shift doubles the value of the register contents.

But a shift register cannot do the job alone. To make a hardware binary-to-BCD converter also requires a storage register and a programmable read-only memory that is operated in an unusual mode. The circuit is especially advantageous when processing large binary numbers, since PROMs may be simply cascaded for additional

BINARY/BCD CONVERTER PROM TRUTH TABLE

n	BCD in (address) $C_1\ I_8\ I_4\ I_2\ I_1$	BCD out (contents) $Q_7 Q_6 Q_5 C_0 D_8 D_4 D_2 D_1$	Function input	Function output
0	0 0 0 0 0	0 0 0 0 0	0	0
1	0 0 0 0 1	0 0 0 1 0	1	2
2	0 0 0 1 0	0 0 1 0 0	2	4
3	0 0 0 1 1	0 0 1 1 0	3	6
4	0 0 1 0 0	0 1 0 0 0	4	8
5	0 0 1 0 1	1 0 0 0 0	5	$0 + C_0 = 1$
6	0 0 1 1 0	1 0 0 1 0	6	2
7	0 0 1 1 1	1 0 1 0 0	7	4
8	0 1 0 0 0	1 0 1 1 0	8	6
9	0 1 0 0 1	1 1 0 0 0	9	8
10	0 1 0 1 0	NO DIRECT CONVERSION		
11	0 1 0 1 1			
12	0 1 1 0 0			
13	0 1 1 0 1			
14	0 1 1 1 0			
15	0 1 1 1 1			
16	1 0 0 0 0	0 0 0 0 1	$0 + C_1 = 1$	1
17	1 0 0 0 1	0 0 0 1 1	1	3
18	1 0 0 1 0	0 0 1 0 1	2	5
19	1 0 0 1 1	0 0 1 1 1	3	7
20	1 0 1 0 0	0 1 0 0 1	4	9
21	1 0 1 0 1	1 0 0 0 1	5	$1 + C_0 = 1$
22	1 0 1 1 0	1 0 0 1 1	6	3
23	1 0 1 1 1	1 0 1 0 1	7	5
24	1 1 0 0 0	1 0 1 1 1	8	7
25	1 1 0 0 1	1 1 0 0 1	9	9
26	1 1 0 1 0	NO DIRECT CONVERSION		
27	1 1 0 1 1			
28	1 1 1 0 0			
29	1 1 1 0 1			
30	1 1 1 1 0			
31	1 1 1 1 1			



BCD converter. Storage register in feedback loop with programmable read-only memory allows continuous updating of the memory's contents. Multidigit conversion, if necessary, is relatively simple because cascade stages are connected by one lead only.

digits. The circuit speed is typically a few megahertz.

The circuit of the converter is shown in the figure. After loading the 74165 shift register, which accepts either parallel or serial data, an n-bit binary word is serially clocked into the carry input of the 74S288 256-bit PROM. This 32-by-8-bit memory has input and output stages that accept or generate BCD data.

The unusual features in the PROM's use are that its contents are updated in each clock cycle and that the updating forms the circuit's desired equation:

BCD output = 2(BCD input) + carry input

The PROM's truth table shows the BCD output for a given BCD input plus carry input. Any BCD sum exceeding 9 will generate a carry output, thus permitting multidigit conversion if the carry output is brought to the carry input of the next stage of the circuit. If the most significant bit of the n-bit number is shifted out first to the PROM, then after n clock pulses, the resulting BCD-equivalent number will be at the output of all the 74174 storage registers.

The output of each storage register is the input for its PROM, and its content is that of its PROM during the previous clock period (ignoring the carry out). The circuit can convert a 20-bit number to its BCD equivalent at speeds of at least a few megahertz. □

Automatic gain control has 60-decibel range

by Neil Heckt
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An automatic-gain-control circuit with an input range of 60 decibels (20 millivolts to 20 volts) can be built using a junction FET as a voltage-controlled resistor in a peak-detecting control loop. The circuit exhibits a quick response of 1 to 2 milliseconds and a delay time of 0.4 second.

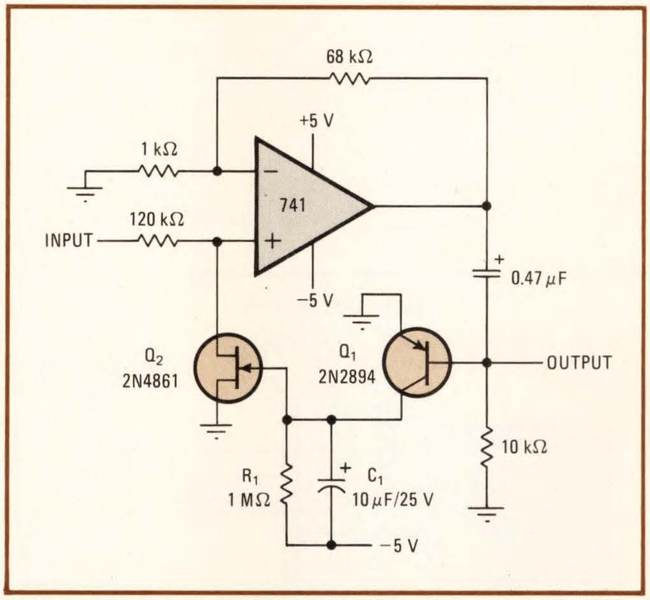
As shown in the schematic of Fig. 1, the 2N4861 n-channel field-effect transistor Q_2, connecting the noninverting input of the operational amplifier to ground, determines the closed-loop gain of the system. Negative base-voltage peaks from the output of the op amp, beyond V_{BE} of Q_1, turns Q_1 on, and its collector current then charges capacitor C_1.

The voltage across C_1 determines the channel resistance of Q_2. Since the range of this resistance is 120 ohms to more than 10^8 ohms, the 60-dB range of the circuit is easily realized.

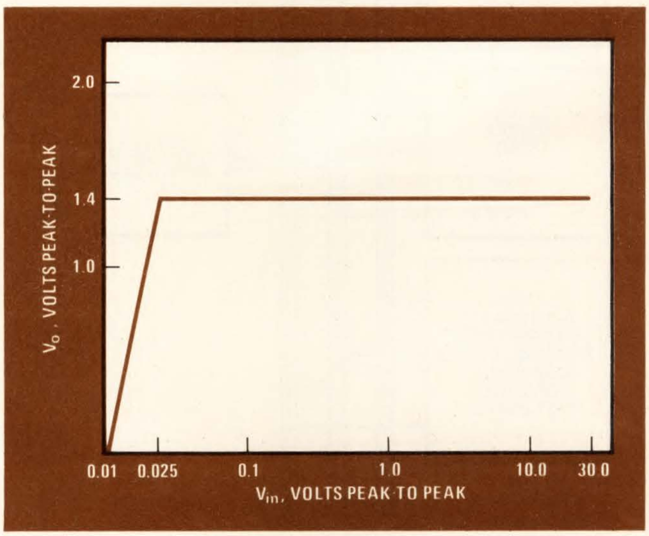
In the absence of an input signal, capacitor C_1 discharges through resistor R_4, cutting off Q_2. It is the C_1-R_4 combination that determines the delay time of the circuit. The collector current of Q_1 and the value of C_1 determine the circuit's attack time.

The op amp can be a 741 or any general-purpose device. Even with input signals of 20 V peak to peak, the maximum signal at the device's input is 25 mV peak to peak. Thus it is possible for the input voltage to be greater than the supply voltage.

The op amp's output is ac-coupled to the base of Q_1 because the dc operating point of its output varies with the changing output impedance of Q_2. To avoid dc bias difficulties when coupling to subsequent stages, the circuit's output is taken from the base of Q_1. Figure 2 shows the gain-control behavior of this circuit throughout its dynamic range. □



1. Audio AGC. Input voltage for distortionless output is from 20 millivolts to 20 volts in this quick-response AGC circuit. The input signal can have greater magnitude than the supply voltage because the maximum signal across the FET is 25 millivolts.



2. AGC characteristics. The output voltage is approximately 1.4 volts over a 60-dB range. A wider dynamic range would be possible if the off/on-resistance ratio of the FET were greater.

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.

Software setup eases traffic flow for multiprocessors

by Janak Pathak,
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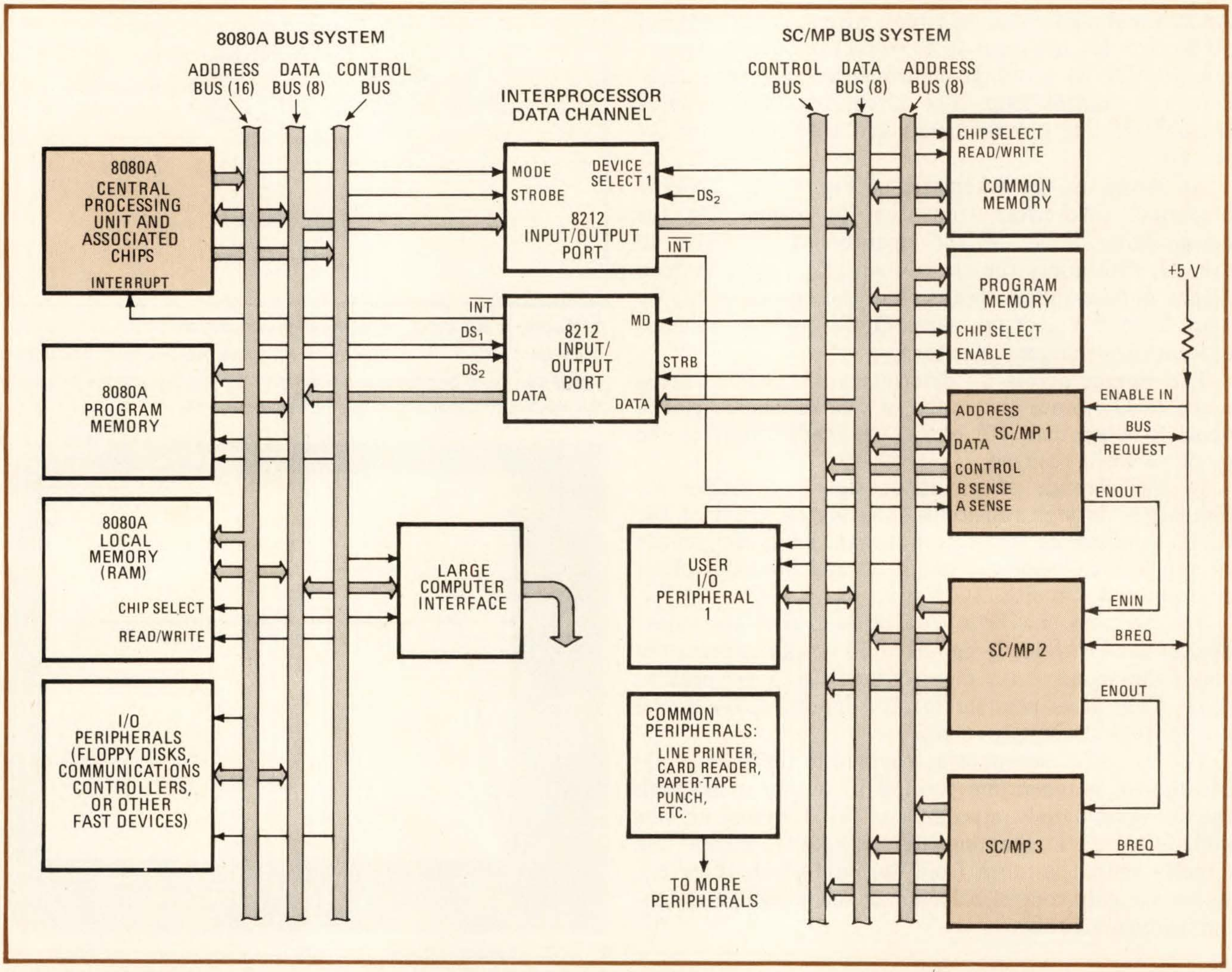
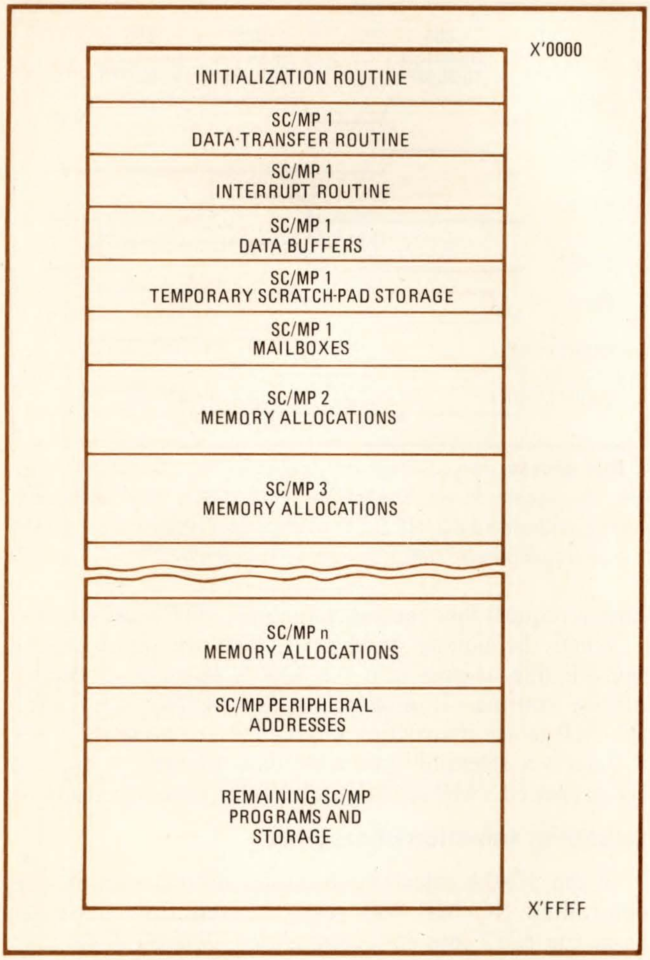
☐ Setting up the software that turns a melange of slow, serial microprocessors into a speedy multiprocessor hierarchy is largely a matter of assuring that the traffic flow among the devices and between them and the outside world is smooth, orderly, and quick. Once the designer has chosen a good device combination for the system—such as an 8080A and several SC/MPs—he faces the problem of transferring data and instructions between the processors. A related and nearly as important a problem is communication with the system's operator through an input/output terminal.

By allowing one of the SC/MPs to perform these supervisory jobs, the 8080A and the other SC/MPs are free to perform the tasks assigned to the system. The 8080A has a powerful instruction set and relatively fast execution time, which are suited to interfacing with high-speed peripherals, while the inexpensive SC/MPs' simplicity makes them an excellent choice for the job of handling the interfaces to less complex, slower peripheral equipment.

In a typical system, three or more SC/MPs (one controlling interprocessor information transfers) can control the input/output operations of such low-speed peripherals as a teletypewriter, a cathode-ray-tube



1. Multiprocessor. One 8080 and three SC/MPs are combined, each type of device handling jobs appropriate to its capability. SC/MP 1 supervises transfer of data between the other processors, as well as serving an interface with the operator's I/O device.



2. Memory organization. A common memory is used for all SC/MPs in the system. When a SC/MP requires service, it places a request in the mailbox, which is polled by the controlling device (which takes the most of the memory, since it has supervisory tasks.)

BIT NUMBER							
7	6	5	4	3	2	1	0
MODE		DESTINATION		SOURCE		OPERATION	
READ = 00		8080 = 00		8080 = 00		START = 00	
WRITE = 01		SC/MP 1 = 01		SC/MP 1 = 01		TRANSFER = 01	
STATUS = 10		SC/MP 2 = 10		SC/MP 2 = 10		ABORT = 10	
N. U. = 11		SC/MP 3 = 11		SC/MP 3 = 11		TERMINATE = 11	

3. Selection character. An 8-bit selection character is used by the 8080 and the SC/MPs to designate the type of data transfer. The 8080 places its selection character in the 8212 I/O port buffer, while each SC/MP places its selection character in a mailbox in memory.

display, a line printer, and such low-speed interfaces as analog-to-digital converters and sensors. The system's 8080A controls high-speed peripherals such as floppy disks and communications controllers.

