

# Digital Design

The Magazine of Digital Systems

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## Giving Minis Maximum Power: EMU

What Do Logic  
Analyzers Do?

Debugging  
Systems In  
The Field

Computer Memory  
Technology / Part II

Microprocessor  
Development  
Systems



# Microcomputers: Just Ask IMSAI.

If you wonder who leads the way in technology, look into IMSAI's list of industry firsts—IMSAI 8048, first complete control computer on a board; IMSAI 65K RAM Board, first to offer four times the memory capacity previously available on one board; IMSAI printers, first with high-speed direct memory access.

If you wonder why IMSAI products have gained the reputation for the standard of excellence in microcomputer systems, check with any one of the more than 10,000 IMSAI owners.

If you wonder who offers the broadest line of hardware, software, and peripherals, visit any one of the more than 275 IMSAI dealers around the world.

If you wonder how microcomputing can fit your specific needs, ask IMSAI. Because when it comes to microcomputers, we have the answers.

## An IMSAI Product to Answer Every Microcomputing Need:

Let's start with our product line. In all, IMSAI offers more than 120 high quality, completely integrated systems, components, peripherals and software. Here's just a sampling:

### Single Board Central Processors:

- MPU-A (8080 based)—Industry standard.
- MPU-B (8085 based)—50% faster 8080.
- 8048—Programmable control computer.

### Interfaces:

- Video I/O—24x80 CRT. Edit & data entry.
- Serial I/O—2 port I/O, all std. protocols.
- Parallel I/O—4 & 6 port TTL level I/O.
- Multiple I/O—2 cassette, 2 parallel, 1 serial & 1 control I/O.
- DMA—for floppies & line printers.

### Peripherals:

- Printers—44/80/132 col. 30 cps-300 lpm.
- Video displays—Large assortment.
- Tape Drive—9 track. 800 bpi. 25 ips.
- Floppy Disks—Single/double density.

### Memory Expansion Boards:

- 4K RAM—Programmable memory protect.
- 16/32/65K RAM-16K paging option for virtual memory addressing.
- Intelligent Memory Mngr.—Handles up to 1 megabyte.

### Self-Contained Systems:

- VDP-80—Computer/terminal/mass storage unit. Assembled & tested.
- PCS-80—Integrated component system.

### Software:

- DOS—Enhanced CP/M.
- BASIC—Interactive or compiler with scientific and/or commercial features.

- FORTRAN IV—Level 2 ANSI compiler.
- Self-contained Systems:
  - SCS 1 & 2/Tcos—Assembler/line editor/debugger.
  - 4 & 8K BASIC—Optional cassette support.

Compare IMSAI. You'll realize that ours is the most complete product line available. Whatever your needs, you can get them from one source. IMSAI.

A wide selection of components is only the beginning. IMSAI offers much more. Just ask.

## Answers For Businessmen:

Announcing IMSAI's VDP-80. This totally self-contained unit includes a megabyte of disk memory via floppy disk, 32K computer memory (expandable to 256K), 12" CRT and 62 pad main keyboard with 10 pad numeric keyboard. Several printer options available.

If you want speed and accuracy in high volume work such as word processing, or business data collection and analysis, the VDP-80 is your cost effective answer.

## Answers For The Personal User & Educators:

Introducing IMSAI's new PCS-80 System, the fully integrated microcomputer component system, configurable to your exact needs. The basic system consists of our Intelligent Keyboard and the PCS-80 which houses an 8085 based CPU, 16K of RAM, intelligent ROM monitor, serial I/O port, 24x80 CRT, with an extra 7 slots in the chassis for expansion.

System component options include single or dual mini and standard floppy disks. The choice is yours, configure the system as you like.

IMSAI has answers for the educator, too. Take the basic PCS-80, add 8K of PROM, 4K of RAM and our self-contained 8K BASIC software, and you have a complete operating system your entire department can use to teach anything from elementary programming to advanced computer science.

Require a bit less sophistication? Use our Intelligent Breadboard system for learning, designing and building microcomputer assemblies.

Rather do it from scratch? Start with our single board MPU-B central processor, the heart of the PCS-80 System. It has a 1K ROM monitor, 256 bytes of RAM and serial and parallel I/O.

Since the MPU-B is 8085 based, you can run all programs previously developed for the 8080. 50% faster. Without requiring faster memory.

## Answers For Industry:

IMSAI products provide the expandability and flexibility manufacturers demand for microcomputing applications.

We offer rack mountable components for the standard 19" RETMA racks, powerful MPU boards, I/O and memory boards for easy system expansion and configuration, and a broad line of peripherals and subsystems fully integrated and ready to go to work.

IMSAI has what you need to make tomorrow's design today's reality.

## Answers For Current IMSAI Users:

There are over 10,000 of you. And, we haven't forgotten. You might say that we thought of you before you even thought of us.

That's why every new product is designed to accommodate expansion, rather than outdated equipment.

For example, our new PCS-80 retrofit kit comes complete with MPU-B, replacement front panel photomask and additional hardware bracketing. So you can enjoy a single cabinet PCS-80 computer, with your choice of integrated component configurations.

## The Answer For Everyone:

Dial (415) 483-2093, Ext. ACT. That's IMSAI's action hotline. Designed to answer the thousands of questions we didn't have a chance to answer in the space of this ad.

Call us. We'll assist you in putting together a system, direct you to your nearest IMSAI dealer, and send you our new catalog with all the details.

In short, if you have any questions at all regarding microcomputers, put us to the test.

Just ask IMSAI.

# IMSAI®

**The Standard of Excellence in Microcomputer Systems.**

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(415) 483-2093 TWX 910-366-7287

Features and specifications subject to change without notice.

# The 8080 "Ice Breaker"

Portable for  
Development - Production Test - Field Service



## BREAKTHROUGH QUESTIONS

**Portable for development,  
test, and field service?**

Real time execution from  
emulator or users system  
memory?

Totally transparent  
control/display functions?

Memory available to user in  
16K emulator system?

High-level relocatable language  
supported by 16K paper tape  
or 32K disk system?

Assembly language efficiency  
with high level language?

Multi-user/Multi-task disk  
operating system?

## muPro-80E

**YES, 4.6" x 6.6" x 15"**  
18 lbs.

YES, phase locked to user  
clock; rate up to 2.86 mHz

YES

ALL 16K

YES, BSAL-80

YES, BSAL-80

YES, plus concurrent batch  
capability

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programs execute slower  
than real time

NO, imposes memory, I/O  
and interrupt restrictions

**LESS THAN 4K (12K+ used by  
ICE-80 driver)**

NO, PL/M® requires 64K disk  
system

NO, PL/M® burdened with  
typical compiler inefficiencies

NO, single user/single task

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Circle

for Demonstration

Circle 100

for Literature

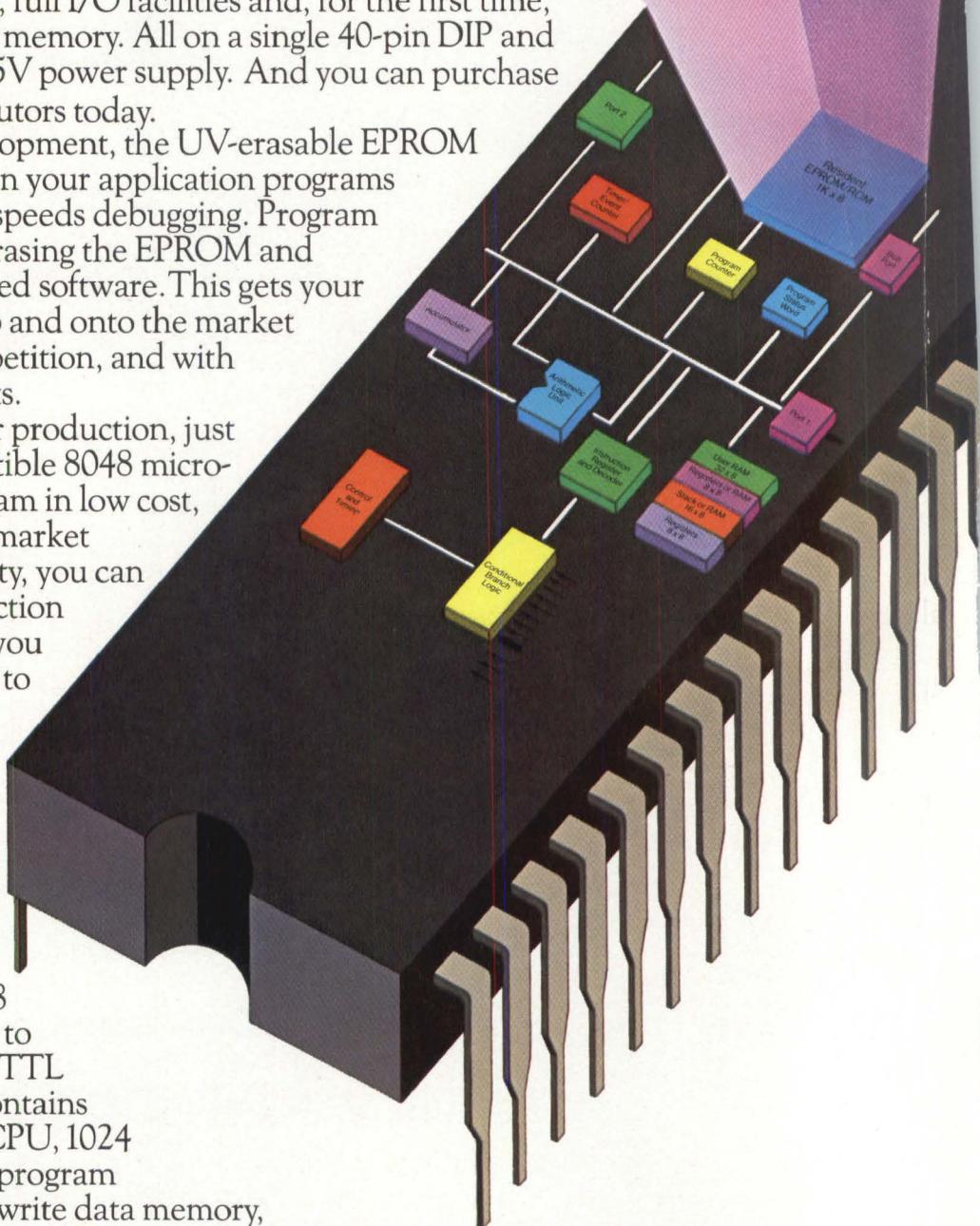
# Intel delivers the first with resident EPROM.