There are three basic configurations for the multiprocessor system:

- All SC/MPs perform different tasks under the control of the 8080A, which also executes its own program.
- All SC/MPs perform the same tasks under the control of the 8080A, which again executes its own program.
- All SC/MPs perform their own tasks and use the 8080A either as a data reference or as a higher-level processor.

Who does what

In the first two setups, the supporting SC/MPs execute macroinstructions from the 8080A, while it monitors them and processes the assembled data. Both of these are "master/slave" arrangements, with the more powerful 8080A serving as master. The third setup is an example of the other possibility, a "master/master" arrangement. With any of the configurations, the 8080A may also function as a slave for a remotely located, large computer.

A bidirectional interface (Fig. 1) allows data transfers between the SC/MP and 8080A microprocessors. The controlling SC/MP (No. 1) transfers the interprocessor data using interrupts. The other SC/MPs execute independent programs while sharing a common memory with the controlling SC/MP.

The system includes individual address-, data-, and control-bus systems for each microprocessor. In the 8080A portion, the program read-only memory, local random-access memory, and peripherals are connected to the central processing unit and its accessory chips through the associated bus system. In the other portion, the program ROM, common RAM, and peripherals are connected to the SC/MP through the bus system. For this portion of the system, the designer must assign locations in the common memory for the data buffers, mailboxes, and temporary (scratch-pad) storage for each SC/MP (Fig. 2).

Since each SC/MP treats the peripheral and memory devices identically, all of them can share the peripherals connected to the bus system. However, SC/MP 1 is assigned the tasks of transferring data between the microprocessors and of communicating with the operator's primary input/output device (user I/O peripheral 1 in Fig. 1). The assignment of the transfer task to one SC/MP eliminates any waiting period from the difference in operating speeds between the SC/MP and 8080A. It also relieves the 8080A from performing a task that does not require its sophistication.

When a particular microprocessor—either the 8080A or a SC/MP—must initiate a transfer, it does so with an 8-bit word called a selection character (Fig. 3). The 8080A places its selection character in one of the 8212 I/O port buffers, which will set the interrupt on the sense B line of the controlling SC/MP. Each SC/MP places its selection character in an assigned memory location (a mailbox). If the controlling SC/MP detects a selection character while polling the microprocessors for a service request, the requesting device may then initiate an information transfer.

The bus-control logic allows individual SC/MPs access to the bus for data transfers and permits bus access by priority, thus achieving maximum bus utilization. During execution, some instructions need only one access to the bus. Others need two accesses, and a few need three. So the bus is idle during most of the processing time, permitting other processors to use it to execute their programs.

Obtaining bus access

Requesting and gaining bus access and resolving priorities in the event of concurrent bus requests takes three signals: the bus request, BREQ, the enable input, ENIN, and the enable output, ENOUT.

The BREQ signal is bidirectional and is wire-ORed to the bus-request terminal of each SC/MP in the system. Any SC/MP wishing access to the bus must wait for a low BREQ, indicating the common bus-request line is free. Then the processor may activate its bus-request line.

The ENIN signal grants the processor access to the bus. It is driven high to initiate a data transfer. At the completion of the data transfer, the bus request is deactivated, and the ENOUT signal is activated. It indicates that the processor has freed the buses.

For bus coordination and for setting priorities, a chained connection is used, rather than a bus controller. The enable-in line of the highest-priority processor (SC/MP 1) is tied to the common bus-request line. The enable-out line from SC/MP 1 is tied to the enable-in line of the second SC/MP, and so on. This arrangement provides the chained priority (see also the timing diagram, Fig. 4).

The ENOUT signal from each processor depends on the state of the enable-in line and the internal bus-request latch. When any SC/MP is not using the bus, its enable-out line is held in the same state as its enable-in line.

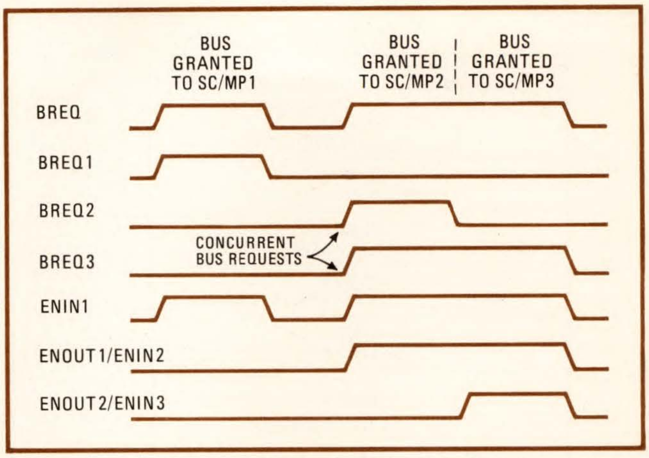
Since the enable-in line of SC/MP 1 is tied to the common bus-request line, the ENIN signal is activated simultaneously with BREQ. Any other SC/MP that raises a bus request concurrently will not be granted the bus until SC/MP 1 activates the ENOUT signal.

When SC/MP 2 raises the bus request, the ENIN signal to SC/MP 1 is activated. If the internal bus-request line of SC/MP 1 is not set, the ENOUT signal from SC/MP 1 is activated, which activates the ENIN signal of the SC/MP 2. SC/MP 3 must go through both SC/MP 2 and SC/MP 1.

Simple data transfer

The data-transfer program (Fig. 5) in the controlling SC/MP is written so that the microprocessors do not need a complicated routine to request service. (Pointer 3 and the extension register of SC/MP 1 are not available because they are reserved for the interrupt routine associated with the operator's primary peripheral.) The initialize segment of the program sets the address pointers, interrupt enable, and interrupt-service-routine pointer. The initialize routine, first of all, directs each SC/MP in the system to its appropriate program sections in common memory. It also resets some software flags and counters to zero.

The controlling SC/MP then enters the polling routine. The 8080A is polled more often than the SC/MPs, since it operates faster and is more likely to



4. Bus access. The SC/MPs are connected in a priority arrangement for access to the common bus. SC/MP 1 has the highest priority, and even if SC/MP 3 has a concurrent request with SC/MP 2, it must wait until SC/MP 2 completes its operations.

have a request that the controlling SC/MP must answer.

When the polling program detects an input on the sense B line, it goes into the 8080A selection-character decode routine. It also scans the mailboxes of each SC/MP to see if selection characters are present. When it detects a selection character in a mailbox, it exits to the proper SC/MP selection-character decode routine.

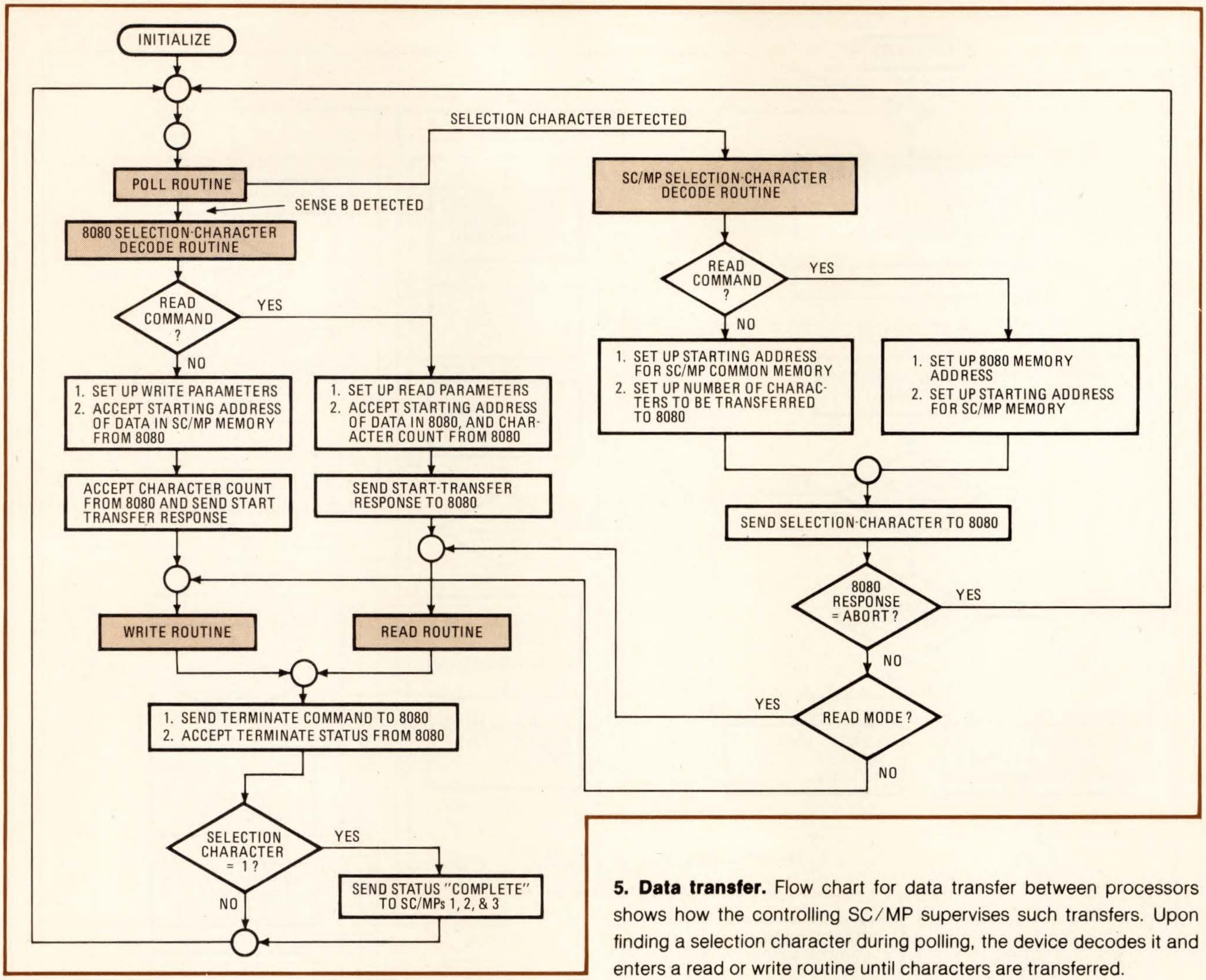
Decoding selection characters

In the 8080A selection-character decode routine, the controlling SC/MP will read the selection character from the 8212 into its accumulator. The SC/MP then establishes the read or write mode, which is defined relative to the 8080A. It also establishes some address pointers and number of characters to be transferred, based on the mode selected.

The device then sends a start-transfer response to the 8080A, indicating the successful beginning of the data transfer, and exits to the write or read routine. The 8080A, upon sending a selection character to the controlling SC/MP, enters the interrupt mode to communicate all subsequent information. Therefore, its program should have a time-out function so that it will wait indefinitely for a response to its selection character.

The SC/MP selection-character decode routine, like that of the 8080A, establishes the modes, address pointers, number of characters to be transferred, and the starting address of data buffers in SC/MP memory. The controlling SC/MP sends a selection character to the 8080A. If it cannot transfer information at this time, the 8080A will respond with an abort signal. If it can transfer information, it responds with a start signal. From this point, the program exits to the read or write routine (here defined relative to the SC/MPs).

In the write routine, data is written from the common memory to the 8080A memory. The controlling SC/MP first loads the starting address of the data to be sent in a pointer register and loads the first data word into the accumulator. Next it sends the first data word to the associated 8212, which in turn sends an interrupt to the 8080A. The SC/MP waits for a response from the 8080A on the sense B input line, decrements the char-



5. Data transfer. Flow chart for data transfer between processors shows how the controlling SC/MP supervises such transfers. Upon finding a selection character during polling, the device decodes it and enters a read or write routine until characters are transferred.

acter counter by 1, and increments the address in the pointer register by 1—repeating this process until the content of the character counter is 0.

In the read mode, the routine sets up in the 8080A the starting address of the buffer from which data is to be read. In the SC/MP, the pointer register is loaded with the starting address of the receiving data buffer. The data is read from the 8080A memory into the SC/MP memory as the controlling SC/MP follows a similar routine to that of writing.

The data-transfer termination sequence, which follows the read and write routines, is used to exchange status and other information. If the read or write routine was a SC/MP routine, the termination status should be passed on to the SC/MP that requested the service. Finally, the program loops back to the poll routine to acknowledge the next service requested. Allowing for typical overheads, this sequence will give a transfer rate of about 5,000 characters per second if the new n-channel SC/MPs are used.

The 8080A program is fairly simple, since the burden of controlling data transfers is placed on the controlling SC/MP. However, the program is responsible for creating a selection character whenever the 8080A wants to transfer information. It also is responsible for accepting the interrupts from the controlling SC/MP.

The operator's primary peripheral communicates with the controlling SC/MP on an interrupt basis. The interrupt-handling program (Fig. 6), allows the operator to enter any of three commands: read, write, or select (defined relative to the SC/MP).

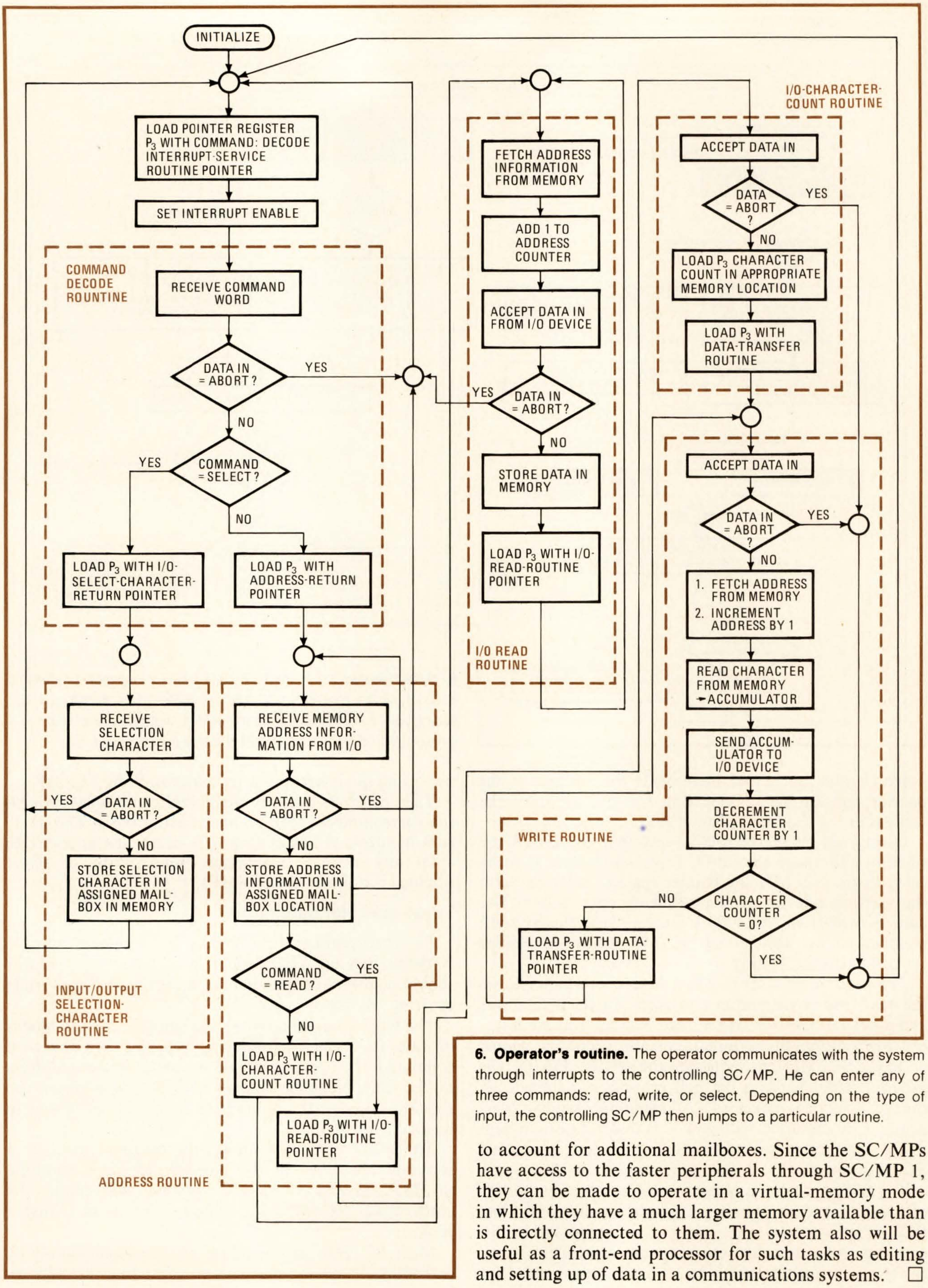
Three operator commands

The read command allows data to be entered into the common memory. To avoid loss of data, the operator should be aware of the memory mapping in Fig. 2 while entering the data.

The write command allows the operator to read blocks of data from the common memory. As with the read command, the operator should enter the starting address of the data block he intends to read. In addition, he should also enter the number of characters he wishes to be read from memory.

The select command allows the operator to place a selection character in the mailbox of the controlling SC/MP. As explained, this character will enable the controlling SC/MP to initiate the data-transfer program.

More SC/MPs can be added to the system simply by extending the polling routine and expanding the memory



6. Operator's routine. The operator communicates with the system through interrupts to the controlling SC/MP. He can enter any of three commands: read, write, or select. Depending on the type of input, the controlling SC/MP then jumps to a particular routine.

to account for additional mailboxes. Since the SC/MPs have access to the faster peripherals through SC/MP 1, they can be made to operate in a virtual-memory mode in which they have a much larger memory available than is directly connected to them. The system also will be useful as a front-end processor for such tasks as editing and setting up of data in a communications systems. □

Controlling switching supplies with LSI circuits

Replacing over 50 discrete components, monolithic controls simplify design, reduce parts count, cut costs, and improve reliability

by Henry Wurzburg and Dave Cave, *Motorola Semiconductor Products Inc., Phoenix, Ariz.*

☐ Because of improvements in components made especially for them, switching-regulated power supplies have proliferated during the past few years, particularly in computer and aircraft applications. The emergence of inexpensive high-speed switching power transistors, low-loss ferrites for transformer cores, and special low-impedance four-lead capacitors for filters has led to switching supplies that perform better and cost less than they used to. Now, large-scale-integrated linear circuits that contain the basic control circuitry are easing the design task, too.

At power levels above 100 to 200 watts, switching supplies are smaller and more efficient than their series-regulated counterparts. However, they are also considerably more complex, requiring pulse-width-modulated drive signals for their switching power transistors, as well as special filter components and shielding. The LSI control chips, though, develop the PWM signals for driving the power transistors, and some even provide for current limiting, soft start, and protection against load transients. Effectively, they do the work of 50 or more discrete components, reducing the parts count for a complete supply appreciably.

Each of the half dozen or so monolithic control circuits currently on the market offers its own set of control features and design options. Moreover, any one of them is capable of controlling hundreds of watts from a miniature dual in-line package. Besides the obvious reduction of supply complexity, such a chip not only means significant savings in the costs of design time and circuit assembly, but also improves system reliability.

Spotlighting one of the chips

Figure 1 shows the block diagram for one of these control chips—Motorola's MC3520 inverter control circuit. In a single low-cost DIP, it incorporates those functions common to all constant-frequency PWM control schemes for switching supplies. Yet it retains enough versatility to be useful in building a wide range of supplies—from simple low-performance ones to complex high-performance systems.

The chip is a mixture of both linear and digital circuitry. Its linear functions include a ramp generator having a built-in voltage reference, a dead-time comparator, a PWM comparator, and two output driver transistors. In the digital section are an edge-triggered flip-flop, which serves as a phase splitter, its driving gate, and a trio of AND gates.

In view of this mixed circuitry, integrated-injection-logic bipolar processing seems ideal for fabricating the chip. However, the performance needed from the device—the capability to handle input voltages of 30 V with output collector voltages as high as 40 V—would require device fabrication with high-resistivity epitaxy that is not conducive to good I^2L operation. So the MC3520 is the product of standard linear bipolar technology, with ion-implanted resistors. With ion implantation, high-value resistors can be packed into a small area, thereby keeping current drain low and die size small.

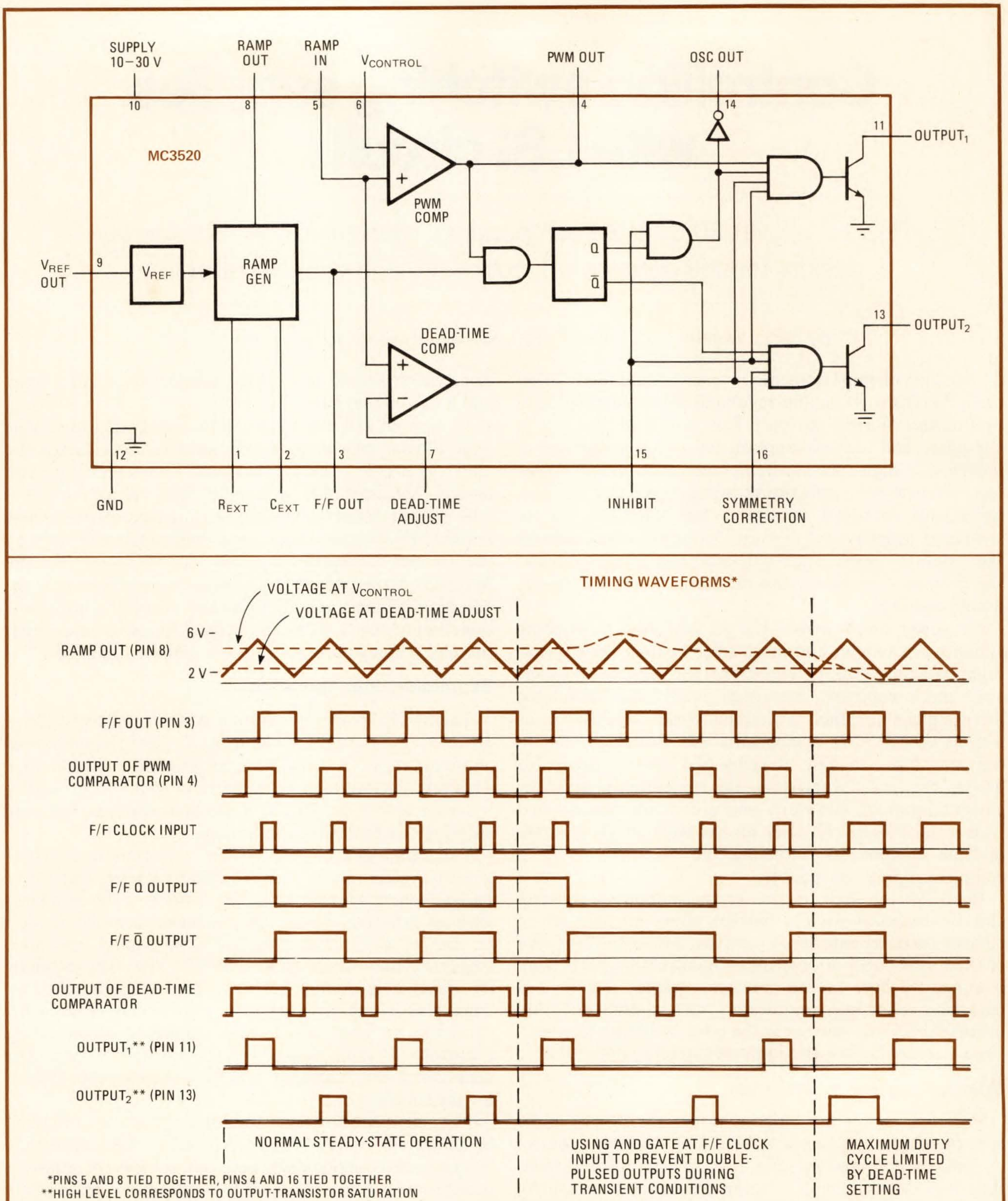
Examining chip operation

The MC3520 operates from a power-supply voltage of 10 to 30 V, internally generating a reference voltage of approximately 7.8 V that is stable to within $\pm 0.02\%/^\circ C$. This reference voltage is brought out to pin 9 for setting the dead time at pin 7 and for use as a reference for error amplifiers in external control loops.

The ramp generator produces a symmetrical triangular waveform having an excursion between 2 and 6 V. Its frequency, which may be set from 4 to 200 kilohertz with an external resistor and capacitor, is twice as high as that of the output transistors, so supply operating frequency may range from 2 to 100 kHz. The external frequency-determining resistor and capacitor are tied from pins 1 and 2 to ground, respectively. Even with variations in line voltage and temperature, the ramp frequency remains stable to within approximately 4%, simplifying the magnetics and filter components needed for the supply.

Normally, the output of the ramp generator (at pin 8) is connected to the ramp-in terminal (pin 5). However, to synchronize more than one control chip for multiple inverter/converter systems, the ramp output of a "master" MC3520 may be used to drive up to two "slave" MC3520 devices, as shown in Fig. 2. (In this application, the ramp-out and frequency-determining pins of the slave devices must be left unconnected for proper circuit operation.)

The inputs to the PWM comparator in Fig. 1 are the control voltage (pin 6) and the output from the ramp generator. The control voltage's level sets the pulse width or duty cycle of the comparator's output. Exclu-



1. Control system on a chip. The MC3520 monolithic control circuit develops the pulse-width-modulated signals needed for driving the power transistors in a switching supply. This linear IC also provides for soft start, symmetry correction, and dead-time adjustment.

sive of dead time, the duty cycle of the output pulses may vary from 50% (for a control voltage of approximately 2 v) to 0% (for a control voltage of around 6 v), yielding a total duty-cycle control range of 0% to 100% for a supply. Since the minimum level for the control voltage is 2 v, a 741-type operational amplifer operating from a unipolar supply voltage may be used to drive the $V_{CONTROL}$ pin.

An additional comparator permits independent adjustment of dead time for the output transistors and the maximum operating duty cycle. Because of their internal charge-storage-time delays, the supply's switching power transistors may conduct simultaneously at high duty cycles. But the MC3520's dead-time adjustment prevents this. To produce a stable dead time, the user simply drops V_{REF} (pin 9) down with a resistive divider or a potentiometer and applies this voltage to pin 7. Dead time may be adjusted to limit the maximum duty cycle to any value between 0% and 100%.

A toggle-type flip-flop functions as a phase splitter, producing complementary pulse trains that are out of phase by 180° for controlling multiple-transistor switching supplies. The clock signal for the flip-flop is derived by ANDing together the output of the PWM comparator and a signal from the ramp-generator circuit. The AND gate ensures that the MC3520's outputs truly alternate—even under control-loop transient conditions when the load is abruptly removed and then reapplied. This feature permits the core of the supply's transformer to be about half as large as might otherwise be needed.

The output transistors of the MC3520 are open-collector devices capable of sinking up to 50 milliamperes and blocking up to 40 V. They may be operated separately for push-pull control or wire-ORed together for controlling single-ended supplies. At a saturation voltage of 0.5 V, each transistor can sink up to 40 mA.

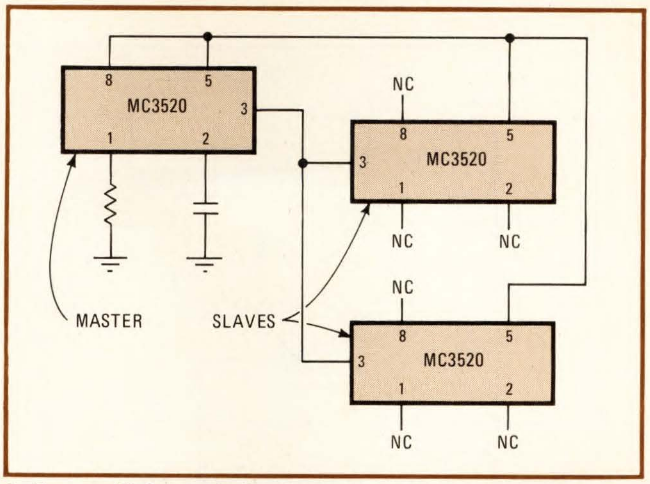
Some supply applications require a symmetry-correcting control loop, so the duty cycle of one output-driver transistor must be independently controllable from the other's. The MC3520 provides for this, too. Its symmetry-correction input (pin 16) enables the user to control, with external circuitry, the duty cycle of $OUTPUT_2$ (pin 13) independently of the duty cycle of $OUTPUT_1$, varying it from 0% to 50%, exclusive of dead time.

Normally, $OUTPUT_2$'s duty cycle is determined by the PWM comparator (with pin 16 connected to pin 4), as is the duty cycle of $OUTPUT_1$. However, with pin 16 driven externally, $OUTPUT_2$ will be on (saturated) during its allowable conduction period when pin 16 is at or above 2.4 V, and off when pin 16 is at 0.7 V or less. Conveniently, these are voltage levels that are directly compatible with both transistor-transistor-logic and complementary-MOS circuitry.

The MC3520 also provides an inhibit function at pin 15. If the voltage at this pin drops to 0.7 V or less, both output driver transistors are instantly forced off into a nonconducting state, and the oscillator output at pin 14 is disabled. This open-collector oscillator output normally switches at the same frequency as $OUTPUT_1$, but with a constant duty cycle of 50%. It may be used to implement various supply features such as limiting inrush-surge current.

Building a high-performance supply

Even with the substantial parts reduction that a monolithic control like the MC3520 permits, switching-power supplies may still be fairly complex, particularly if they are high-performance systems incorporating such features as soft start and protection against overcurrents. For example, the line-operated logic supply of Fig. 3 is a high-performance system built with the MC3520 monolithic control. Although the design is not simple, the MC3520 does cut parts count, and it makes implementing protection and error-sensing circuits a lot easier.



2. For multiple controls. One master MC3520 inverter-control circuit can synchronize up to two slave devices for multiple inverter/converter systems. The ramp-generator output (pin 8) of the master device is connected to the ramp-in (pin 5) of each slave.

The logic supply is a 250-W system that develops 5 V at 50 amperes from an unregulated ac line input. Switching frequency is 20 kHz, yet output ripple and noise are held to 60 millivolts peak-to-peak, 25 mV root-mean-square. With an efficiency of 80%, the supply provides line regulation within 0.4% and load regulation within 0.25%. Also, the design provides constant-current limiting, soft start, and inrush-surge-current limiting.