Intel's new single chip microcomputer, the 8748, makes it easier than ever to add intelligence to your products. And it enables you to do it at a lower cost than ever before. It's a complete system with powerful central processor, full I/O facilities and, for the first time, resident EPROM program memory. All on a single 40-pin DIP and operating from a single +5V power supply. And you can purchase the 8748 from Intel distributors today.

During product development, the UV-erasable EPROM enables you to load and run your application programs in minutes. The 8748 also speeds debugging. Program changes can be made by erasing the EPROM and reloading with your updated software. This gets your new product out of the lab and onto the market months ahead of the competition, and with reduced development costs.

When you're ready for production, just substitute the fully compatible 8048 microcomputer with your program in low cost, resident masked ROM. If market entry timing has top priority, you can even ship your first production units with the 8748 while you gear up for the switchover to 8048. And by using the 8748 you can respond to non-standard customer requirements without waiting for ROM turnaround.

Intel's advanced MOS/LSI process technology allows a single 8748 or 8048 chip to replace up to 100 or more conventional TTL devices. The 8748/8048 contains an 8-bit general purpose CPU, 1024 bytes of EPROM or ROM program memory, 64 bytes of read/write data memory,



# single chip microcomputer

## The 8748.

three programmable 8-bit I/O ports, 8 additional control/timing lines, programmable interval timer/event counter, priority interrupts, system clock generator and a full set of system controls. It's a single chip solution to a wide variety of applications, yet it's fully expandable by adding compatible MCS-80™/MCS-85™ I/O chips and Intel® standard memories.

There's also a new 8035 microcomputer that is exactly like the 8748/8048 but without resident program memory. It enables you to precisely match system memory size to your needs, using external ROM or EPROM.

The 8748 is the best supported single chip microcomputer you can buy. To speed development there's the Intellec® Microcomputer Development System with assembly language programming, symbolic debugging, and full EPROM programming capability. The ICE-48™ In-Circuit Emulation module simplifies hardware/software integration and debugging. And the Intel Prompt-48™ Design Aid is a low cost, stand alone alternative for 8748 programming, simulation and debugging. Intel supports you from prototype to production with development software, documentation, training and application assistance.

The new 8748 will give manufacturers of instruments, terminals, communications equipment, controllers, electronic games, automotive products, home appliances and hundreds of other products the competitive edge. It will help you get better products to market ahead of the competition at lower cost.

The 8748, 8035 and all compatible components can be purchased now from franchised Intel distributors: Almac/Stroum, Components Specialties, Cramer, Elmar, Hamilton/Avnet, Harvey Electronics, Industrial Components, Liberty, Pioneer, Sheridan, L.A. Varah, or Zentronics.

Or, for a copy of our single-chip microcomputer brochure write: Intel Corporation, 3065 Bowers Avenue, Santa Clara, California 95051. Telephone: (408) 246-7501.

**intel® delivers.**

Part No.	Description	Availability
<b>MCS-48 Components</b>		
8748	Single chip µC with 1K bytes EPROM	NOW
8048	Single chip µC with 1K bytes masked ROM	NOW
8035	Single chip µC without resident program memory	NOW
B243	I/O Expander with 16 high current drive I/O lines	NOW
B355	ROM, 2K bytes, 16 I/O lines	NOW
B155	RAM, 256 bytes, 22 I/O lines and timer	NOW
<b>Compatible MCS-80/85 Components</b>		
2316E	Standard ROM, 2K × 8, 450 ns	NOW
2708	Standard EPROM, 1K × 8, 450 ns, light erasable	NOW
2716	Standard EPROM, 2K × 8, 450 ns, light erasable	NOW
2111A-4	Standard RAM, 256 × 4, 450 ns, common I/O	NOW
2101A-4	Standard RAM, 256 × 4, 450 ns, standard I/O	NOW
5101	Standard RAM, 256 × 4, 650 ns CMOS	NOW
8255A	Programmable Peripheral Interface	NOW
8251	Programmable Communications Interface	NOW
8214	Priority Interrupt Controller	NOW
8253	Programmable Interval Timer	NOW
8259	Programmable Interrupt Controller	NOW
8279	Programmable Keyboard/Display Controller	NOW



# MODEL 70

The new standard for the CRT terminal industry from the first independent commercial CRT manufacturer.

- Microprocessor controlled
  - 80 characters X 25 lines
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- AND MUCH MORE



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CIRCLE 6

# THIS MONTH

## Features

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### Enhancing Mini Capabilities

Dr. Robin Lake of Monolithic Systems Corp. discusses the Extended Memory Unit, a memory system for the PDP-11.

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### Where Conductive Elastomers Fit

Conductive elastomers, in use for some time as signal measurement and transmission probes, RFI shields and static arrestors, are now finding applications in digital systems.

**54**

### What Do Logic Analyzers Do?

The 'oscilloscope of the digital world,' logic analyzers play an important role in debugging digital systems. Ken Pines tells you what they do and how to select one. Also, a manufacturer's guide and a special section on what logic analyzers are available.

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### Field Servicing Microprocessor-Based Systems

Systems built around microprocessors present unique field servicing problems; the problems they develop are often highly complex.

**86**

### Computer Memory Technology

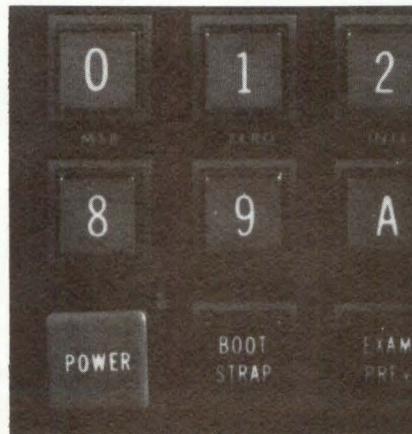
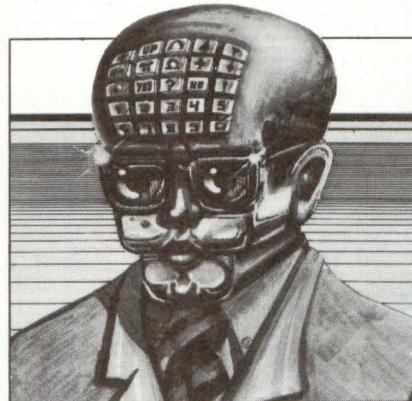
Completing our Benwill/Technocast coverage of memory technology, this month's report covers some of the newer technologies for data storage.



**September, 1977**

**Vol. 7 No. 10**

This month's cover story can help you get more out of your minicomputer via a memory extender. Intended to replace fixed head disks and extra core, Monolithic Systems Corporation's Extended Memory Unit is one such device. Cover illustration by Bill Zanitsch, design by J Porter.



**101**

### Using Microprocessor Development Systems

The microprocessor development system, introduced in response to the special design problems posed by microprocessor-based digital systems, plays an interactive role in the design process.

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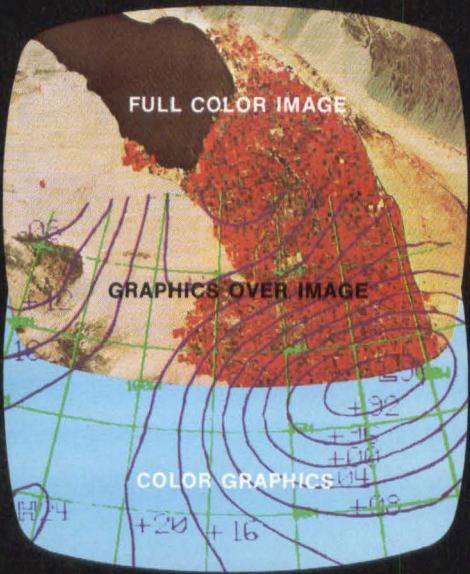
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### Alpha Bits

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**There's only one thing  
about Genisco's full  
color display systems  
that isn't on the high side.**

## **Their low price.\***

High in performance, versatility, reliability, processing speed and data display density. These are just some of the highpoints that put Genisco's fully programmable GCT-3000 Series a whole generation ahead of stroke-writer and storage tube display systems. And they're expandable, so you can get "on-line" now at minimal cost, and make additions as the need arises. Check these feature highlights:

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- Automatic DMA Access**
- High-Resolution Grey Scale Versions Too**

\*All these highs, yet the basic GCT-3000 is priced on the low-profile pocketbook side — \$6,000 in OEM quantities; \$7,500 singly.

So contact Genisco, a name that has stood for technological leadership over the past 30 years, and get the whole story.



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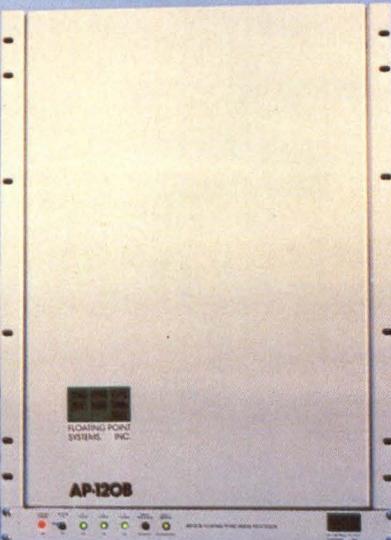
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# The age of array processing is here...



and FLOATING POINT SYSTEMS  
is the array processor company.

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- SIGNAL PROCESSING
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- and MORE

FLOATING POINT SYSTEMS' ARRAY PROCESSORS provide the high throughput required for computer systems used in scientific, engineering, and signal processing applications. They can increase the throughput of minicomputers up to two hundred times...of mainframes up to twenty times. Yet the AP-120B system is typically less than \$50K.

While the conventional, scalar computers of today require the restructuring of algorithms to fit the computer, the architecture and instruction set of FPS Array Processors are specifically designed to accommodate algorithms in both scalar and vector form.

Floating Point Systems' Array Processors offer high reliability (more than 3600 hours MTBF) and compactness (only 26 1/4" high in a 19" rack). They are found in shipboard and mobile installations, as well as computer rooms throughout the world.

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**EASY PROGRAMMING:** More than 150 routines callable from FORTRAN or the AP assembly language. Its symbolic cross-assembler and simulator/debugger helps you create new routines.

**COMPATIBLE:** Interfaced to all popular computers and their operating systems. A flexible format converter translates data to and from the host CPU. And a high speed DMA port is available to use with other peripherals.

**HIGH CAPACITY:** 8k to 1 megaword of 167 or 333 nanosecond 38-bit memories.

**PRECISION:** 38-bit floating-point arithmetic, normalized and convergently rounded, produces eight decimal digit accuracy, not just six.