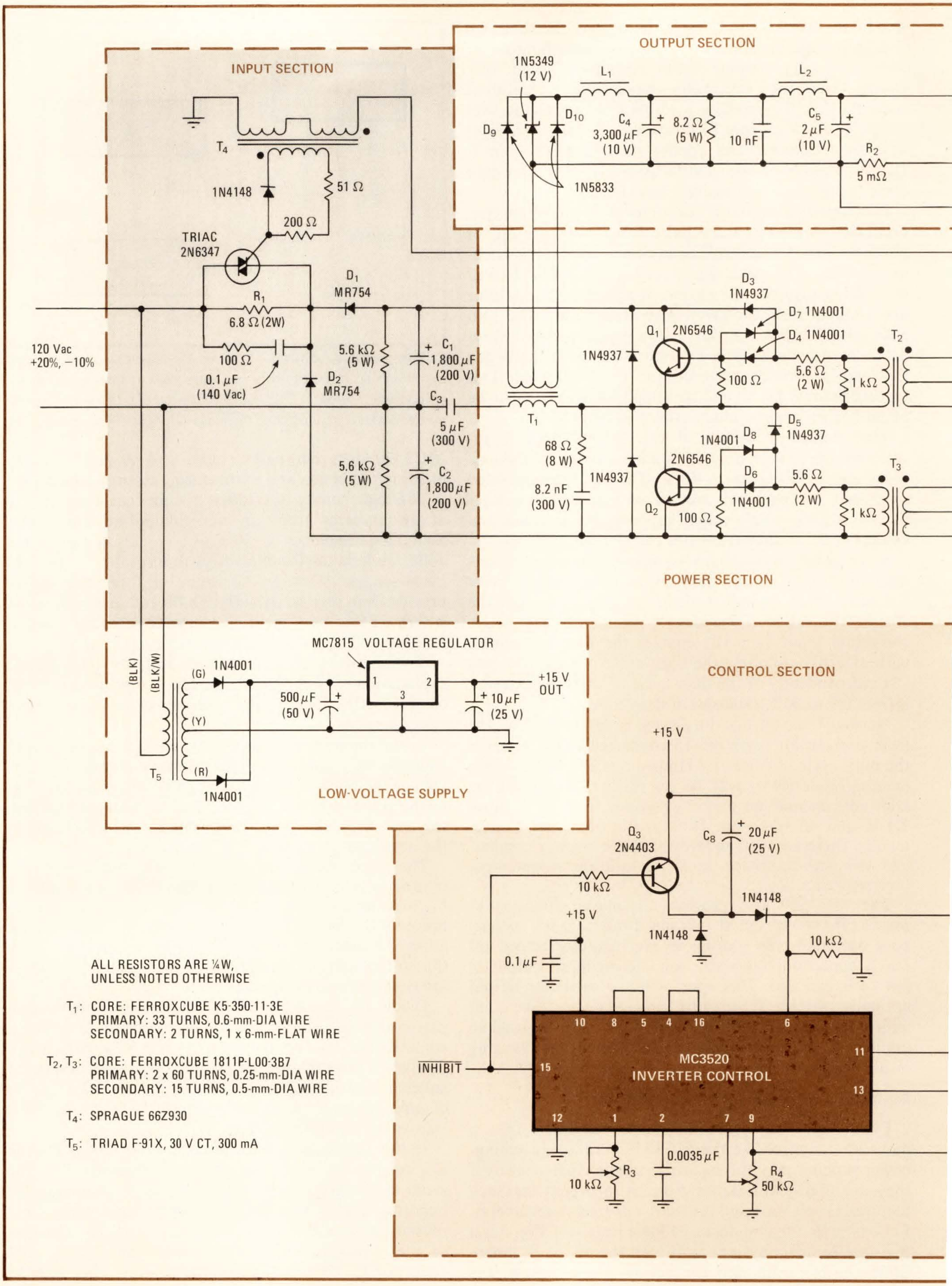
Dividing the supply into various sections simplifies the explanation of how it operates. The five principal circuit blocks are the input, power, output, control, and triac-driver sections.

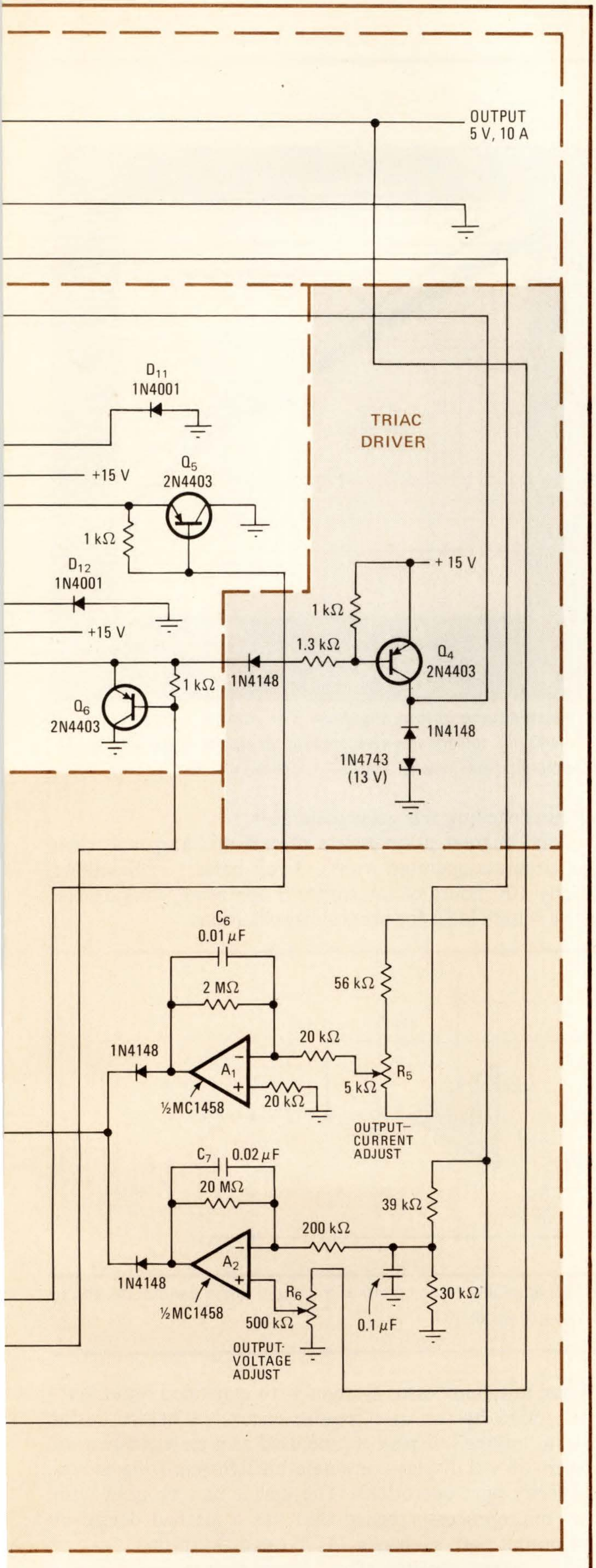
In the input section, diodes D_1 and D_2, together with capacitors C_1 and C_2, provide full-wave rectification and voltage doubling of the 120-V ac line, delivering 310 V dc to the power section. Once C_1 and C_2 become charged, the triac fires, shorting out resistor R_1, which is part of the inrush-surge-current-limiting circuit.

The power section contains two switching transistors, Q_1 and Q_2, in a half-bridge configuration for driving the high-frequency power transformer, T_1. Capacitor C_3 prevents T_1 from saturating because of circuit imbalances. Transformers T_2 and T_3 drive the bases of Q_1 and Q_2, so the control and base-drive sections of the supply are isolated from each other.

Diodes D_3, D_4, D_5, and D_6 form antisaturation clamps that ensure fast uniform switching speeds for Q_1 and Q_2, while diodes D_7 and D_8 allow reverse base currents to flow when these transistors are off. The diodes across the collector-emitter junctions of Q_1 and Q_2 also act as clamps, limiting the collector-emitter voltages of these transistors to the bus voltage.

In the output section, Schottky-barrier diodes D_9 and D_{10} rectify the output of power transformer T_1. The zener diode serves as a surge suppressor, protecting the Schottky diodes from transients that might cause their reverse breakdown. Inductor L_1 and capacitor C_4 serve as the principal output filter, while inductor L_2 and capacitor C_5 form a high-frequency filter that reduces


OUTPUT SECTION
INPUT SECTION
POWER SECTION
CONTROL SECTION
LOW-VOLTAGE SUPPLY
1N5349
(12 V)
L1
L2
D9
D10
C4
3,300 μF
(10 V)
8.2 Ω
(5 W)
10 nF
C5
2 μF
(10 V)
R2
5 mΩ
1N5833
T4
1N4148
51 Ω
200 Ω
TRIAC
2N6347
D1
MR754
R1
6.8 Ω (2W)
120 Vac
+20%, −10%
100 Ω
0.1 μF
(140 Vac)
D2
MR754
5.6 kΩ
(5 W)
C1
1,800 μF
(200 V)
C3
5 μF
(300 V)
C2
1,800 μF
(200 V)
T1
68 Ω
(8 W)
8.2 nF
(300 V)
1N4937
Q1
2N6546
Q2
D3
1N4937
D7 1N4001
D4 1N4001
D5
1N4937
D8
1N4001
D6
5.6 Ω
(2 W)
1 kΩ
T2
T3
MC7815 VOLTAGE REGULATOR
(BLK)
(BLK/W)
(G)
(Y)
(R)
T5
500 μF
(50 V)
10 μF
(25 V)
+15 V
OUT
+15 V
Q3
2N4403
C8
20 μF
(25 V)
10 kΩ
0.1 μF
INHIBIT
MC3520
INVERTER CONTROL
R3
10 kΩ
0.0035 μF
R4
50 kΩ
ALL RESISTORS ARE ¼W,
UNLESS NOTED OTHERWISE
T1: CORE: FERROXCUBE K5-350-11-3E
PRIMARY: 33 TURNS, 0.6-mm-DIA WIRE
SECONDARY: 2 TURNS, 1 x 6-mm-FLAT WIRE
T2, T3: CORE: FERROXCUBE 1811P-L00-3B7
PRIMARY: 2 x 60 TURNS, 0.25-mm-DIA WIRE
SECONDARY: 15 TURNS, 0.5-mm-DIA WIRE
T4: SPRAGUE 66Z930
T5: TRIAD F-91X, 30 V CT, 300 mA



3. High-performance system. The MC3520 is at the heart of the control section for this line-operated 250-W logic supply, which delivers 5 V at up to 50 A. The supply includes such features as soft start and inrush-surge-current limiting. Efficiency is a high 80%.

the commutation spikes passing through L_1 because of its interwinding capacitance. For the most effective filtering, C_4 should have a very low equivalent series resistance at 20 kHz. Resistor R_2 simply provides over-current sensing for the control section.

Linear chip is key to control

The heart of the control section is the MC3520, which develops the PWM signals for the switching transistors in the power section. Resistor R_3 sets the switching frequency, which is 20 kHz, while resistor R_4 determines the dead time, which is approximately 5 microseconds each half-cycle. Two feedback loops correct output errors—one contains amplifier A_1 for sensing output current, and the other contains amplifier A_2 for monitoring output voltage. In the first loop, resistor R_5 sets the output-current limit, and capacitor C_6 is for frequency compensation. Similarly, in the second loop, resistor R_6 determines the output-voltage level, and capacitor C_7 provides frequency compensation.

Both transistor Q_3 and capacitor C_8 are part of the soft-start circuit. During supply power-up or after an inhibit, the control voltage at pin 6 of the MC3520 starts at 15 V, gradually decreasing as C_8 charges. The supply remains inactive during this period, allowing the input capacitors, C_1 and C_2, to charge up slowly through resistor R_1 so as to eliminate any high inrush surge currents.

When the voltage at pin 6 falls to 6 V, after approximately 100 milliseconds, the MC3520's output driver transistors become active, the supply starts up, and the triac shorts resistor R_1 to prevent its power dissipation from becoming excessive. As the voltage at pin 6 continues to fall, the supply's duty cycle increases slowly, until either the output-current feedback loop or the output-voltage feedback loop assumes control.

The gate drive for the triac is derived from transistor Q_4 and transformer T_4. After the initial 100-ms delay created by the soft-start circuit, Q_4 begins operating, allowing capacitors C_1 and C_2 to charge up before firing the triac.

In the base-drive section, transistors Q_5 and Q_6 turn on alternately, with the saturation of the MC3520's output driver transistors. Once on, Q_5 and Q_6 apply 15 V to the primary of their associated transformers, with Q_5 driving T_2 and Q_6 driving T_3. In turn, the transformers supply the forward base drive for the switching transistors, Q_1 and Q_2, in the power section. When Q_4 or Q_5 turns off, the forward base drive is removed from its respective switching transistor.

Meanwhile, however, the magnetizing energy stored in the core of T_2 or T_3 is transformed into a negative flyback voltage at the secondary winding, producing a reverse base drive that ensures the associated switching transistor is truly off. Diodes D_{11} and D_{12} act as clamps, preventing this flyback voltage from becoming too large and damaging the transformer secondary. □

MOS op amps form 'pink noise' source

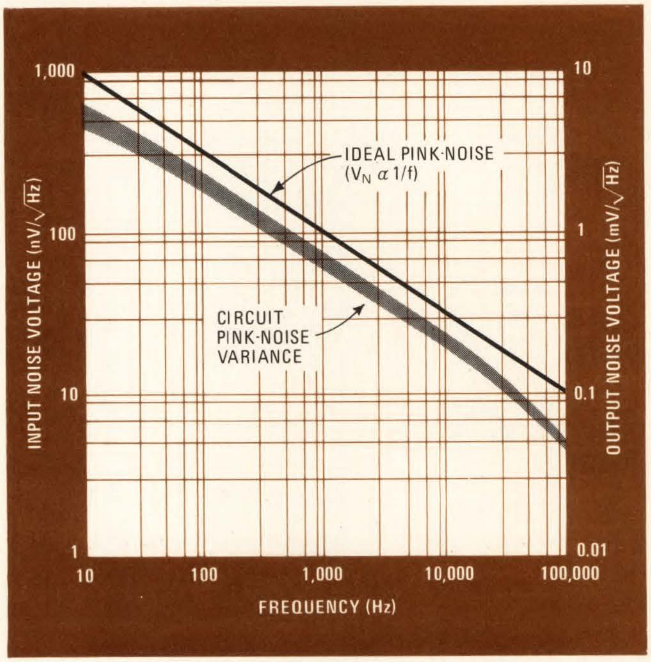
by John Maxwell
National Semiconductor Corp., Santa Clara, Calif.

Many amplifier and acoustical measurements need a "pink noise" source—that is, one having constant noise power per octave, in contrast to a white-noise source, which has constant noise power per unit bandwidth. Such a generator can be built using a pair of MOSFET-input operational amplifiers, as well as a few passive components.

The circuit uses the low-frequency noise characteristics of the metal-oxide-semiconductor field-effect transistor (pink noise is not usually produced by complementary-MOS devices). The transistor eliminates critical components and the "pinking" filter typically required in lab units. It is significantly lower in cost than commercial noise sources.

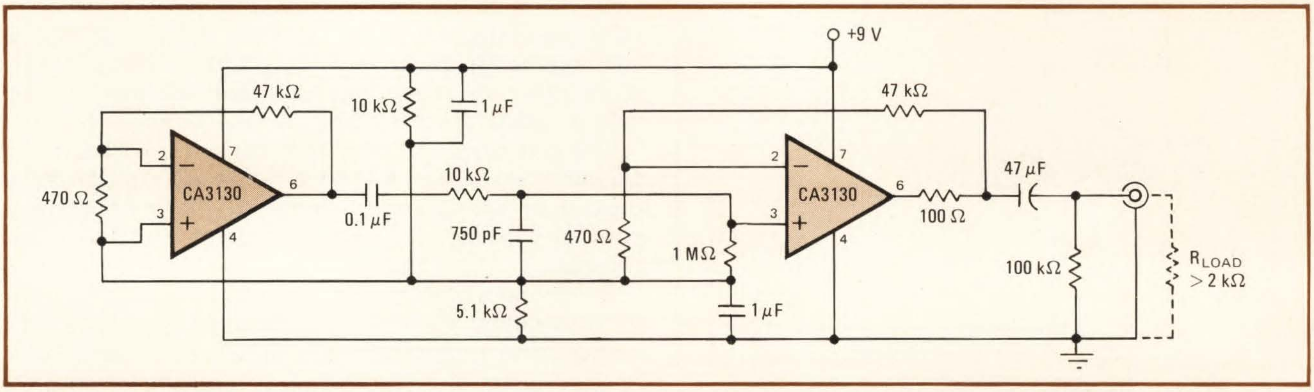
The circuit, shown in Fig. 1, uses two cascaded CA3130 amplifiers with a composite gain of 10,200. Generally, any MOSFET amplifier can be used to produce similar characteristics to those plotted in Fig. 2.