**RELIABLE:** Goes where your CPU goes—computer room, lab, or in the field.

**FULL SUPPORT:** All the software, installation and operation manuals, and consultation you need goes with your Floating Point Systems' Array Processor.

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My Computer System is \_\_\_\_\_

My application is \_\_\_\_\_

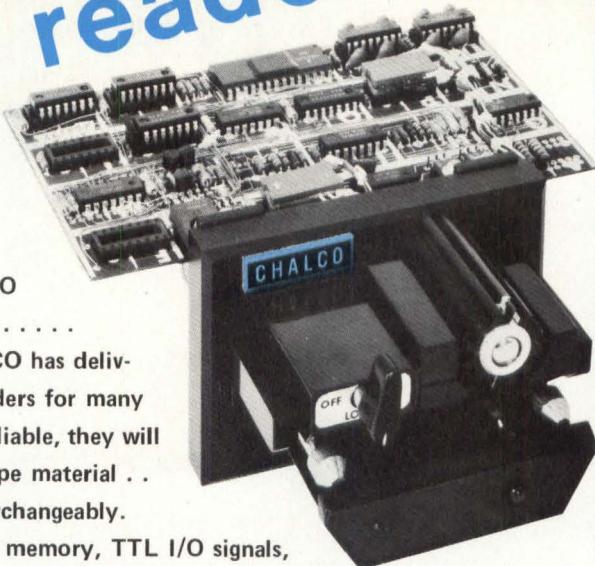


# punched tape readers

operating at ANY rate from 0 to 1,000 ch/s are available in 2 weeks from CHALCO for as low as \$250.00 . . . .

Since 1957 CHALCO has delivered thousands of readers for many applications. Highly reliable, they will read ANY punched tape material . . . and ANY format interchangeably.

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CIRCLE 9

## ROYTRON™ plug-compatible reader/punch

Desktop combination reader/punch with serial asynchronous RS-232C compatible interface. Designed to operate with a terminal device on the same serial data lines or alone on a dedicated serial line.

Reader will generate data at all standard baud rates up to 2400 baud.

Punch accepts data at all standard baud rates up to 600 baud continuous or 4800 baud batch, utilizing a 32 character buffer.

Two modes of operation are provided: *Auto Mode* — Simulates Model ASR 33 Teletype using ASCII defined data codes (DC 1, 2, 3 and 4) to activate/deactivate the reader or punch; *Manual Mode* — Code transparent mode. Panel switches control activation/deactivation of reader or punch and associated terminal device.

Tape duplication feature is provided by setting unit to LOCAL mode.



### MODEL 1560-AS

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CIRCLE 10

# MEMO From The Editor



Growth and change—these two key words are as important to us, the journalists of the digital electronics industry, as they are to the industry itself.

Thus, **Digital Design** must grow and change: this month we add two Editors and take on a new look. The new editors will help us stay on top of the developments that you are interested in, and the new appearance will make it easier and more enjoyable for you to read **Digital Design**.

Joining **Digital Design** as West Coast Editor, Henry K. Simpson brings an extensive background in technical writing and communication. Henry holds a B.S.E.E. from San Diego State University and an M.A. in English from the University of California at Santa Barbara. He has worked as an engineer in the research industry and is the author of more than twenty technical reports and publications. Also an engineer by training, Carol Baran serves as an Assistant Editor of **Digital Design**. Carol received a B.S. in Mechanical Engineering from Worcester-Polytechnic Institute and has studied Science Communication at Boston University.

Our Art Director, J. Porter, takes full responsibility for redesigning the magazine. Shortly after joining our staff in April, J began the difficult task of giving us a new look; this job is now completed.

# At only \$1088\*, you can't offer your customers a better buy.



\* Our quantity-50 OEM price for the *Silent 700*<sup>†</sup> Model 743 KSR Terminal is now just \$1088. In larger quantities, the price goes below \$1000.

And it keeps on costing less because the real payoff is in the cost of ownership. In the long run, it costs less than any other printer terminal with comparable performance.

The reason is easy. Superior design. The 743 KSR is built around a TI microprocessor. So, there are fewer components and circuit boards than in other printer terminals. That means less maintenance and more uptime performance. Plus standard EIA and current loop interfaces in a lighter, desktop package.

The 743 features the speed, reliability and quietness that made the *Silent 700* terminal family so popular. Incoming data is buffered, so you get true 30-character-per-second throughput.

## TI's Model 743 KSR

Disturbing noises associated with impact printers are eliminated with the 743's non-impact electronic printing.

Use it as a console I/O for software development. Keyboard terminal for inquiry/response.

Data entry. Interactive remote computing. Or as a message terminal network. And it's now available with APL. The 743 is backed by TI's worldwide maintenance and support services.

Find out more about TI's 743 KSR printer terminal. Fill out and mail the coupon today. Or call your nearest TI sales office, or Terminal Marketing, (713) 494-5115, extension 2126.

**TEXAS INSTRUMENTS**  
INCORPORATED

**SILENT 700**  
electronic data terminals

Yes! I am interested in the 743 KSR Printer Terminal.

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 Please send me more information.

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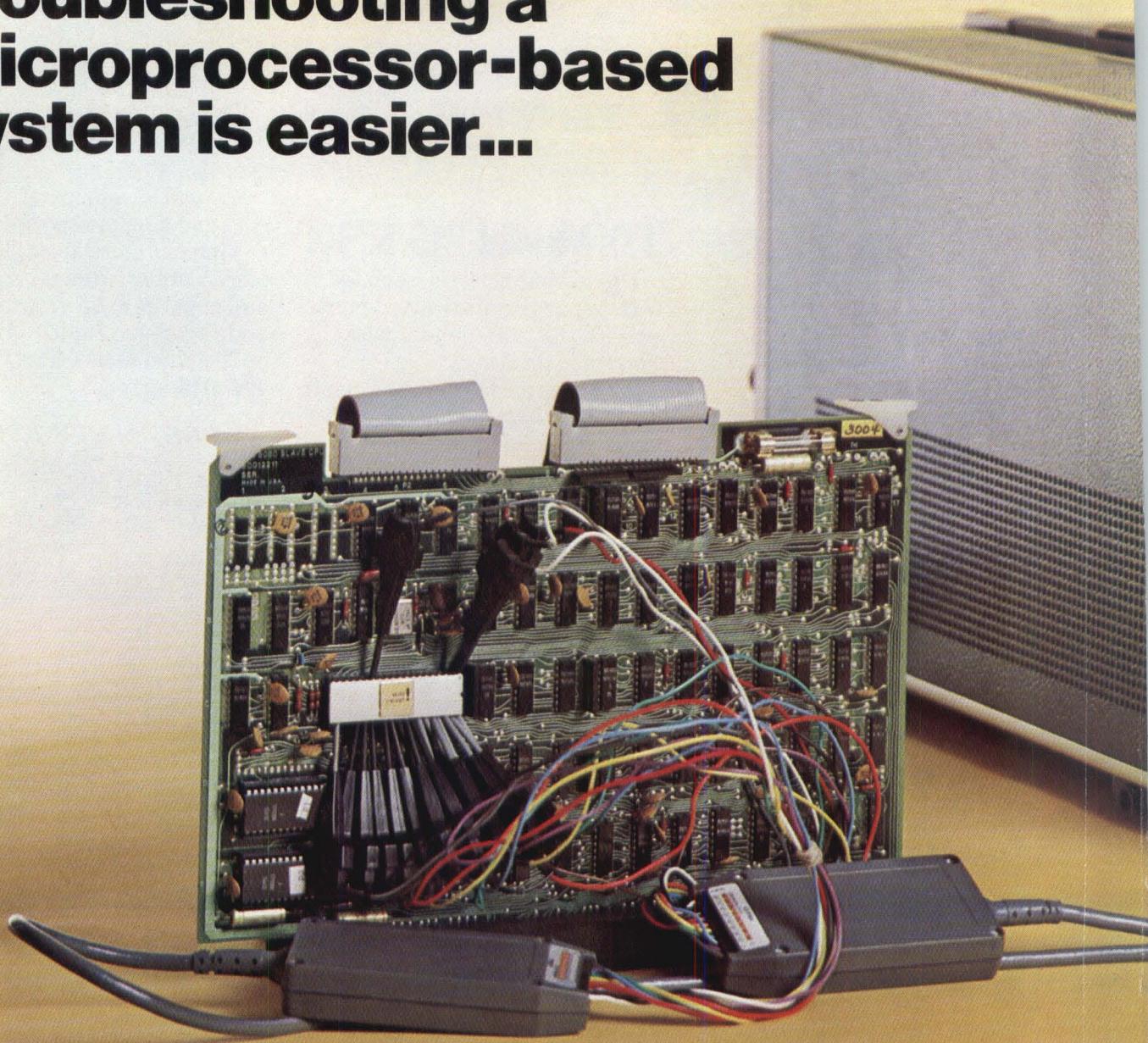
#### **Look at data in different ways.**

The 7D01F lets you choose from five display modes: maps; state tables in hexadecimal, binary, or octal code; or timing diagrams. How often have you encountered a problem you knew you could spot just by scanning overall program flow? How often have you wished you could compare state tables in the hexadecimal code you work with as well as the binary code your microprocessor knows? How often have you wanted to switch from a state table display to its corresponding timing diagram? The 7D01F can help at each step of this troubleshooting procedure.

You've designed, debugged, and loaded your system software. Now you need several powerful capabilities to ensure trouble-free execution on the prototype: the ability to look at data in different ways . . . to compare known good data with new data quickly and easily . . . to analyze both system and peripheral-interface timing.

The TEKTRONIX 7D01F Logic Analyzer offers you all those capabilities in a single instrument.

## **Troubleshooting a microprocessor-based system is easier...**



**Compare known good data with new data.**

The 7D01F features two comparison modes which facilitate in-depth software/hardware debugging. The EXCLUSIVE-OR and RESET-IF modes speed up what would otherwise be a very tedious process: checking the program flow chart against what falls out when the program is run.