The spectral output of the noise circuit closely follows the ideal pink-noise curve. The output noise is 16 millivolts per octave. The total output is 70 mv rms (420 mv peak to peak), which should be adequate for most circuits needing this noise generator.



2. Noise-source output spectrum. For adjustable noise output of 7 to 140 mV, replace the 47-kΩ resistor in second stage with a 100-kΩ potentiometer in series with a 4.7-kΩ fixed resistor.

Total current drain is less than 5 milliamperes when the circuit is operated from a 9-volt battery. This allows nearly 100 hours of intermittent operation, making the noise source ideal for portable applications. □



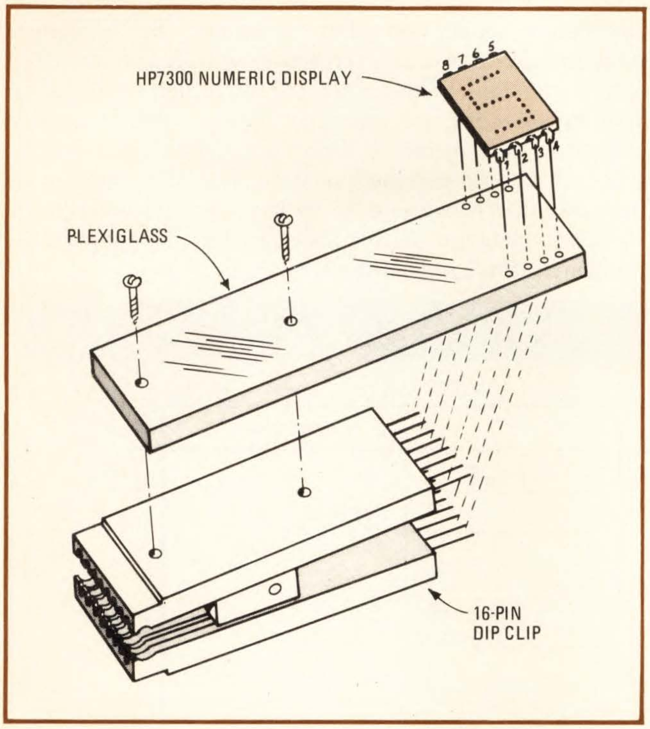
1. Pink-noise generator. An RC low-pass filter is inserted between the two amplifiers to compensate the upper audio band noise and to eliminate unwanted high-frequency noise. Each amplifier's stage provides a gain of about 101.

Roving display checks microprocessor I/O

by Knute A. Berstis
National Oceanic and Atmospheric Administration, Rockville, Md.

When microprocessor systems with expanded input/output added by the user require check-out before initial use, a "roving" display can be used as a tester instead of expensive I/O displays or single-bit light-emitting diodes to verify port operations. The device can be used with any microprocessor board that has a latched device at the output port, such as a 74175 quad D flip-flop.

The tester consists of a 16-pin dual-in-line-package



Roving display. Low-cost tester is easy to build. There are no critical dimensions; any insulated mounting material like plexiglass will do, and self-tapping screws will hold insulator to clip surface.

clip and an HP 7300 numeric display. The 7300, which has a built-in binary-coded-decimal-to-seven-segment decoder and driver, is wired to the clip shown in the figure and then the tester is clipped to an output latch.

The BCD input of the numeric-display device can be connected to either of the complementary outputs of the latch. However, when it is wired to the inverted outputs, a complement-accumulator instruction needs to be inserted at a point in the program before the data is written on the selected I/O port to ensure that the data appears correctly at the 7300.

As the test program is being run by the microprocessor, a chosen sequence of data is generated at every port. The display may be moved to verify the data sequence at each port. This device can easily detect both hardware and software difficulties and is especially useful in troubleshooting data-acquisition problems. □

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.

Calculator notes

Conversion program helps deal with decibels

by John H. Bryant
Indianapolis, Ind.

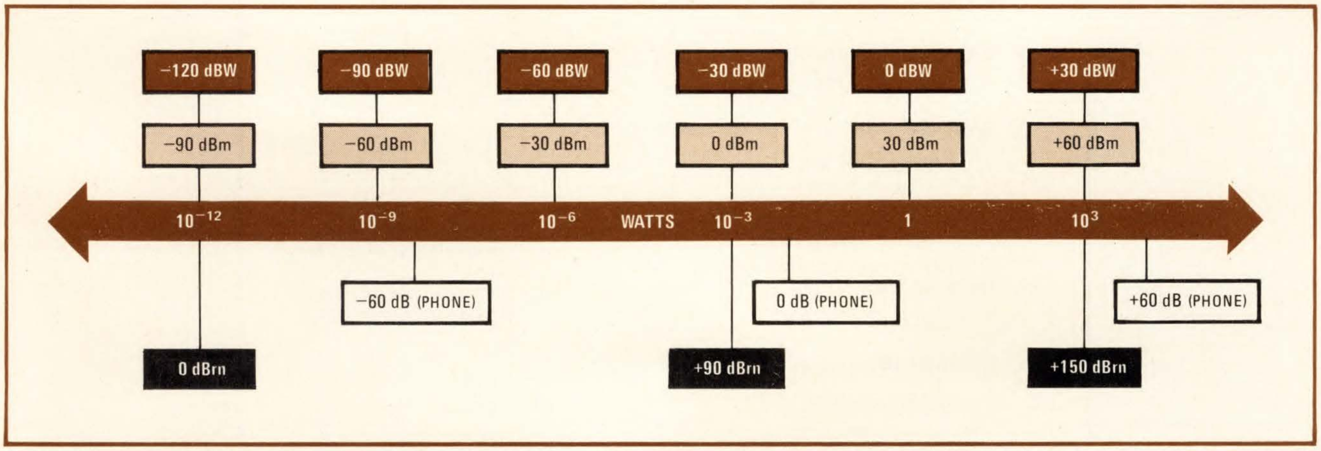
A thought to keep in mind when trying to pin down those confusing and elusive decibels is that the decibel is a ratio—and without a reference point, it is meaningless. With an understanding of the various types of references and with a short SR-56 program for interconversion between power (or voltage) and dB, anyone can deal comfortably with decibel units, whether discussing active bandpass filters or stereo equipment.

The decibel was first defined to express a sound intensity change—1 dB is the smallest change in sound level that the human ear can distinguish. Mathematically, this intensity change is expressed as a ratio of powers:

$$\text{dB} = 10 \log(P_2/P_1)$$

where a base-10 logarithm is implied. A dB value, therefore, is an exponent, which makes for easy accommodation of gains or losses in a system—dBs are either added or subtracted.

To impart an absolute value to decibel quantities, references are appointed to represent the value of P_1 in the equation above. Though there are many in use today—probably more than 75 different references in all—two common references for audio and other applications are designated dBm and dBW. The first refers to a power level of 1 milliwatt, while the second is referenced



Decibel relationships. Values of power are shown relative to decibel levels of different references. Note that linear decibel scales (four are shown out of at least 75 with different references throughout the world) correspond to logarithmic power scale.

to 1 watt. By substitution into the equation above:

dBm = 10 log (P/0.001)
dBW = 10 log P

By manipulation of terms, it can be shown that for interconversion between the two:

dBm = dBW + 30.

Most other references are established to suit the particular application. For example, the telephone company uses 6 mW as a reference, since it is compatible with its system. Those involved with noise-measuring systems use dBrn, for reference noise, which is usually referenced to 1 picowatt. The figure shows the relationships among the various dB references. The program in the table interconverts dBm with power and voltage for a given impedance. With a little practice, it should be no problem to think logarithmically. □

SR-56 DECIBEL INTERCONVERSION PROGRAM

LOCATIONS	CODES	KEYS	COMMENTS
00 – 04	*44 03 32 15 41*	*EE 3 x↔t CLR R/S*	*Convert volts to dBm for given circuit impedance*
05 – 08	*43 54 32 84*	*x^2 ÷ x↔t =*	
09 – 13	*18 64 01 00 94*	**log × 10 =*	
14 – 17	*49 03 41 42*	**fix 3 R/S RST*	
25 – 28	*54 01 00 94*	*÷ 10 =*	*Convert dBm to volts for given impedance*
29 – 32	*19 32 15 41*	**10^x x↔t CLR R/S*	
33 – 36	*64 03 19 64*	*× 3 *10^x ×*	
37 – 41	*32 94 48 49 03*	*x↔t = *$\sqrt{x}$ *fix 3*	
42 – 45	*41 22 02 05*	*R/S GTO 25*	
50 – 52	*54 03 93*	*÷ 3 +/−*	*Convert watts to dBm*
53 – 55	*19 94 18*	**10^x = *log*	
56 – 60	*64 01 00 94 41*	*× 10 = R/S*	
61 – 63	*22 05 00*	*GTO 50*	
64 – 67	*54 01 00 94*	*÷ 10 =*	*Convert dBm to watts*
68 – 71	*19 64 03 93*	**10^x × 3 +/−*	
72 – 74	*19 94 41*	**10^x = R/S*	
75 – 77	*22 06 04*	*GTO 64*	

INSTRUCTIONS

1. Enter circuit impedance:

   [Z], press R/S

2. To get level in dBm, enter voltage level in millivolts:

   [mV], press R/S

3. To convert dBm to volts:

   [dBm], GTO 25 R/S

4. To convert watts to dBm:

   [W], GTO 50 R/S

5. To convert dBm to watts:

   [dBm], GTO 64 R/S

If voltage levels are to be in μV, change [3] in steps 01 and 34 to [9].

For multiple conversions, follow each with R/S.

Engineer's newsletter

It's time to size up CCDs and bubble chips for jobs like . . .

With useful hardware finally becoming available in CCD and bubble memories, it's time for system designers to evaluate the technologies and gauge their merits against the competition. Texas Instruments, Fairchild Semiconductor, and Intel will be supplying 65,536-bit charge-coupled devices, and TI will be offering 92,304-bit bubble chips. **These serially-accessed chips will be used for bulk storage**—they're not RAMs and they're not fast, so forget them for main memory. The competition is disks, tapes, and drums, depending on the size of the system.

Suddenly we're in the price-conscious, slow, moving-magnetic-memory domain, and not in the performance-is-everything mainframe and buffer area once dominated by core memories. There, the higher-performing semiconductor products quickly overcame their greater entry costs. **In short, the new memories will have to make it on price.**

. . . mass-storage gear

First consider the drum, tape-file, or rigid-disk systems holding up to several hundred million bytes of memory. For these systems, access times of more than 1 millisecond a word are perfectly acceptable, and costs fall well under 1 millicent per word. **That cost is so far out of the present grasp of CCDs and bubbles** that it's difficult to perceive when either will dig out the entrenched mass-storage gear. Take another look in five years.

. . . mid-sized systems

Next consider the medium-capacity storage system—that 300,000-to-500,000-byte peripheral or minicomputer-based system that is now the bread and butter of floppy-disk manufacturers. **Again the prospects for CCDs and bubbles quickly grabbing the business are dim.** For about $500, a designer can buy a floppy-disk drive with 400,000 bytes of memory. With power supplies and controllers, he's in the $600-to-$700 range.

A 65-k CCD chip currently sells for $195 in prototype. Even at a 1978 production price of $25, the 50 chips needed to make up 3.2 million bits would cost about $1,200, or nearly twice as much as the average floppy. Same for bubbles, where a 92-k chip now costs about $200. **Bubble chips, however, will rapidly get denser**—reaching the 250,000-bit level by the end of the year. Depending on the bubble learning curve, the price per bit might drop fast enough to have an impact on the half-million-bit floppies. Unfortunately, bubble chips need plenty of peripherals to make a system, and these add to system costs.

So the medium-capacity storage systems still appear too tough for present CCD or bubble chips to crack. Look again in two years.

. . . small-storage files

Ah, but the small storage file—that's where the CCD and bubble chips could move right in. There's an increased need for an under-100-kilobyte memory storage in microprocessor-based peripheral and terminal equipment, as well as in consumer-oriented microprocessor-based designs. The competition here is the minifloppy, currently costing about $300 for a 64,000-byte system, excluding interface circuits. **That's right in the ball park for CCDs and bubbles.** By year's end, the parts for a 64,000-word memory store composed of 8 to 10 CCD chips could cost less than $250 and require very little additional overhead circuitry. The chips would fit on the same pc boards that handle the rest of the system and share the same components, including power supplies.

The cost for a small bubble store may initially be higher. But bubbles have the advantage of being nonvolatile and just right for designs where memory loss from power interruption is critical—point-of-sale terminals, home video games, telephone gear, and so on. **Laurence Altman.**

System aims at universality

Tektronix is first major instrument house to move toward marketing a development system for all microprocessors

by Stephen E. Scrupski, Instrumentation Editor

The days of a multiplicity of microcomputer development systems—practically one from each semiconductor manufacturer making a microprocessor—may be coming to an end. Tektronix Inc. has become the first major instrument manufacturer to offer the beginnings of a universal system—one that can handle more than one microprocessor manufacturer's device.

The system, called the 8002, is based on a design from Millennium Information Systems, Santa Clara, Calif. [*Electronics, Sept. 16, p. 91*], but Tektronix has enhanced it. Early versions of the system will handle the 8080 and 6800 microprocessors. The company says support for additional devices will follow, promising a Z-80 module for late summer. "During the life of the product, we would expect to support somewhere between 10 and 15 chips," says Lewis McFarland, marketing product manager for the 8002.

The Beaverton, Ore., company says it recognizes a growing need among microprocessor users to be able to select the best device for a particular job without having the decision biased by an existing big investment in a development system that handles only one device. A universal system would make it easy to change from one device to another, and "the market is growing fast enough so that we feel that people will need a firm like Tektronix, which can offer nationwide support for a product such as this," adds McFarland.

The 8002 is a full development system, including facilities for program development and assembly, along with in-circuit emulation for debugging. A smaller version, the 8001, is aimed at those who already have program-development equipment and want to add in-circuit emulation.

The system differs from Millennium's by having a third processor. The Millennium system used a master processor—called the "system processor" by Tektronix—to control the disk operating system and such jobs as file management and system input/output. A second processor—Tektronix' "emulator" processor—personalizes the system to the target microprocessor, executing the program in the prototype system and controlling the prototype input/output. In the 8002, the third processor—the "assembly" processor—is given only one job: performing program assembly in a table-look-up mode.

The 8002 consists of:

- The basic system box, which holds the processor cards, random-access memory, interface boards, and a programmer for read-only memory.
- A Tektronix CT-8100 video terminal for interactive programming.
- A dual floppy-disk drive storing about 300 kilobytes on each disk.

In running the system, the user first enters his program and edits it. The program is converted to the object code for the target microprocessor, and the object code is stored on the disk. The program then is debugged while it runs on the emulator CPU.

By plugging a cable into the socket where the actual microprocessor will be inserted in the prototype, the user gains access to all the I/O circuitry of the prototype, while using the system's memory for program storage. Finally, when the user is satisfied with the program, he can transfer it to PROMs, which can be inserted in the prototype and debugged.

The basic price of the 8002 is $9,950. The emulator module is an additional $1,850, and prototype cable needed for in-circuit emulation is $850. The 8001, which will be available in late summer, will be priced about $2,000 less.

Tektronix Inc., P.O. Box 500, Beaverton, Ore. 97077. [338]

Digital scope keeps it simple

Nicolet hopes to find demand for personal instrument that stands on the bench, rather than serving as part of a system

by Larry Armstrong, Midwest bureau manager

The term "digital oscilloscope" has been applied to many different types of test and measurement equipment—from analog scopes with a few digital features to expensive all-digital units with complex controls and sophisticated processing capability. But now, a small Madison, Wis., firm is stripping much of the mystery, as well as the cost, from digital scopes.

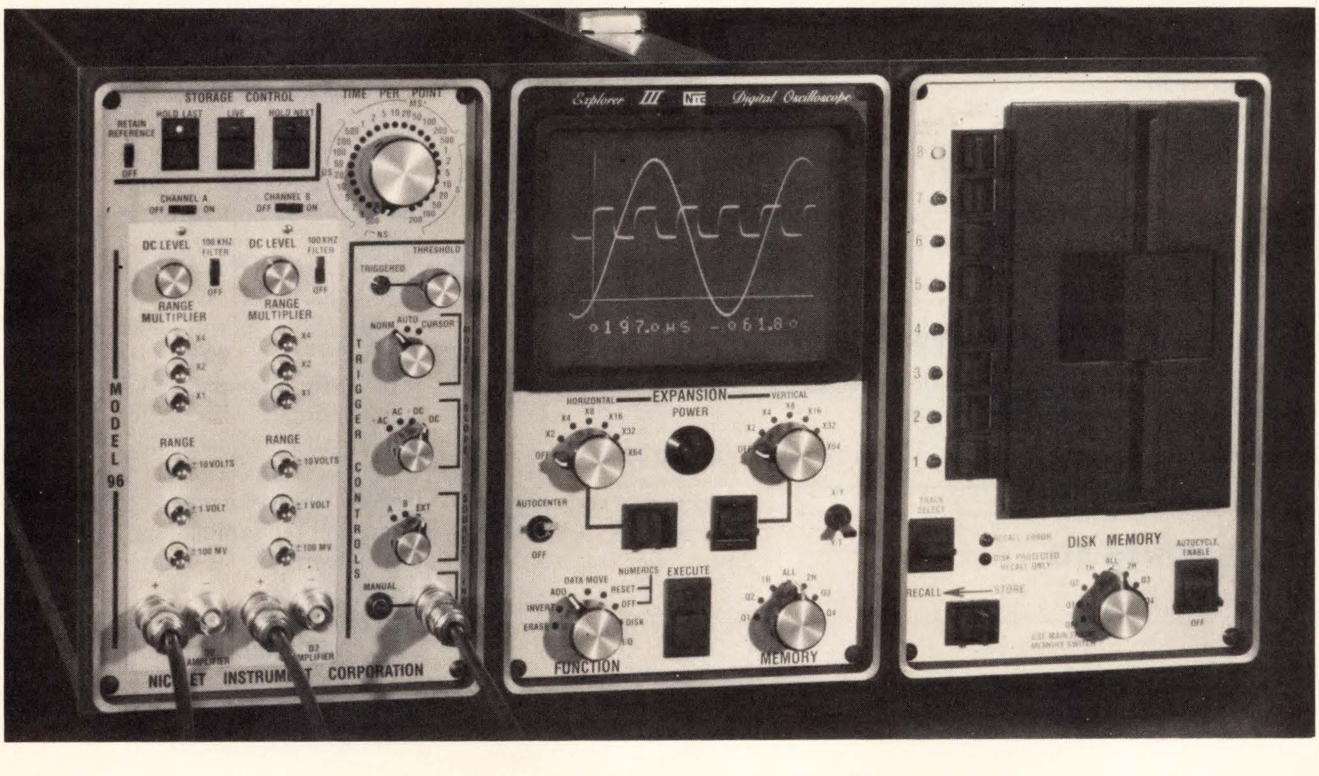
Nicolet Instrument Corp. hopes buyers will view its new Explorer II digital oscilloscope as an analog-scope replacement. The company, which has been shipping digital scopes for two years, redesigned its model 1090, eliminated the input/output ports, and reduced the price by nearly 30%. Deliveries of the $4,400 unit will begin in June.

"We're now at the edge of getting into the general-purpose market with a 'personal' tool, a digital scope that belongs on the engineering workbench, instead of belonging to a group or dedicated to a system," says Robert W. Schumann, president of Nicolet's Oscilloscope division. While the scope's 1-megahertz bandwidth will limit the Explorer II to precision low-frequency applications, "that's an important part—perhaps 10%—of the total scope market," he notes.

"Loosely, it can be described as an area where people use transducers. Thermocouples, strain gages, accelerometers, and flowmeters, for example, work at low frequencies, and users aren't interested in wideband scopes there because of noise problems." Another segment of that market is communications, where users are looking at electrical signals in which there are no high-frequency components.

Nicolet, which has started work on a series of plug-ins with higher sampling rates, later this year hopes to have available plug-ins that offer a slightly wider bandwidth with the same resolution and accuracy, as well as a series that sacrifices performance for dramatically improved bandwidth. "But we haven't considered expanded bandwidth as urgent a problem as getting the cost down. All our engineering for the past year has been in cost reduction," Schumann says.

The new scope is all-digital: input signals are converted to digital form



by any one of several plug-in modules, and that information is thereafter handled by ADM 2901 bipolar microprocessors in the scope's mainframe. "But Explorer II is an analog-scope replacement, a stand-alone digital scope that can only be used for the visual display of waveform information," Schumann emphasizes. Only limited waveform-manipulation capability has been included, but the scope has storage and display, of course, as well as inversion, automatic centering, and vertical repositioning.

Advantages. Having the information in digital form gives advantages that should outweigh the price premium over analog scopes. Besides the high accuracy and resolution of digitally displayed voltage and time for any point on the waveform, digital scopes also can:

- Look at signals preceding an event, using the scope's mid-signal trigger capacity and associated buffer memory.
- Operate very slowly, acquiring and displaying high-resolution signals overnight, for example, since the display will not fade or bloom as can displays on analog storage oscilloscopes.
- Compare a signal on-screen with a retained reference signal taken from the same source.

Nicolet also plans to introduce its Explorer III digital oscilloscope in June. Priced at $7,200, it is identical to the Explorer II but has an input/output port so it can communicate with a computer. This oscilloscope also has a provision for a plug-in diskette.

Plug-ins for both include the 205-1 single input, 206-1 single input with buffer memory, and 206-2 two-channel input with buffer. Resolution on all plug-ins is 0.025% of full scale rms from 0.1 to 10^6 hertz. Rise time is 500 nanoseconds to the 70% point, and the sample-and-hold aperture uncertainty is limited to 5 ns. Sweep-timing accuracy is within ±0.02% with an additional sweep-start uncertainty that is put at 25 nanoseconds.

Nicolet Instrument Corp., 5225 Verona Rd., Madison, Wis. 53711. [339]

Components

Bubble memory bows at 0.2¢/bit

92,304-bit device sells for $200, has 4-ms access time

When bubble memories were first developed at Bell Laboratories, it was widely assumed they were destined for mass memories in large computer systems. But that is not the way things are turning out.

The first commercially available magnetic-bubble memory, recently announced by Texas Instruments [*Electronics*, March 17, p. 40], is expected to find its major applications in microcomputer systems. Its main advantages in such systems are those that had been predicted—nonvolatility, low power consumption, and low cost. Its chief competitor in terms of speed and capacity—the floppy disk—cannot compete in price for systems that need less than about a megabit of mass storage.

At present, sample quantities sell for $200 each or about 0.2 cent per bit. By the end of the year, when the memory is in high-volume production, the price is expected to drop to about $45 or 45 millicents per bit.

The TBM0103 is a 92,304-bit device housed in a 14-pin dual in-line module measuring 1.1 by 1.0 by 0.4 inches. The package contains the memory on its gadolinium-garnet substrate, two orthogonal coils that provide the necessary rotating magnetic field, a pair of permanent magnets, and a magnetic shield to protect stored data from external fields.

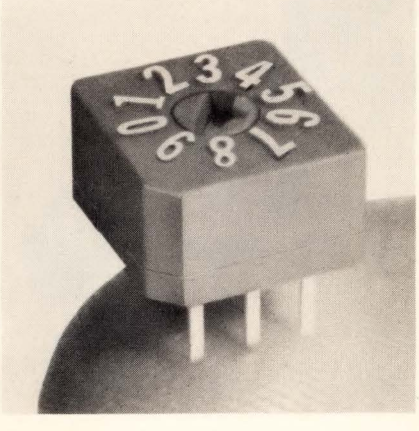
The memory has major-loop/minor-loop architecture. Data bits are written into and read out of the major loop. Storage is accomplished by transferring the data into the 144 minor loops, each of which has 641 bubble positions. Key specifications for 100-kilohertz operation include an access time of 4 milliseconds for the first bit, a cycle time of 12.8 ms for a 144-bit page, and a power consumption of about 0.5 watt for continuous operation. The memory will operate over the temperature range from 0°C to 50°C, but it will provide nonvolatile storage from −40°C to 85°C.

Since the TBM0103 is a magnetic device, it must be driven by accurate current pulses. It therefore needs a function driver to convert standard TTL voltage levels into the required drive currents. Similarly, its coils must be driven by appropriate current sources, and its output must be detected by a sense amplifier. Finally, the overall operation of the system must be controlled by a device that starts and stops bubble shifting, maintains page-position information, and maintains synchronism within all of the memory elements. Interfacing circuits to perform these functions either exist or will soon be available from TI.

Texas Instruments Inc., Inquiry Answering Service, P.O. Box 5012, M/S 308 (Attn: TBM0103), Dallas, Texas 75222 [341]

Tiny 10-position switch handles 100 mA at 5 V dc

The Micro-Dip is a 10-position coded switch that occupies only half of a 14-pin DIP socket. Able to handle loads up to 100 milliamperes at 5 V dc, the switch operates over the temperature range from −10°C to 60°C. It can be rotated in either direction by means of a screwdriver; numbers on top of the switch indicate its position.

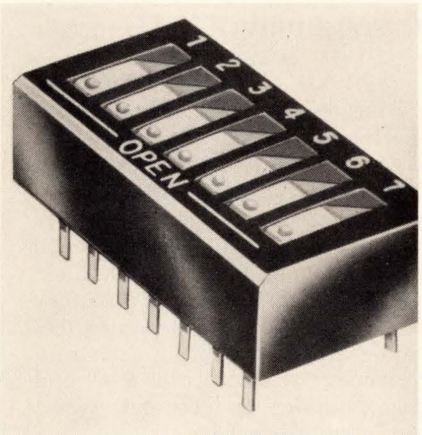


The switch's glass-filled epoxy housing measures 0.38 by 0.40 by 0.24 inch. Its contacts are gold-plated. Available codes include BCD and complemented BCD. In quantities in excess of 10,000 pieces, the Micro-Dip is priced below $1.

EECO, 1441 East Chestnut Ave., Santa Ana, Calif. 92701. Phone (714) 835-6000 [344]

Rocker DIP switch has recessed actuators

In the recessed rocker DIP switch, the rocker actuator is recessed below the top surface of the housing, permitting tape to be used as a seal for the



top of the switch during the solder cleaning operation. Recessed rockers also reduce the likelihood of accidental operation. Offered with from two to 10 spst switches, the recessed-rocker DIP switch is priced from $2.01 (two-station) to $2.46 (10-station) each in lots of 500 pieces.

Grayhill Inc., 561 Hillgrove Ave., La Grange, Ill. 60525. Phone (312) 354-1040 [347]

Latching relays conserve energy

A push-to-latch or push-to-release relay can save energy by requiring no coil current during long "on" times. The model R10H and R10K are offered with two or four form-C circuits that are rated for use up to 3 amperes at either 28 v dc or 115 v ac, resistive. On the R10H, pushing in its button closes the normally open contacts and opens the normally closed contacts. Energizing the coil releases the latch but does not affect the contacts. When coil power is removed, the contacts return to their normal position.

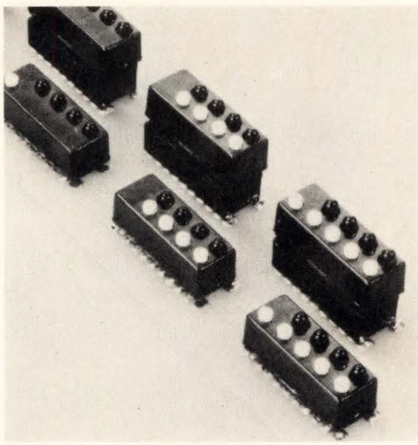
The R10K works in an analogous but opposite fashion. Energizing the coil moves the contacts and allows the latch to fall into place. When the coil power is removed, nothing happens. With the power removed, pushing the button opens the latch and allows the contacts to return to their normal position.

The relays are well suited for use in power-off alarm circuits, fail-safe circuits, battery chargers, and security systems. They are offered with coil voltages from 3 to 115 v dc. In large quantities they sell for $3.63 each. Delivery time is six to eight weeks.

Potter & Brumfield Division of AMF Inc., Princeton, Ind. 47671. Phone Roy Stewart at (812) 386-1000 [346]

Push-button switches are combined with LEDs in DIP

A line of components in which push-button switches and miniature light-emitting-diode lamps are combined in a dual in-line package is suited for many applications in logic circuits. The lamps can be used to check logic codes, for example, while the mom-

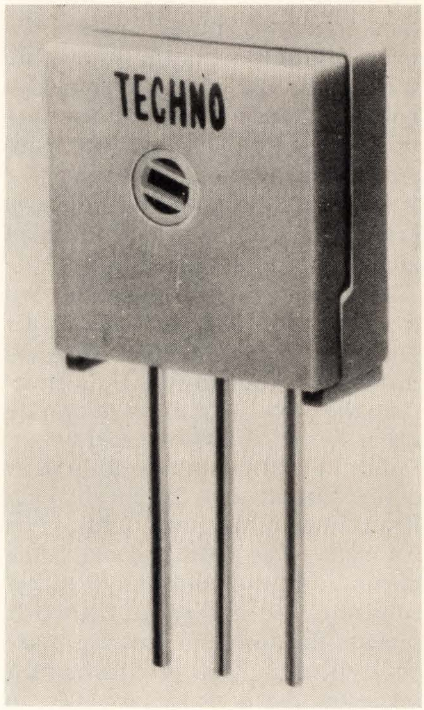


entary-contact single-pole, single-throw switches are used to clear individual bits, to clear codes, or even to test the LEDs. The type 43 DIP is available with as many as four LEDs and five normally open switches. It can be installed in a standard 18-pin DIP socket.

Licon, Division Illinois Tool Works Inc., 6615 West Irving Park Road, Chicago, Ill. 60634 [345]

Multiturn trimmer fits in single-turn package

Housed in a package that measures about ⅜ inch square by less than 0.2 in. thick, a three-turn film potentiometer combines the convenience of a single-turn trimmer with the vibration and shock resistance of



multiturn devices. The model 413/414 is offered with resistances from 100 ohms to 1 megohm and can dissipate 0.5 watt at 85°C. Maximum required torque is 5 ounce-inches, and minimum rotational life is 200 cycles.

Techno-Components Corp., 7803 Lemona Ave., Van Nuys, Calif. 91405. Phone (213) 781-1642 [343]

Microprocessors

Analyzer handles up to 10 types

Undedicated tester can also function as 32-bit logic analyzer

The load is going to be a little bit lighter for troubleshooters and field engineers testing more than two or three types of microprocessors with a microprocessor analyzer. They need no longer add special "personality" boards when testing the additional types if they use an Edac Corp. analyzer that can handle up to 10 types.

Now in the prototype stage, the Edac 2001 microprocessor analyzer is based on an 8080-type microprocessor. It has the room for a number of extra features not found in any one analyzer on the market. The $5,000 instrument is not only "a highly sophisticated microprocessor analyzer, but since it is undedicated, it can be used as a 32-bit logic analyzer as well," says Fred Kreiss, general manager.

"It's not that much more expensive if you design it that way from the beginning," says Jonathan Gabel, engineering manager. "The results should provide software engineers with a simple tool for their troubleshooting." Programs can be entered in binary, octal decimal, or hexadecimal. Some logic analyzers require the use of a display formatter for display in these formats, as well as for digital timing diagrams, mnemonics or combinations. Thus, says Gabel, "any data field can be in any format." Clock rate is 20 megahertz in normal mode and 10 MHz in internal sampling.