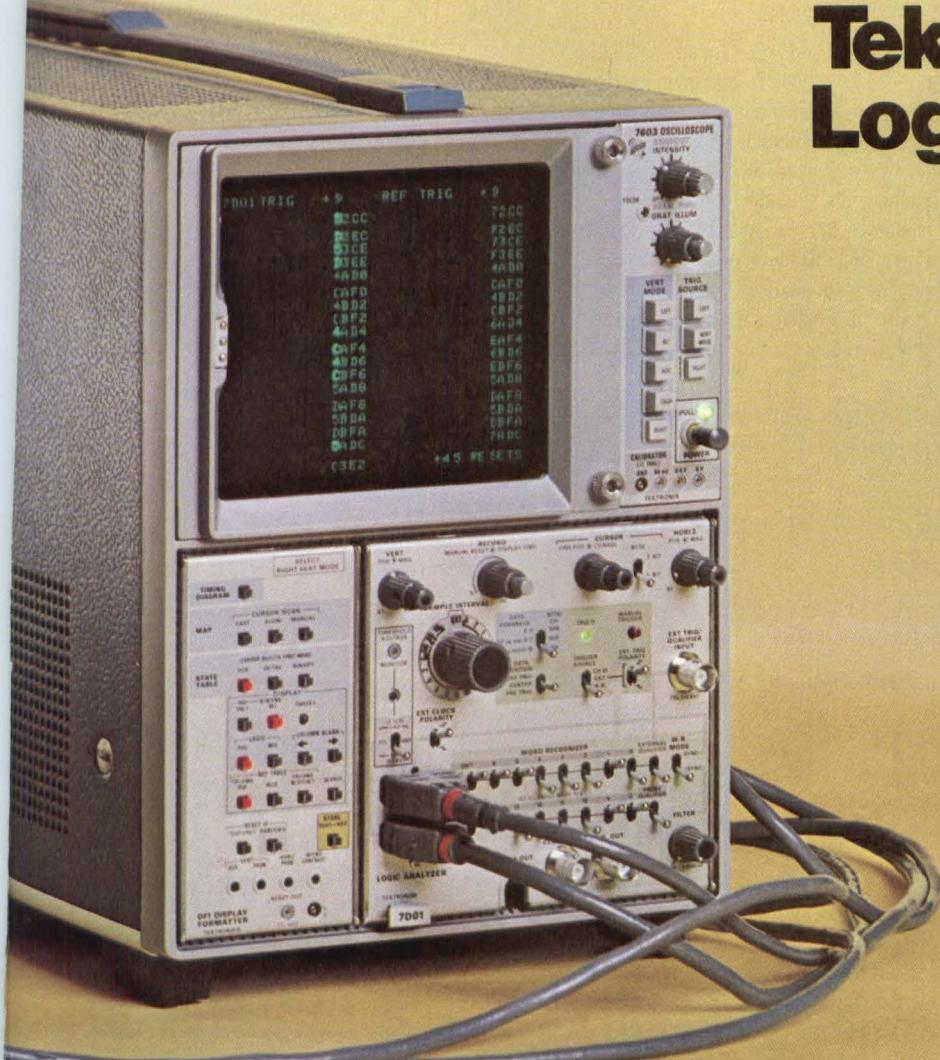
For an EXCLUSIVE-OR comparison, simply verify known good data, store it in reference memory; acquire new data, and select a table comparison mode. The reference table and the compared table (which may be in hex, octal, or binary) will be displayed side by side, and the differences between the two will be highlighted for ready identification.

Use RESET-IF to track down an intermittent fault. In this mode the 7D01F can automatically acquire and compare up to 4096 bits of new data to 4096 bits of reference data. Data is continually reacquired until a mismatch occurs. If there is a mismatch, the instrument holds the display, highlights the differences, and displays the number of resets that occurred. This frees the operator from continually monitoring for wandering programs, intermittent loops, or ragged-edge timing problems.

**Analyze system and interface timing.**

The 7D01F offers synchronous data acquisition at speeds up to 50 MHz. But it is sometimes necessary to view microprocessor operation with increased timing resolution, as well as to locate timing discrepancies in the system's interface with the outside world. You may, for example, need to asynchronously examine data coming into the I/O port before you can determine whether incorrect information is coming from the I/O port itself or the hardware on the other side. The 7D01F offers asynchronous data acquisition at sample intervals of up to 100 MHz.

## ...with the Tektronix 7D01F Logic Analyzer.

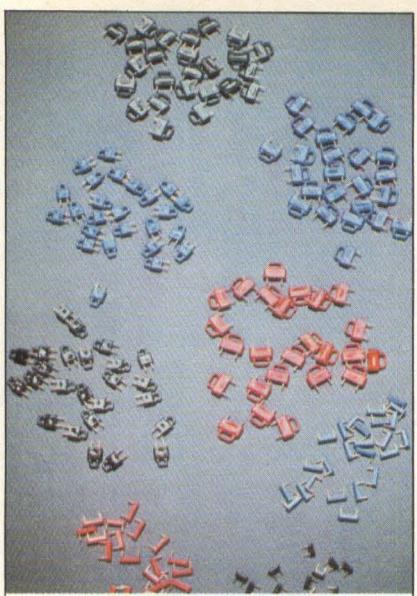


All these unique features are available only in the TEKTRONIX Logic Analyzer. To find out more about how the 7D01F can simplify your work with microprocessor-based systems, just call your local Tektronix Field Engineer. He'll demonstrate the 7D01F in your application, and acquaint you with its many other features, including 16-channel word recognition,  $1M\Omega/5\text{ pF}$  logic probes, 16-channel data acquisition, 4k formattable memory, and 7000-Series mainframe compatibility.

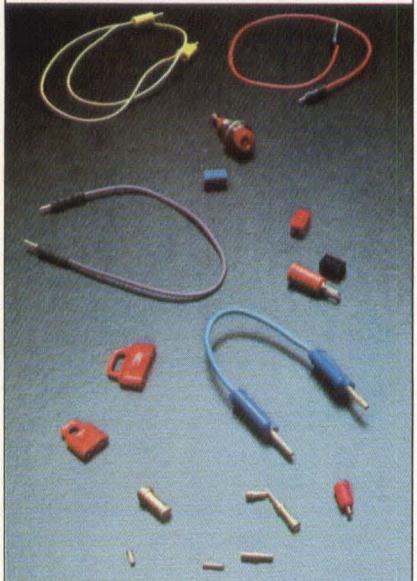
You should also send for our newest application note, describing in detail how a 7D01F can be used with microprocessor-based systems. Write Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97077. In Europe, write Tektronix Limited, P.O. Box 36, St. Peter Port, Guernsey, Channel Islands.

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# LETTERS



## Uses are jumping for our low cost switches.



Tiny jumpers mated to spring-loaded receptacles are increasingly popular for use as low-cost highly reliable circuit switches. In longevity tests they easily passed 50,000 insertion/extraction cycles. Color coded and positive position indication adds to their usefulness and application possibilities. To help you put them to use, we offer a catalog, samples or a call from a sales engineer if you wish. Write: Cambridge Thermionic Corporation, 445 Concord Avenue, Cambridge, MA. 02138. Phone: 617-491-5400. In California: 2733 Pacific Coast Hwy., Torrance, CA 90505. Phone: 213-326-7822.

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The Guaranteed Electronic Components

CIRCLE 13

## Yes to no-language

Dear Editor:

We were interested in the Viewpoint by Karl Amatneek, 'Assembling the No-Language: Another Proposal' (June 1977). Diversified Technology has had available for approximately a year such a no-language device which we call a 'keytop assembler'. In fact our equipment appeared in DIGITAL DESIGN Product News (July 1976).

Gerald Youngblood  
Diversified Technology  
Rigeland, Mississippi 39157

## List missed disks

Dear Editors:

In your Diskette Drive Buyer's Guide (June, 1977, p. 89) it was indicated that Wangco manufactures only mini-diskette drives. In fact, Wangco's Orbis Division manufactures IBM-compatible and double density standard size diskette drives. In addition Wangco offers flexible disk subsystems, controllers for standard and micro-floppys, micro-media and the micro-floppy diskette drive.

Bill Miller  
Orbis Division, Wangco  
Los Angeles, California 90066

## Radiation mangles stored data?

Dear Editor:

Your item about the effects of nuclear radiation on magnetic storage media (June, 1977, p. 24) states that radiation will not affect the data but will degrade the plastic base over a long period of time and that fields strong enough to damage the base material are a human safety hazard and are unlikely to be encountered. However if radiation is from a pulse reaction rather than a continuous source, a strong electromagnetic field may exist for a short time. Depending on the size of the reaction and the distance and shielding considerations, the intensity of this pulse may be strong enough to change the data stored on the magnetic me-

dia. The short period of the pulse usually does not cause cell tissue damage and the question of human safety is likely to depend upon the other nuclear particles from the reaction. Although such a reaction is unlikely to occur during the normal operation of a controlled source such as a power plant reactor, strong electromagnetic fields must be considered for military and other critical applications.

Mike Hordeski  
Siltran Digital  
Silverado, CA 92676

## Lost line

Dear Editor:

In my article on digital sequencers (May, 1977), one line was omitted. The text on page 78 should read:

Inconditional Jump. Disregarding the input lines  $X_i$ , the next state *does not correspond* to the next bistable in the register: consequently...

Angelo Yong  
Universidad San Bolívar  
Sarteneja-Caracas, Venezuela

## Cassette left out

In the listing of cassette manufacturers (Digital Design, June, 1977), we inadvertently omitted MFE Corp., Keewaydin Drive, Salem, New Hampshire, 03079.

In addition to the Model 250 digital cassette tape transport, MFE recently introduced a floppy disk drive, the Model 700/750.

## Please don't call

In the July issue of DIGITAL DESIGN, we reported that CBS Laboratories was researching laser deflection and developing a piezoelectric device for laser beam deflection. This is an error; we apologize to the CBS Technology Center (formerly CBS Laboratories) and ask that readers do not contact them with regard to this.

All letters should be signed and are subject to editing for length, libel and standards of good taste. Signature may be omitted upon publication if so requested.



## altair™ floppy disk system

Disk capabilities can transform an ordinary microcomputer system into one of infinite magnitude. By introducing one Altair Floppy Disk System (88-DCDD), your 8800 series system acquires a mass storage capacity of 310,000 bytes per diskette.

The 88-DCDD includes a disk drive, controller, power supply, interconnect cable and case. Featuring a Pertec FD-400, the disk drive unit has direct drive dc motor operation which is insensitive to disrupting line frequency variations.

Up to 16 disk drives may be interfaced with the Altair Disk Controller. Consisting of two PC cards that plug into the Altair 8800 bus, the

Disk Controller regulates all mechanical operations and disk status.

Two software systems are available for the Altair Floppy Disk. Altair Disk BASIC offers the many features of Altair Extended BASIC plus increased program and data file load/save facilities. Our new DOS provides comprehensive tools for assembly language program development and disk file maintenance.

See the Altair Floppy Disk System along with the complete Altair product line at your local Altair Computer Center, or contact the factory for further information.



2450 Alamo SE Albuquerque, N.M. 87106



**Your next high-speed  
programmable memory  
just doubled its density.**

**Again.**

**The 16K PROM.**

# BIPOLAR PROM PROGRESS: Last year, we invented 8K. This year, we invented 16K. Next year, they'll both be industry standards.