Trigger features include a 32-bit-wide compare path and multiple trigger delay. The trigger word and an "equal/not equal" capability are associated with each of the 32 data lines. For instance, if a jump instruction is incorrect in one of the lines and branching to the wrong place, a push of "not equal" will pinpoint its locations and set up the correct jump instruction. Intermittents are clearly shown by word inversion. "The machine stops taking measurements, and the snapshot is left on the screen with the items that are not equal inverted so you can see where it doesn't match," Kreiss says.

Another method of viewing problems, he says, is hitting the display button, which alternates between showing the stored comparison and the "not equal" information. "Equal/not equal" is also available for block comparison, allowing the user to look at just three lines rather than the whole screen.

In addition, the 2001 has a self-test mode that performs error correction in the read-only memory and a standard memory test in the random-access memory. Map mode is also available. The 2001 offers a $300 memory option and dissemblers at $350 each. The firm will be taking orders in late March, with a 60-day delivery.

Edac Corp., 1417 San Antonio Ave., Alameda, Calif. 94501 [399]

Programmer added for MCS-48 family

To complement its new one-chip MCS-48 microcomputer family, Intel Corp. has begun marketing the Prompt 48, a stand-alone easy-to-use microcomputer programmer. According to John Doerr, Prompt product manager, the Intellec Prompt 48 is a fully assembled, self-contained design aid that can be used either as a personal programming tool and MCS-48 development station or integrated with other development aids. For example, with the addition of the specialized Prompt SSP kit, it can serve as an economical programmer in an Intellec microcomputer-development system.

Available now, Prompt 48 is priced at $1,750, which includes two of the MC-48 one-chip processors—the 8748 and the 8035 [*Electronics*, Nov. 25, 1976, p. 99]. The Prompt 48, says Doerr, has been designed for ease of use. Programs written first in assembly language can be entered on a hexadecimal keyboard in machine language. Most MCS-48 operations can be specified with only two keystrokes. The unit contains program memory, data memory, and input/output and system monitor capabilities beyond those available on MCS-48 single-component computers.

Prompt's programming socket programs an 8748 "smart programmable read-only memory," and a fail-safe interlock ensures that the device is properly inserted before the programming pulses are applied. Each location may be individually

programmed, one byte at a time. A read-before-write programming algorithm prevents device damage from the inadvertent programming of unerased memory.

An execution socket accepts either an 8035 or an 8748, since either can serve as the heart of the Prompt system. "There are no processors within the Prompt 48 mainframe," says Doerr. "Instead, it contains monitor ROM and RAM, peripherals, drivers, and sophisticated control circuitry."

Once a processor is seated in the execution socket and power is applied, the system comes to life. Various access modes, such as program execution from Prompt system random-access memory or from on-chip PROM, can be selected. When debugging is complete, an 8035 in the execution socket can program the 8748 in the programming socket. Finally, a programmed 8748 can be exercised by itself from the execution socket.

Prompt 48 commands are grouped and color-coded on a separate keyboard to simplify access to the 8748's separate program and data memory. The user can, via these keys, examine and modify registers, data memory, or program memory. In addition, 13 functions on another keyboard on the front panel simplify programming even further. Each is started merely by pressing a hex data/function key and entering parameters as required.

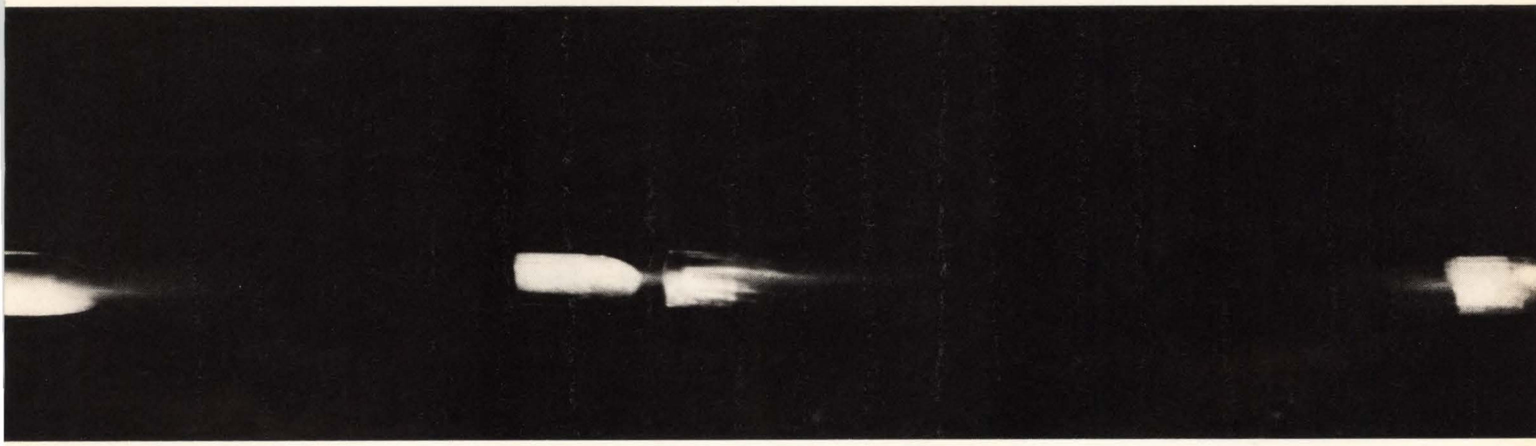
Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051 [400]

Analog board works with Z-80

The MAD-one real-time input/output board is designed to enhance overall throughput rates of systems based on Zilog Inc.'s Z-80 microprocessor. It is the first of a family of analog interface cards compatible with the Z-80.

Developer Signal Laboratories Inc., Orange, Calif., says the interface offers a "commutating memory" feature that speeds up processing of analog data by some 25% over conventional handling techniques. This speed-up is accomplished, explains Del Flagg, vice president of engineering, by storing the input channel sequence in the 64-byte-deep memory on the analog board itself. In other interfaces, the signals go directly to the random-access memory associated with the processor, which is slowed by having to devote some processing time to them.

The interface board accepts up to 32 input channels and provides both sample-and-hold and programmable-



gain amplifiers, as well as a 12-bit a-d converter. Options are two 12-bit d-a converters, 4- to 20-milliampere current outputs, and a single 5-volt power supply. Maximum throughput rate is 100 kilohertz, based on a 2-microsecond settling time, followed by an 8-microsecond a-d conversion time. Operating temperature is 0°C to 70°C. Size of the board is 7.7 by 7.5 inches, with 0.5-in. board-to-board spacing.

Price of the basic interface is $595, in quantities of 1 to 9, going up to $910 with all options, including an analog multiplexer expender. Delivery is in four weeks.

Signal Laboratories Inc., 202 N. State College Blvd., Orange, Calif. 92668. Phone (714) 634-1533 [401]

Microprocessor set uses C-MOS

Paralleling a trend in standard metal-oxide-semiconductor microcomputer technology, complementary MOS is moving from short-run, high-cost applications to the higher-volume microcontroller market. National Semiconductor Corp. is introducing a C-MOS microcontroller/processor chip set designed for low-cost, low-power calculators, watches and control systems.

Architecturally similar to National's present family of p-channel MOS processor/microcontrollers [*Electronics*, May 27, 1976, p. 146], the two chips, designated the M58102 and MM59102, are aimed at some of the same applications, especially where long battery life and nonvolatile memory storage are important. The two devices are available in unpackaged die form for $15 per set in quantities of 10,000 or more.

The control read-only-memory chip holds the function program and is organized as 32 pages of 64 eight-bit instruction words, says Erick McCleod, project manager. Addressing is by an 11-bit program counter register with two 11-bit push-down address-save registers. Five switch inputs and eight matrix-drive outputs allow scanning of up to 40 switches.

A divide-by-32,000 countdown chain is contained on the chip and accepts a 32-kilohertz quartz-crystal input to provide a 1-hertz output for timekeeping. There are also three program-definable input/output ports and an additional output port.

The second chip, the memory and processor element, contains 384 bits of C-MOS random-access memory organized as eight 12-digit registers. Arithmetic and logic functions are performed by an on-chip bit binary adder with the results stored in an accumulator.

Forty-eight latched outputs provide for direct driving of a six-digit liquid-crystal display. For each digit position there are seven segment outputs plus a decimal-point output. Also included is voltage-doubler circuitry that takes a 3-volt battery input and generates a 6-V peak-to-peak square wave for the LCD backplane voltge. Each chip in the set consumes about 25 microamperes.

Using this chip set, National engineers have built a full-capacity scientific-calculator-cum-digital-watch module complete with keyboard and liquid-crystal display. It is priced at $110 each in single-piece evaluation quantities. Besides the six-digit continuous display of hours-minutes-seconds, the unit has a month/date calendar, a.m./p.m. indicator and dual viewing lights. In the calculator mode it employs algebraic logic and has scientific notation, store/recall memory, pi, powers of numbers, register exchange, and reciprocals.

National Semiconductor Corp., 2900 Semiconductor Drive, Santa Clara, Calif. 95051 [402]

Semiconductors

V-f converter is linear

For $6.10, monolithic unit offers 12-bit performance to 10 kHz

Voltage-to-frequency converters provide an inexpensive means of digitizing analog signals, but only fairly costly modular units have delivered the linearity performance necessary for precision applications. However, a new low-cost monolithic V-f converter from Burr-Brown Research Corp. holds nonlinearity to a guaranteed maximum of ±0.01% at 10 kilohertz full-scale, which is equivalent to ±½ least significant bit for a full scale of 12 bits. At 100 kHz, the new VFC32 offers 10-bit linearity, keeping errors to within ±0.05% maximum.

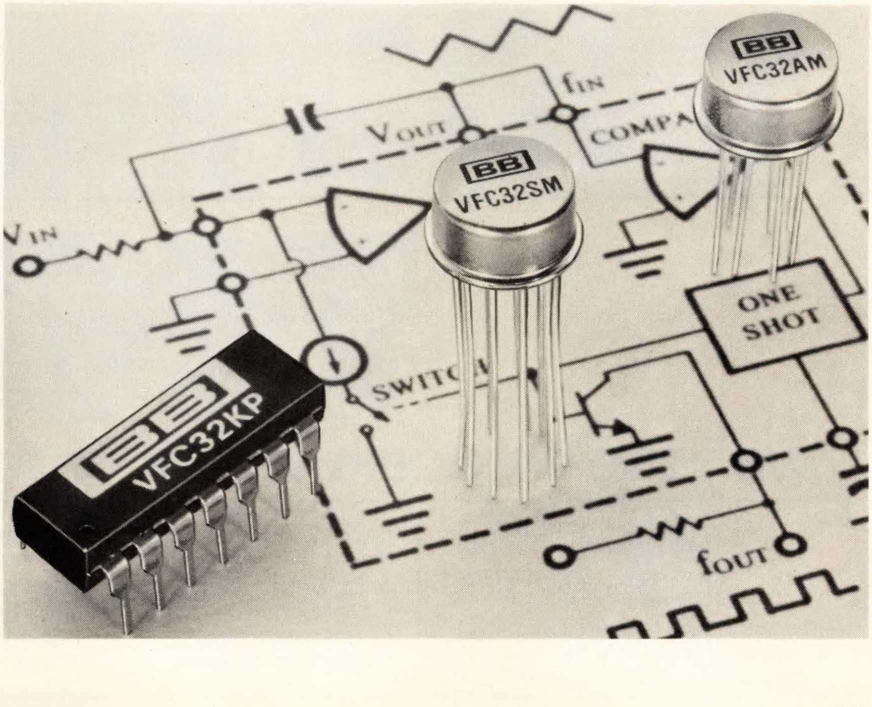
The 10-kHz linearity performance "represents at least a seven-fold improvement over many listed competitive specifications," claims Joe Santen, manager for data-conversion products. Also, he notes, most other monolithic V-f converters have a 100:1 range, compared to the VFC32's six-decade dynamic range of 0.5 hertz to 0.5 megahertz. The device, which sells for $6.10 each in 100-up quantities, is priced "significantly below similar monolithic converters that provide only ±0.07% linearity," he adds.

Essentially, the VFC32 generates a train of constant-width, constant-amplitude pulses with a repetition rate proportional to the amplitude of the analog input voltage. However, the unit may be used as either a V-f or f-V converter. The VFC32 has an open-collector output that is compatible with DTL, TTL, and C-MOS logic families. It accepts input voltages of ±10 volts and positive current inputs of up to 0.25 milliampere.

Santen sees the improved linearity of the device making it "an excellent choice for use as the front end of a-d converters with 8-to-12-bit resolution." Additional applications include those requiring "highly accurate transfer of analog data over long lines in noisy environments," a common situation in industrial process control, where the 500-millisecond operating speed of the VFC32 is adequate.

Along with taking a "good deal of care" over thermal characteristics and device geometries, Burr-Brown designers get the improved converter performance with a different technique for capacitor discharging. Instead of the usual single current source, which sometimes varies enough to cause unacceptable errors, the VFC32 employs a pair of current-matched transistors. Any errors in one transistor cancel out proportional errors in the other, thereby providing precise control over timing.

Available in three models, the VFC32's lowest-cost KP version is a 14-pin epoxy dual-in-line unit specified from 0°C to 70°C, while the BM and SM models are in hermetically sealed TO-100 packages, specified from −25°C to +85°C and −55°C to +125°C, respectively. Full-scale drift is rated at 100 ppm/°C for the two higher-performing versions, 150 ppm/°C for the lower. Offset drift is less than ±2 ppm/°C.

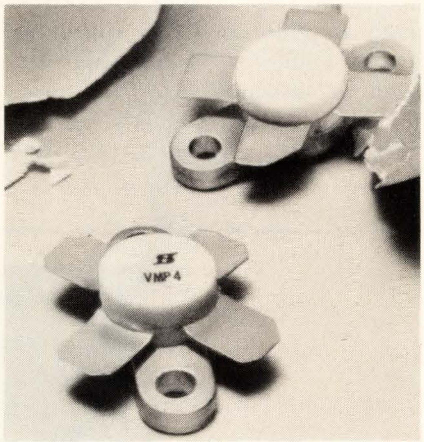


In quantities of 1 to 9, model KP sells for $10.20, model BM for $13.90, and model SM for $19. For 100 to 249, prices drop to $6.10 for the KP version, $10.10 for the BM, and $11.70 for the SM.

Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. 85734
Phone (602) 294-1431 [411]

High-power MOS transistor withstands any VSWR

The VMP 4 is a MOS field-effect transistor with a minimum gain of 10 decibels at 200 megahertz. Because it is a MOS device, it cannot exhibit thermal runaway or second-



ary breakdown; thus, it is immune to load-mismatch burnout, the most common cause of failure of rf transistors.

The n-channel enhancement-mode device has a maximum power-dissipation rating of 35 watts. In continuous operation, it will deliver about 14 w with less than 1 w of rf input. Its saturated output exceeds 20 w for 1 w in.

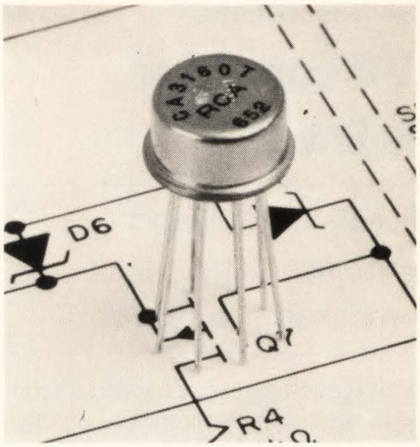
Some of its other key specifications include a typical small-signal noise figure of 2.5 dB at 150 MHz, a maximum output capacitance of 35 picofarads, and a typical two-tone third-order intercept point of 46 dBm over the frequency range of about 50 MHz to 250 MHz. Further, its switching time of less than 10 nanoseconds makes the VMP 4 useful as a switch-mode amplifier as well as a medium-power amplifier in very-high-frequency transceivers.