Signetics' acknowledged technological leadership in Bipolar PROMs just took another lengthy stride forward.

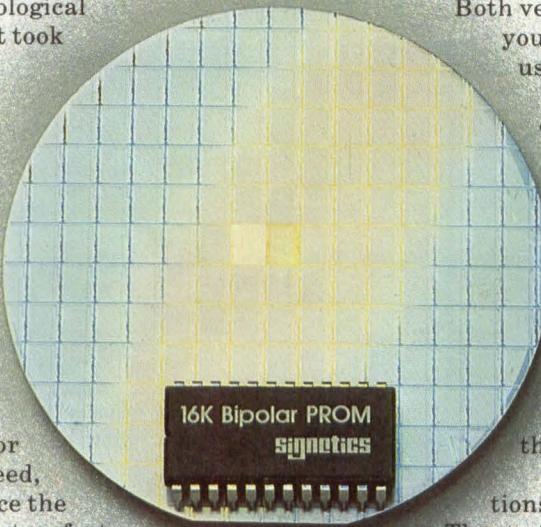
Just over a year ago, we announced the world's first field-programmable Bipolar PROM with 8K memory capacity. It was news then, and it's an industry standard now.

Here's even more important news for users of high-density memories—the 16K PROM is a reality. It's the 82S190/191—from Signetics.

**More than a Larger Memory.** The 16K PROM has a lot more going for it than just raw storage. Like speed, for example—although it has twice the density of its 8K cousin, it's almost as fast, with a maximum address access time of only 80 nsec. Current drain, though, is unchanged—at 175 mA. That's a big advantage for you—half the power per bit, twice the storage capacity.

Like most of its smaller cousins, the 16K PROM is available with two output options: The 82S190 is Open Collector, the 82S191 is Tri-State. That means you can choose the output you need for optimizing word expansion in bused organizations.

The 82S190/191 is available now in limited sample quantity. Full production due in January 1978.



Both versions are field-programmable, so you can produce custom patterns by using prescribed fusing procedures.

On-chip decoding and three chip-enable inputs are also provided, permitting easy memory expansion.

**Signetics—Your Supermarket for PROMs.** The partial listing of PROM products in the table below will give you a fair idea of why Signetics stands at the forefront of high-speed PROM technology. Each of the types listed is available in economical Power Plastic DIPs or packaged for use in the military temperature range.

Take a closer look at the specifications shown. There's a lot there to find. The parts themselves can be found on your distributor's shelves. Call him today or use the coupon below to order additional evaluation data.

# Signetics

a subsidiary of U.S. Philips Corporation

Signetics Corporation  
811 East Arques Avenue  
Sunnyvale, California 94086  
Telephone 408/739-7700

SIGNETICS PROM SELECTION GUIDE (4K & ABOVE)							DD9
Size	Organization	Type	Output*	Pins	Max. TAA (ns)	Max. I <sub>CC</sub> (mA)	Key Benefits
4K PROMs	1024 x 4 (4096)	82S136	OC	18	60	140	High speed.
		82S137	TS	18	60	140	
	512 x 8 (4096)	82S115	TS	24	60	185	High speed. Has built-in latch.
		82S140	OC	24	60	175	Four chip-enable inputs for easy memory expansion.
		82S141	TS	24	60	175	
		82S146	OC	20	45	155	Fastest available 4K PROMs. .3" wide pkg. saves space.
8K PROMs	82S147	TS	20	45	155		
	2048 x 4 (8192)	82S184	OC	18	100	120	Low current drain.
		82S185	TS	18	100	120	
	1024 x 8 (8192)	82S180	OC	24	70	175	High speed.
		82S181	TS	24	70	175	
		82S2708	—	24	70	175	High speed with 2708 pinout.
16K PROMs	2048 x 8 (16,384)	82S190	OC	24	80	175	16K capacity with drain of only 175mA. 80nsec speed.
		82S191	TS	24	80	175	

\* OC - Open Collector; TS - Tri-State

To: Signetics Information Services, 811 E. Arques Ave.  
P.O. Box 9052, MS 27, Sunnyvale, CA 94086

- Please send me technical data on the 82S190/82S191 16K PROM.
- I'd like additional data on the \_\_\_\_\_ (type).
- Send me general product reference material on all PROMs, including those with smaller capacities.
- I have an urgent requirement. Please have a PROM specialist phone me at once: ( ) \_\_\_\_\_

Name \_\_\_\_\_ Title \_\_\_\_\_

Company \_\_\_\_\_ Division \_\_\_\_\_

Address \_\_\_\_\_ MS \_\_\_\_\_

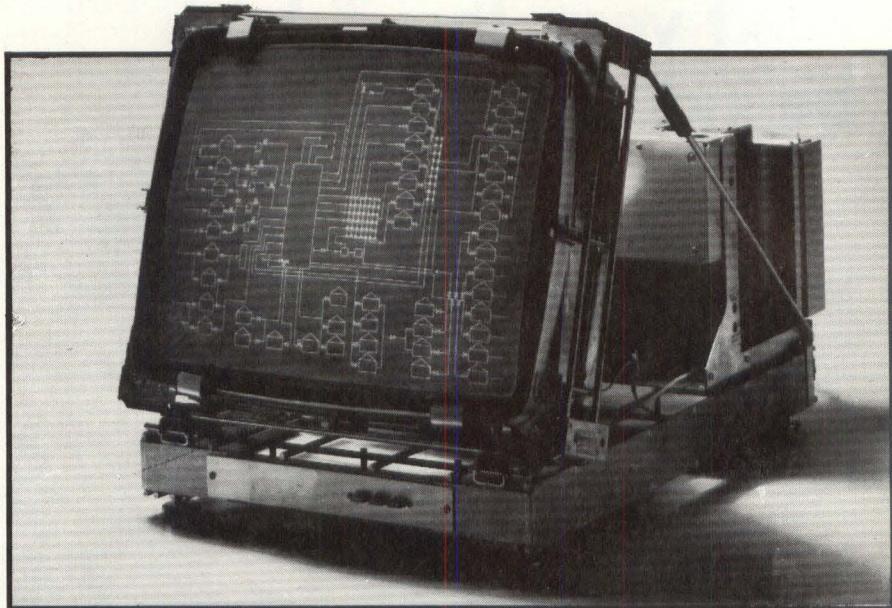
City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_

# TECHNOLOGY TRENDS

## DVST Technology Competes With Directed Beam

Designers of graphic display systems traditionally make heavy demands on the various display technologies, requiring high resolution (addressability), high vector density and maximum display interactivity (refresh), all at the lowest possible cost. According to Tektronix Corp. of Beaverton, Oregon, of the four presently available technologies — DVST, plasma, directed beam and video (raster) — only DVST and directed beam displays come close to meeting these demands. Both offer inherently high resolution (typically 60 to 100 addressable points per linear inch) and high vector density (several thousand inches of stored/refresh vector). The major difference between DVST and directed beam display is cost. DVST offers high resolution, high vector density displays at low cost. The cost of directed beam systems runs much higher, Tektronix says, because of the dependence on expensive refresh memory. Thus, even without refresh, DVST displays hold a significant position in the graphic display marketplace.

The two technologies have existed side-by-side in the graphic display market for a number of years; users choose between them on the basis of cost versus refresh. With the decline in the cost of refresh memory, directed beam displays appear to be gaining an edge. However, with the development of write-through, a technique allowing combined refresh-storage display, Tektronix is now confident that DVST displays will maintain their favorable cost/performance edge over directed beam, plasma and video displays. Write-through reduces beam intensity to just below the storage level of the DVST phosphor, allowing information to be written on the phosphor without storing. Using greater beam potential and high speed amplifiers, Tektronix produces up to 1200 inches of refreshed



The GMA102A graphic display system uses a high speed vector character generator to provide up to 1200 inches of refreshed vector.

vector with their new graphic display module, the GMA102A, while still maintaining display storage capability.

The GMA102A 19" display offers a practical mix of performance, packaging and support options. The mechanical design uses the popular wireframe-type construction and modular layout. Performance options include plug-in vector and character generator circuit cards; the unit may be ordered with either horizontal or vertical orientation. Electrically, the GMA102A operates with digital electronics except for the X and Y inputs; the interface is TTL-compatible.

**Applications.** When selecting a graphic display for their application, graphic system designers have traditionally asked the question, 'Do I need refresh?' With the advent of the GMA102A, Tektronix feels that the question becomes, 'How much refresh do I need?' A little ingenuity, they say, leads to the answer, 'Surprisingly little.'

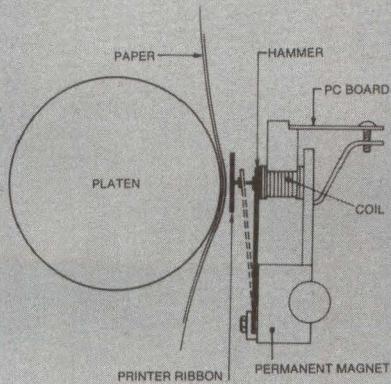
One application considers computer-aided circuit board layout. Circuit boards are designed in layers; to display all the runs and pads of a six layer board in refresh requires a considerable refresh memory. Tektronix points out that the GMA102A permits laying out the circuit board in refresh, one layer

at a time. Thus, selective editing is possible while building the layer. When all runs and pads for a layer are established, that layer is stored and the next layer is built in refresh. A high resolution, high density circuit board system results, using only one-sixth the refresh memory required to design the same system with a directed beam display, Tektronix claims.

Another system presently using write-through involves a finite-element modeling system, used to build three-dimensional models for structural analysis. The software package for this system provides a menu of user commands; these commands are displayed on one side of the screen. The system also offers the ability to display parts of the model in refresh, allowing three-dimensional dynamic rotations of the model. Again, the system uses storage for those parts of the display that don't change; refresh is used for the parts that change or require selective editing.

With its combined storage-refresh capability, modular construction and performance and packaging options, Tektronix feels that the GMA102A should prove very popular in the OEM market. For further information, write Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97077, or call (503) 644-0161.

# The concept and design of the Printronix 300 Impact Matrix Line Printer/Plotter offers you several remarkable cost/performance advantages.