Housed in the popular 380SOE flange-mount, ceramic, stripline package, the VMP 4 sells for $19.43 in small quantities. The price drops to $16.28 for 30 to 99 units, and to $13.97 for 100 to 999. Delivery is from stock.

Siliconix, 2201 Laurelwood Rd., Santa Clara, Calif. 95054. Phone Jim Graham at (408) 246-8000 [413]

Bi-MOS op amp has internal compensation

The CA3160 series of Bi-MOS (RCA's name for bi-FET) operational amplifiers, features on-chip frequency compensation, typical input impedances of 1.5×10^{12} ohms, and the ability for the output to swing to within 10 millivolts of either (or both) supply rails. The op amps combine a p-MOS input stage with a mixed bipolar-MOS intermediate stage and a complimentary-MOS output stage.



Among the other benefits of this combination are a typical input current of 5 picoamperes at 15 volts, a typical open-loop gain of 110 dB, and the ability to be used easily in single-supply applications. The units have a slew rate of 10 volts per microsecond and a unity-gain crossover of 4 megahertz.

The basic 3160 has a maximum

input offset voltage of 15 millivolts and a price of 80 cents in thousands. The 3160A reduces the offset voltage to 5 mv and raises the price to $1.35. The 3160B, which has established limits for input current, temperature coefficient of input offset voltage, and gain from −55°C to 125°C, sells for $9.95.

RCA Solid State Division, Box 3200, Somerville, N.J. 08876 [414]

Bi-FET circuit forms analog portion of 12-bit converter

The LF13300 is a bi-FET device that constitutes the analog portion of a 12-bit dual-slope analog-to-digital converter. It operates with a companion digital controller built using p-channel MOS technology. In large volumes the two-chip set is expected to sell for less than $10.

Using the bi-FET process, the LF13300 combines two kinds of structures: bipolar op amps with J-FET input stages, and J-FET analog switches with bipolar drivers. The result is a converter with an input impedance in excess of 1,000 megohms. It has a comparator with a typical response time of 2.5 microseconds and an op amp with an open-loop gain of 70,000. Other features include automatic offset correction and compatibility with C-MOS and TTL levels.

The digital controller for the LF13300 is designated the ADB1200P. Conversion time of the two-device a-d converter is about 30 to 40 milliseconds for a clock frequency of 250 kilohertz. For parts that operate from 0°C to 70°C, in hundreds, the LF13300 sells for $6.65 and the ADB1200P for $5.50. Delivery is from stock.

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051. Phone (408) 737-5000 [417]

16-word buffer memory operates from dc to 10 MHz

An asynchronous 16-word, 5-bit buffer memory has independent inputs and outputs that can operate at rates from dc to 10 megahertz. The Schottky-clamped TTL device is intended to interface between digital systems or subsystems that run at different data rates.

On-chip control logic provides status lines to indicate when the memory is full and when the output is ready. It also provides a clock output that permits the easy expansion of the memory to 16N words by 5N bits. Designated the SN74S225, the buffer sells for $4.50 in hundreds.

Texas Instruments Inc., Inquiry Answering Service, P.O. Box 5012, M/S 308, Dallas, Texas 75222. Phone Gerald McGee at (713) 494-5115, Ext. 2621 [415]

Instruments

A meter for all atmospheres

Sensitive rms-responding ac voltmeter is safe for refinery use

Working from the basic design of an ac rms-responding voltmeter intended for use by the Air Force in hazardous atmospheres, Ballantine Labs has come up with a similar meter that conforms to OSHA and UL safety requirements for use in industrial high-hazard areas. The model 9601A covers six decade ranges from 5 millivolts to 500 volts full scale, at frequencies from 10 hertz to beyond 1 megahertz.

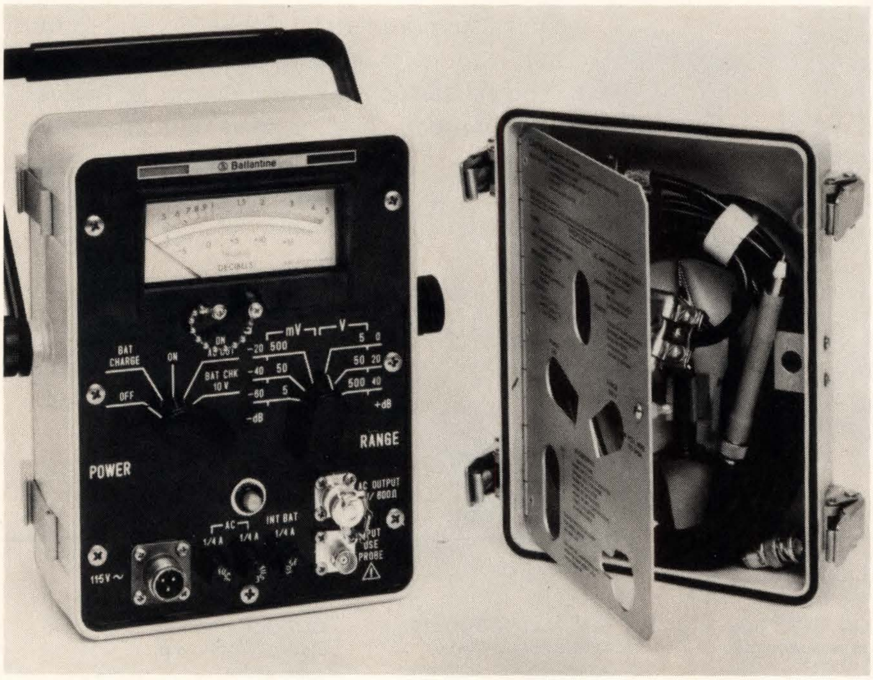
The military version of the meter was originally developed for use on Air Force flight lines to check out fire-control systems while airplanes were being refueled. Now, says Fred Katzmann, president of the Boonton, N. J., company the new meter can be used in such hazardous locations as mine pits, petroleum refineries, gas-processing plants, and other chemical manufacturing facilities.

Packaged in a glass-filled Lexan case with gasketed front and rear covers, the meter is portable, operating from rechargeable batteries as well as from an ac power line. The piggyback battery pack is built into a separate compartment within the rear cover and is isolated from the meter case to avoid damage to the internal circuitry.

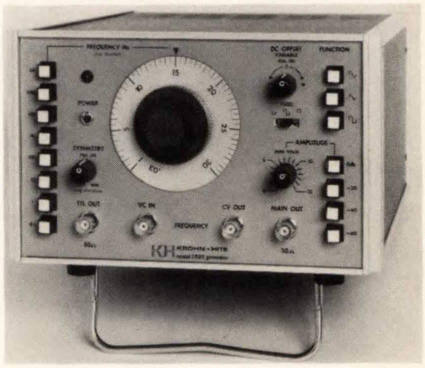
Cold accuracy. Katzmann says that one of the meter's major features is its capability to maintain accuracy at temperatures as low as −40°C. The meter's basic accuracy is within ±3% of reading at room temperature, and the temperature coefficient of accuracy is less than ±0.05%/°C from −40° to 15°C and from 35° to 55°C.

Maximum probe input amplitude is 1,500 V rms. The meter recovers from an overload within seconds after removal of the overvoltage. What's more, it can operate without damage while floating off-ground up to a ±500-V peak. The input probe cable is 40 inches long, and the input impedance is 10 megohms shunted by 25 picofarads. The price of the meter is $995.

Ballantine Laboratories, Inc., P.O. Box 97, Boonton, N.J., 07005. [351]



30-MHz function generator sells for only $895



A 30-megahertz function generator from Krohn-Hite Corp. is the Avon, Mass., company's first high-frequency model for such applications as video and communications testing, checking noise immunity levels of complementary-MOS logic, low-level amplifier testing, and gain/response testing of operational amplifiers. At $895, the model 2000 is $100 cheaper than the nearest competitive 30-megahertz model.

With a frequency range of 0.003 hertz to 30 MHz, the function generator provides multiple waveforms such as sine, square, triangle, positive and negative pulse, positive and negative ramp, and transistor-transistor-logic pulse to a 2% dial accuracy. It delivers 30 volts of peak-to-peak output at a maximum power of 0.5 watt. For more precise readings within 1% accuracy, the control voltage can be monitored with a dc voltmeter or analog monitor.

Sales manager Ernie Lutfy notes that the output is controlled by a four-position push-button attenuator calibrated in 20-decibel steps from 0 to −60 dB. An additional vernier control offers a minimum output of less than 2 millivolts for low-level amplifier testing. "The push-button operation also lends itself to production testing where repeatability and operating ease are desirable," says Lutfy.

Symmetry control, with an adjustable ratio of 100 to 1, allows the operator to shape a waveform from square to pulse and triangle to sawtooth, and so on. The output frequency, determined by a dial and multiplier setting, can also be controlled by external voltage. With use of an external voltage control, the output frequency can be varied over a ratio of 1,000 to 1 across a selected range.

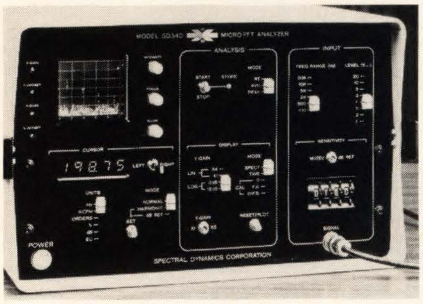
The model 2000 features both variable and fixed dc offset controls "to allow people in the digital world to use the function generator for incoming tests or the design of logic circuits," Lutfy says. The variable offset control allows all waveforms to be positioned from about 0 to a maximum of +15 V. The fixed offset automatically halves the amplitude and fixes the baseline at 0. Both offsets may be used simultaneously to position a fixed base line about zero. Delivery time for the function generator is eight weeks.

Krohn-Hite Corp., Avon Industrial Park, Bodwell St., Avon, Mass. 02322. Phone (617) 580-1660 [352]

Spectrum analyzer resolves 0.25 Hz

A microprocessor-based spectrum analyzer, the SD340 is a low-frequency instrument that can resolve 0.25 hertz on its lowest (0-to-100-Hz) range. The 400-line real-time analyzer has six frequency ranges, the highest of which extends from 0 to 20 kilohertz. Its dynamic range is 60 decibels.

The analyzer includes a light-emitting-diode readout in addition to its cathode-ray-tube display. This readout gives precise values of frequency and amplitude of spectrum components that have been

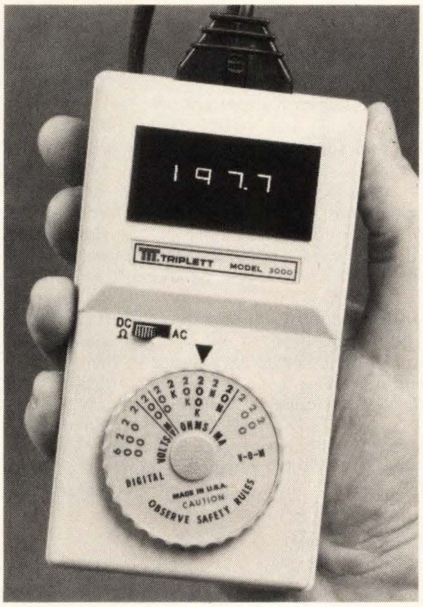


singled out on the CRT screen by a joystick-controlled cursor and light spot. Other key features of the instrument are a times-five expander for detailed examination of a portion of a spectrum and automatic highlighting of harmonics.

Spectral Dynamics Corp., P. O. Box 671, San Diego, Calif. 92112. Phone Leon Corcoran at (714) 565-8211 [353]

Compact digital multimeter offers long battery life

The model 3000 digital VOM is a 10-ounce $3\frac{1}{2}$-digit multimeter that is powered by a snap-in pack of rechargeable nickel-cadmium batteries. A switch on the unit's probe



can be used to turn the instrument on only when a reading is to be taken, permitting several thousand readings to be made on a single charge.

The 22-range meter measures ac and dc voltage, current, and resistance. Full-scale ranges run from 200 millivolts to 600 volts, 2 milliamperes to 200 mA, and 200 ohms to 20 megohms. In addition to battery operation, the model 3000 can be run from its ac adapter/charger. Priced at $140, the meter is available from stock.

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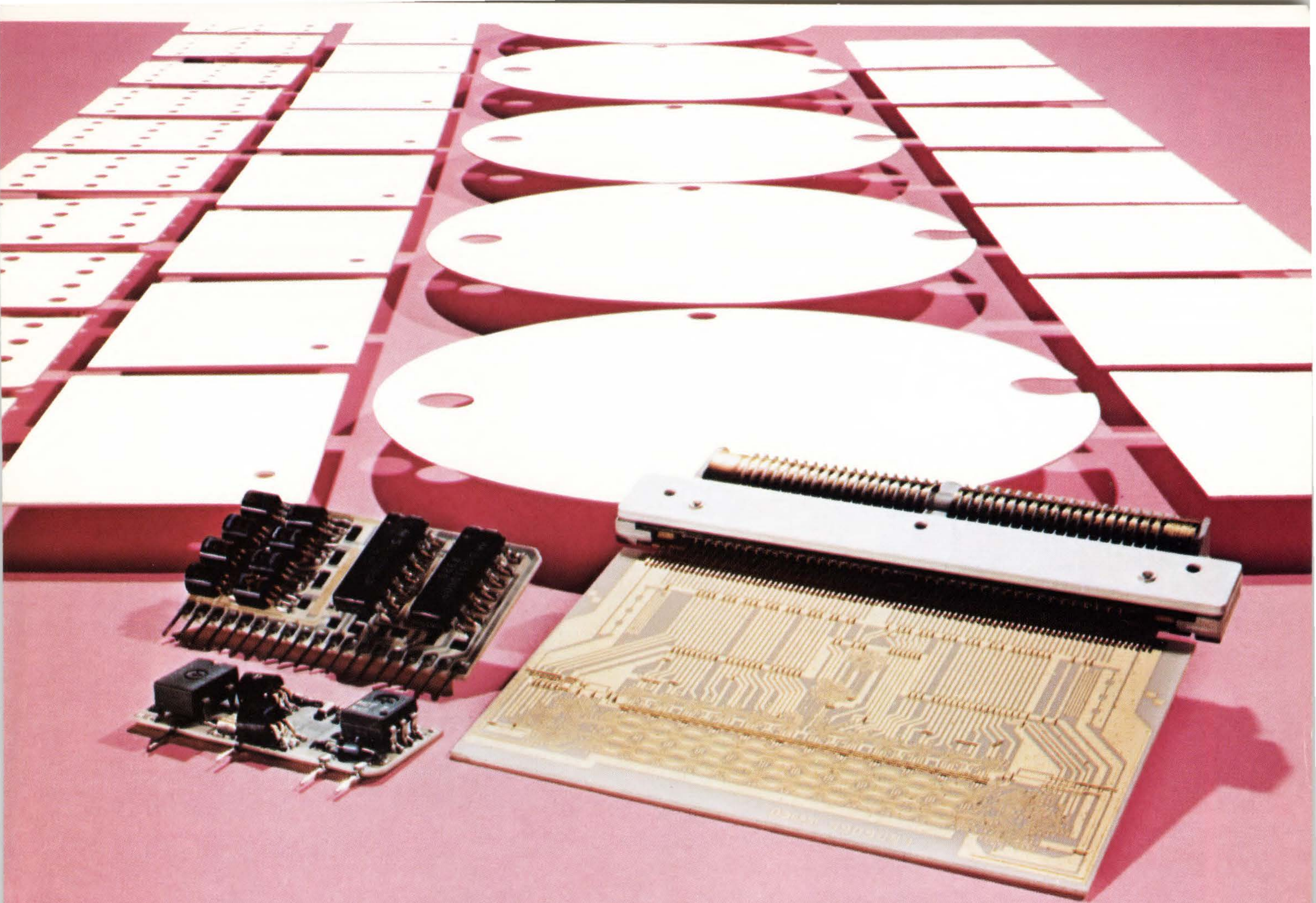

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