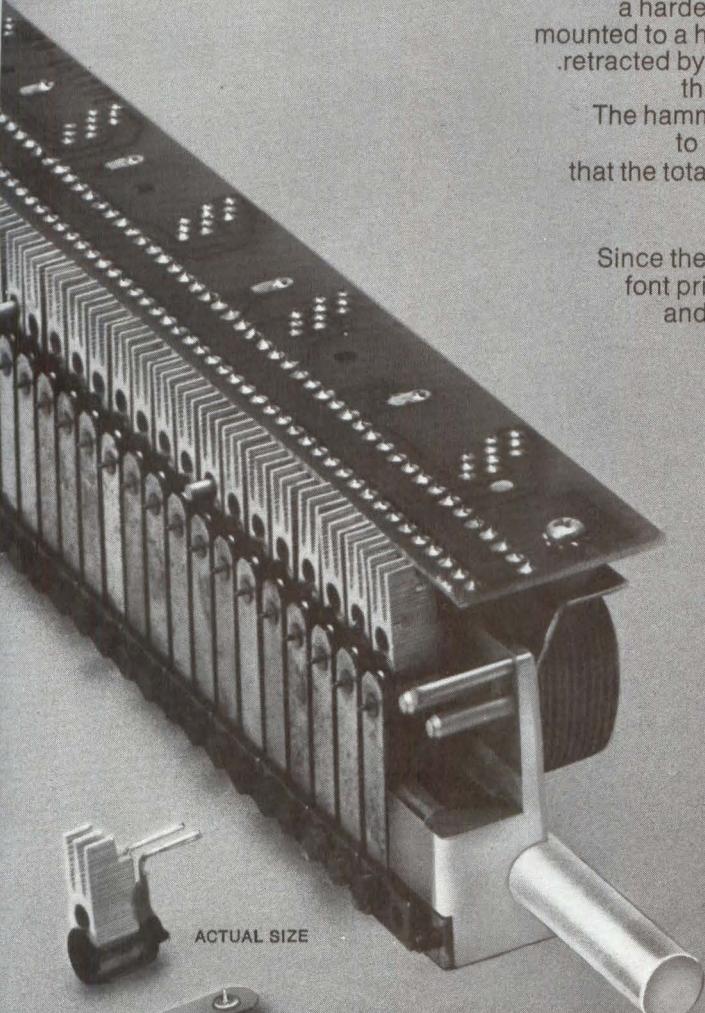


## Like the far greater MTBF this elegantly simple mechanism assures.

Downtime frays nerves. It costs money, too. But take heart. You'll see a lot less of it with a Printronix 300. That's assured by its elegantly simple mechanism based on a flat strip of spring steel with a hardened tip, pictured below. Forty-four springs, or hammers, are mounted to a hammer bank. Each is fastened at one end and normally held retracted by a permanent magnet. (See the diagram.) A pulse of current thru a coil at the tip end of the hammer releases it to print a dot. The hammer bank is shuttled horizontally 0.3", enabling each hammer to cover the space between its tip and the tip of the next one, so that the total field covered is 132 columns. Aside from paper and ribbon feed, that is the only mechanical motion in the printer.

Since the Printronix 300 has 50% fewer components than mechanical font printers . . . a head life 4 to 8 times longer than serial printers . . . and never needs adjustments of hammer flight time or character alignment as drum/chain/belt printers do, you can see why it has a longer MTBF, and why we've felt comfortable offering a one-year warranty from the beginning.

Send for our brochure. You'll discover why it produces 300 lpm print quality others can't match, has a shorter MTTR, and can give you full plotting capability . . . at no extra cost! Printronix, Inc., 17421 Derian, Irvine, CA 92714. (714) 549-8272.



# PRINTRONIX 300

It's your best buy!

# An Editing Pet That's

The perfect editing terminal for transaction processing must be more than a little bit smart. It has to be wise like our OWL-1200. With features that assure high accuracy source data entry, fast data editing, simplified host computer programming, and reduced host computer loading.

Our OWL gives you all the human engineering features you get with our FOX-1100, plus a lot more. And the price is right. Just \$1496 in quantities of 25.

Check the comparison chart of editing terminals to see all the reasons why the OWL-1200 is simply "incomparable."

## USER REQUIREMENT FEATURES

High Operator Data Entry Accuracy	Protected fields
	Low-intensity fields
	Numeric only fields
	Inverse video fields
	Blink fields
	Line drawing capability
Simple, Fast Editing of Data	Insert/delete character
	Insert/delete line
Minimized Loading on Host Computer	Host programmable send keys: send all data, send only unprotected data, send only data modified by operator, send only a "request to send" header.
Simplified Programming	Ability of host CPU to read device status
	Ability of host CPU to read device mode key settings and communication option straps
	Program override on mode key settings
Simplified Program Debugging	Transparent mode permits all characters to be displayed
Cost Effectiveness	OEM price in quantities of 25*

PERKIN-ELMER	HAZEL-TINE	LEAR SIEGLER		ADDS
OWL-1200	MOD. I EDITING	ADM-1A	ADM-2	980
Yes	Yes	Yes	Yes	Yes
Yes	Yes	Partial	Partial	Partial
Yes	Yes	No	No	No
Yes	Yes	No	No	No
Yes	Yes	No	Yes	Yes
Yes	No	No	No	Yes
Yes	Yes	Partial <sup>1</sup>	Yes	Yes
Yes	Yes	Partial <sup>1</sup>	Yes	Yes
Yes	No	No	No	No
Yes	No	No	No	No
Yes	No	No	No	No
Yes	No	No	Yes	No
Yes	No	No	No	No
\$1496	\$1670	\$1795 +\$1395	\$2395 +\$1295	\$1995

\*When unit includes editing capabilities, 24 x 80 display, numeric pad, and upper/lower case characters.

<sup>1</sup>No Key. Requires Two Key Code.

\*Just announced price changes

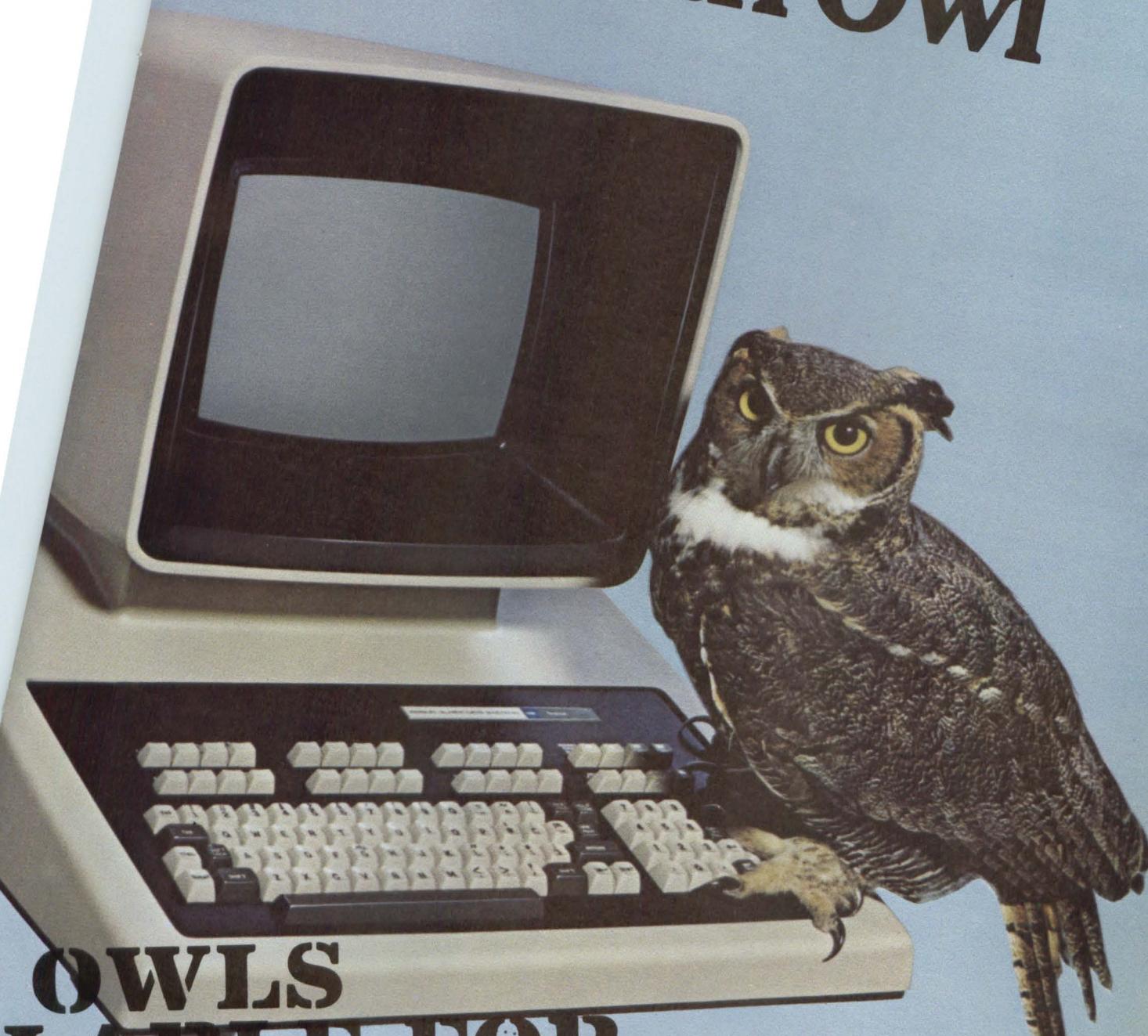
## PERKIN-ELMER | TERMINALS DATA SYSTEMS DIVISION

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Randolph, N.J. 07801 (201) 366-5550 TWX: 710-987-7913

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(714) 544-9093	Los Angeles, CA	753-3451	Slough, Berkshire, UK
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AVAILABILITY

# Wise as an Owl



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CIRCLE 17

## FCC Registered 'Protective Circuitry' Required on DAA's

The Federal Communications Commission ruled that, effective January 1, 1978, all data communications interface devices must be FCC certified as "registered protective circuitry". Known as Data Access Arrangements (DAA), or data couplers, these interface devices connect customer-provided electronic data processing (EDP) and computer equipment with switched telecommunications networks for data communications.

The FCC registration requirement results from an FCC opinion and order (FCC Rule 68) issued in November 1975. The ruling, amended several times since its issue, includes reconsideration of policy and technical points, improvements in registration

filing procedures for data coupler manufacturers and standardization of plugs, jacks and cables for connection of telephone instruments, data and auxiliary equipment. A last minute amended tariff filing by AT&T on May 31, extended the ruling's complete implementation until January 1, 1978.

Under the ruling, EDP/computer manufacturers and users install registered data couplers to their equipment. This move allows users to purchase their own registered data couplers and other similar equipment and connect it to telephone company lines. EDP/computer equipment manufacturers can bypass the traditional methods of interface connection by installing registered data couplers or similar registered protective circuitry directly into their product. Until this ruling, installation and ownership of data couplers for interface purposes was restricted to telephone companies when direct connection to the switched network was

desired. Installation of non-registered data couplers is still restricted to operating telephone companies.

A meeting was held June 29, 1977 for EDP/computer industry trade and business press editors at the Marriott Motor Hotel in Newton, Massachusetts. At this meeting Elgin Electronics representatives E. Joseph Seppala, marketing manager-telecommunications products and Harry A. Montgomery, vice-president-engineering, discussed the implications of the FCC ruling.

Since all DAA's, also called RPC's (for Registered Protective Circuitry), must be registered by the FCC, Montgomery outlined the steps that any company wanting to register their products must take. First, he said, the design engineer has to be educated and fully informed about the FCC design criteria. The earlier he becomes informed about FCC Part 68, the easier his designing becomes. If he finishes his design for the DAA without this information from the FCC he may have a lot of trouble getting the device registered and he may have to start over again.

Secondly, a number of tests have to be made on the finished product before application can be made to the FCC for registration. Tests for longitudinal balance, hazardous voltage, signal power limitations, timing circuits, temperature and humidity cycling and shock and vibration tests require a substantial investment in capital equipment. Laboratory personnel can easily spend 80 hours per unit running these tests, according to Montgomery.

Once the tests are completed and the device meets FCC requirements, the third step consists of documenting the test data and organizing it on paper so that the FCC sees that the device meets their requirements. Fourth, you must submit all the test forms and documentation to the FCC. Documentation includes complete schematics and photographs of the unit.

The design of the DAA's must allow for the different types of connection that the FCC has written into the technical rules. The FCC permits three means of connection. The first, called "permissive level", alludes to the power level to be transmitted over the switchboard network. The protective circuitry accepts the output of the modem, a tone device, and regulates it so that the noise level going to the

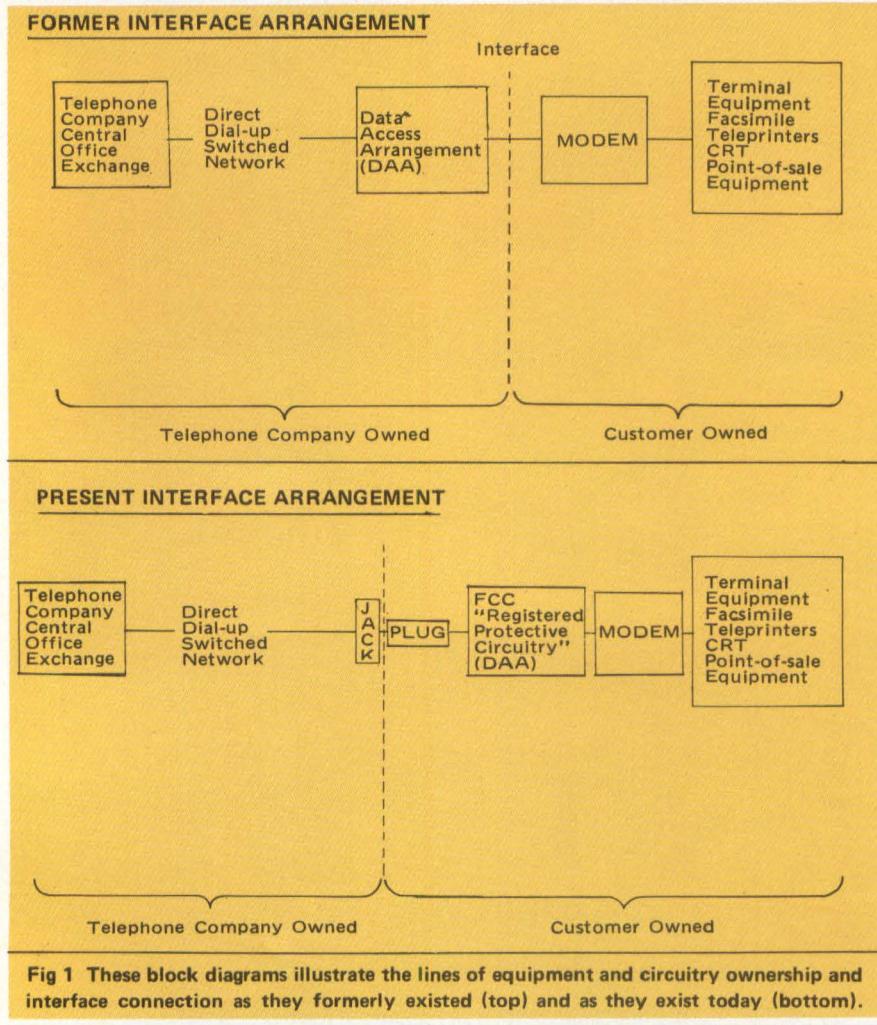
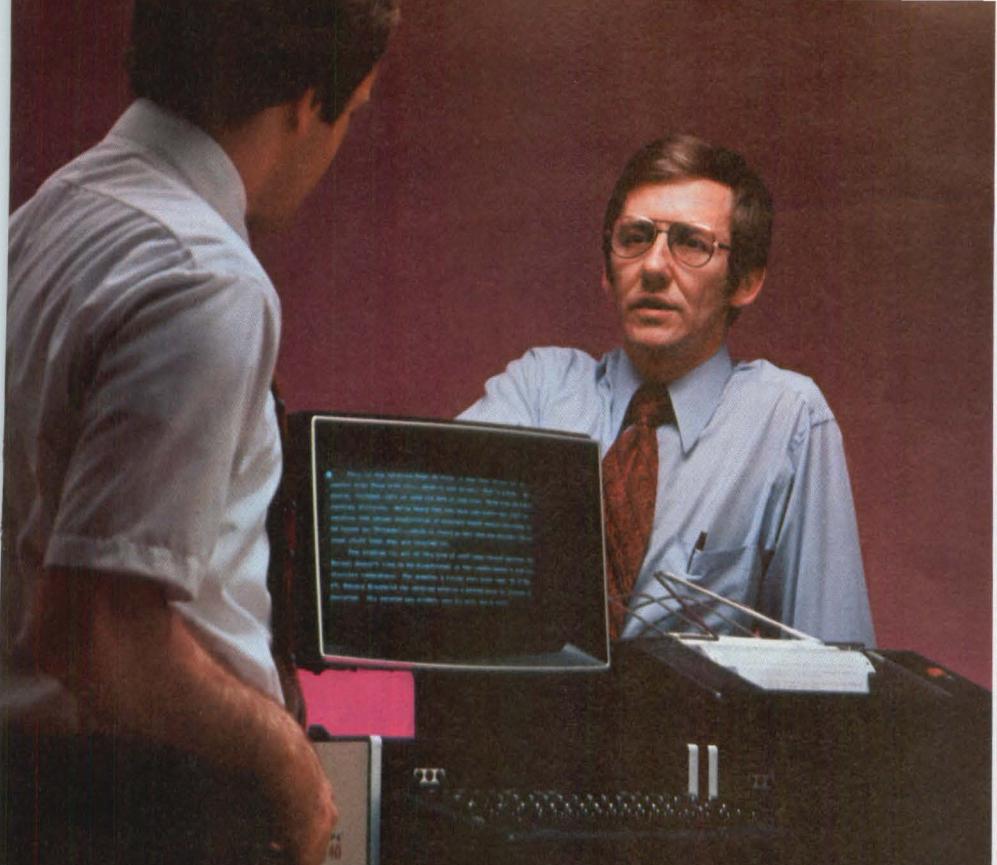


Fig 1 These block diagrams illustrate the lines of equipment and circuitry ownership and interface connection as they formerly existed (top) and as they exist today (bottom).



## IF THE TELETYPE® MODEL 40 SYSTEM EVER MALFUNCTIONS, IT'S DESIGNED TO TELL YOU WHAT'S WRONG.

Even though we probably go to more trouble to insure uninterrupted reliability than anyone else, we're still realistic enough to admit that sometime something's going to go wrong.

So instead of burying our heads in the sand and pretending it won't, we've concentrated our efforts on what can be done to make downtime as short and painless as possible.

For starters, we gave the model 40 product line its own diagnostic capability. To tell you quickly what's wrong. Then, to make it easy to fix, we used a modular design concept. The result is an average mean-time-to-repair of only 3/4 hour.

We also made sure that when something does go wrong, you'll never be alone. We've got a nationwide service network standing behind every product with the Teletype name on it. We offer on-call repair service, maintenance contracts, and even an exchange repair service on components and parts.

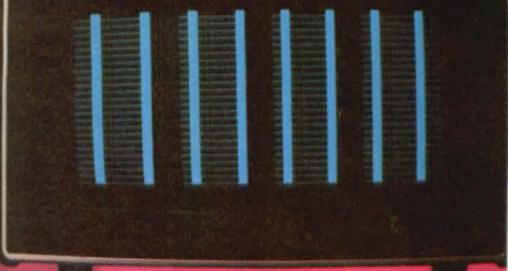
The way we look at it, building something the best way humanly possible is only half our job. The other half is being ready for the unexpected.

For more information about the Teletype model 40 product line, write: Teletype, 5555 Touhy Ave., Skokie, IL 60076. Or call: 312/982-2000.

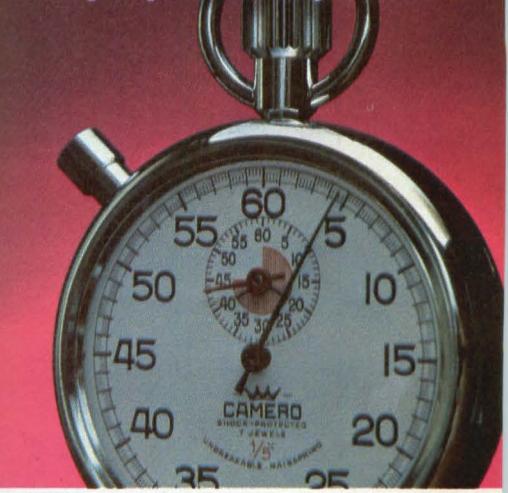


Teletype is a trademark and service mark registered in the United States Patent and Trademark Office.

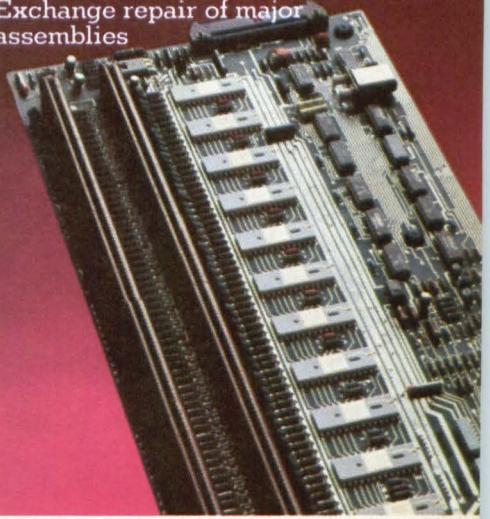
Built-in diagnostics pinpoint trouble



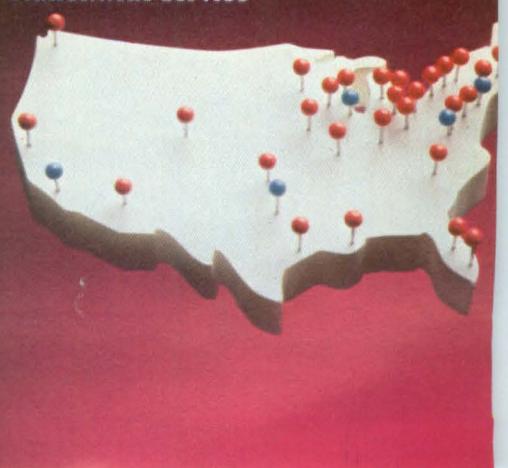
Average repairs take only 3/4 hour

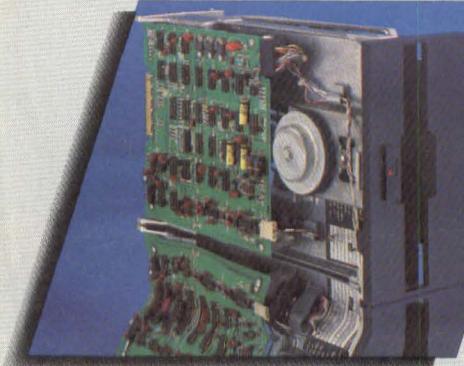


Exchange repair of major assemblies



Nationwide service



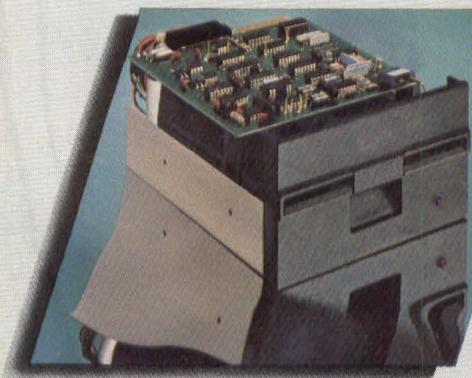


### **Flexible Disk Drive**

**GSI-FDD 110**

A compact, random access, flexible disk drive for single or double density data storage.

It will accommodate up to 6.4M bits of data on one side of standard media using MFM or M<sup>2</sup>FM encoding techniques for double density applications. Single density storage in variable formats provides up to 3.2M bits of data. Fully IBM compatible the disk drive will read and write IBM 3740 formatted diskettes up to 1.9M bits. The high performance unit offers up to 4 drive daisy chain operation, parallel ready lines plus unit select, separation of clock and data and Track "00" photo sensing. It also has automatic diskette ejection and a fail safe interlock.



### **Flexible Mini-Disk Drive GSI-FDD 050**

The GSI family of highly reliable small Mini-Disk Drives: MDD 050, 100K bytes; MDD 051, 200K bytes and the MDD 052, 465K bytes are designed to fit into many applications where conventional disk drives (GSI-FDD 110) are physically inappropriate and space is at a premium.

Low in cost, the MDD 050 Mini-Disk Drive utilizes a small flexible disk permanently housed in an envelope with the necessary apertures for drive spindle, head and sector hole access. Each envelope is 5<sup>1</sup>/<sub>4</sub>" by 5<sup>1</sup>/<sub>4</sub>" but otherwise is conceptually like the familiar IBM diskette.



### **Horizontal Autoloader**

**GSI-H155**

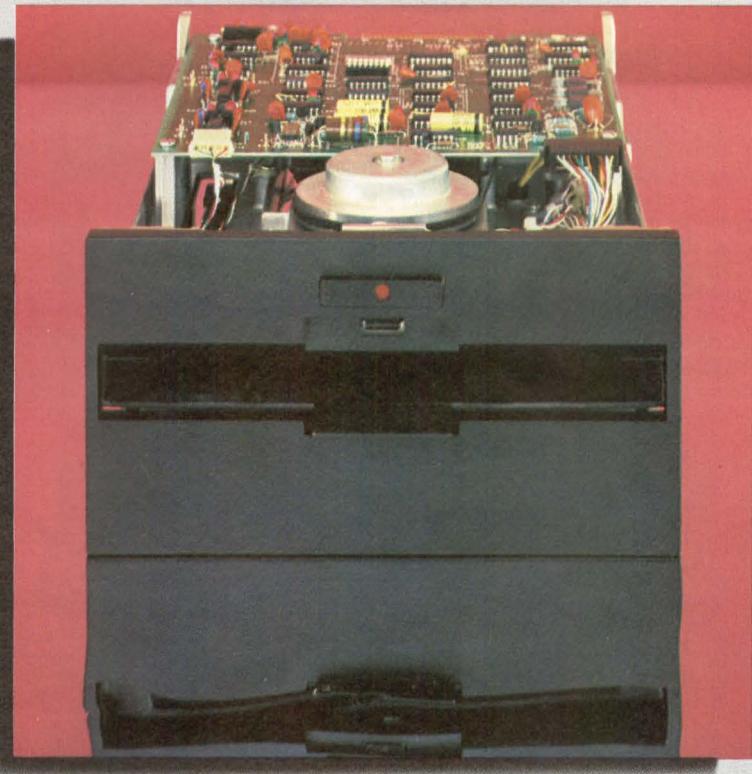
The Horizontal Autoloader automatically loads and unloads open or closed flap diskettes to and from a GSI-FDD 110 Flexible Disk Drive. Diskettes are loaded sequentially from the hopper. After processing in the diskette drive, the diskettes are electronically selected and stacked horizontally in either of its two bins. The bins are removable and suitable for general handling of diskettes.



### **Flexible Disk Drive Sub-Systems GSI-FDD 2100**

Packaged horizontally into a 19" Retma rack mount chassis, the GSI-FDD 2100 series sub-systems provide single and dual drive capability. Included in the sub-system is the necessary power to drive two flexible disk drives and a customer supplied formatter. Input AC power is supplied from the host computer controller via a relay system included in the GSI-FDD 2100.





***Go with the winner-GSI-FDD 200.***  
***Double-sided, double-track density, flexible disk drive.***

The winner in high quality, delivery and price. GSI's FDD 200 disk drive accommodates up to 25.6M bits using MFM or M<sup>2</sup>FM encoding techniques. Downward compatible with GSI's FDD 110 and available in the same package design, it is available for upgrading with minor system modifications. It is fully IBM compatible and will read and write IBM 3740 formatted diskettes. You also can daisy chain up to 4 drives.

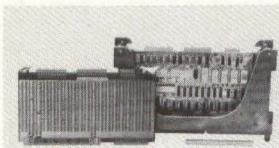
Important features include: parallel ready lines plus unit select, separation of clock and data, Track "00" photo sensing, automatic diskette ejection and fail-safe interlock latch mechanism.

Go with the thousands of happy GSI winners. What have you got to lose?

CIRCLE 19

**THE WINNER**  
GENERAL SYSTEMS INTERNATIONAL, INCORPORATED  
GSI, 1440 Allec Street, Anaheim, California 92805, (714)956-7183, Telex 69-2488

## NEW GARRY SBC 80/10 UNIVERSAL MICROPROCESSOR WIRE-WRAP INTERFACE BOARD



interface connections for  $\pm 5$  and  $\pm 12$  volts dc.

The Garry SBC 80/10 Universal Wire-Wrap board provides 38 columns of 44 low-profile socket terminals per column, with alternate rows of committed ground and voltage wire-wrap terminations. The P/N EP 272-38-15 interface board will accommodate up to 95 16-position I.C. chips or an equivalent mix of 14, 16, 18, 22, 24, 28 or 40-position I.C. chips.

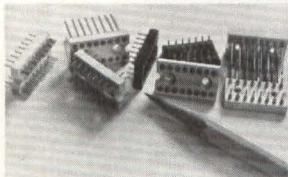
For complete information concerning the SBC 80/10 and other Universal Microprocessor/Minicomputer Wire-Wrap Interface boards, please contact Garry Manufacturing Company directly.

Garry Manufacturing Co., 1010 Jersey Avenue, New Brunswick, NJ 08902, 201-545-2424

Use the Reader Service Card number.

## NEW SERIES OF SOCKETS FOR PACKAGING 8, 14, 16, AND 18 CONTACT DIPs

Has approved MIL-Spec 5-83734



The new sockets have an ultra-low profile, for the most compact packaging of components.

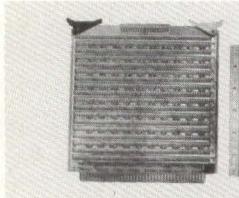
The insulating bodies of these parts are of SE-O Grade Valox: the individual socket terminals are in two precision-machined pieces. The inner contact is gold-plated beryllium copper. The outer contact is brass, available in a variety of platings, including gold and tin. Both printed-circuit and wire-wrappable terminations (pins) are offered; the ends are closed to eliminate danger of solder or flux wicking.

The new DIP sockets are available off-the-shelf.

For complete information contact Garry Manufacturing Co. directly. Garry Manufacturing Co., 1010 Jersey Avenue, New Brunswick, NJ 08902, 201-545-2424.

Use Reader Service Card number.

## MULTI-UNIVERSAL HIGH-DENSITY WIRE-WRAPPABLE PACKAGING PANELS



A new line of Multi-Universal High-Density wire-wrappable packaging panels, particularly suitable for use in microprocessor and digital-circuit applications, is now available from the maker, Garry Manufacturing Co., of New Brunswick, NJ.

These universal panels will accommodate:  
.100-inch spacing (SIP) Single-in-line packages  
.300-inch spacing (DIP) Dual-in-line packages  
.400-inch spacing (4K Ram) Memory packages  
.500-inch spacing (UART)  
.600-inch spacing (LSI) Large Scale Integrated Circuits

Designated the MU Series, the new packaging panels are available with 18 columns of 55 terminals per column, as plug-in modules P/N EP/80-18/55-15 or they can be manufactured to a customer's individual "slot" requirements. These panels are available in two to four weeks.

For complete information contact Garry Manufacturing Co. directly. Garry Manufacturing Co., 1010 Jersey Avenue, New Brunswick, NJ 08902, 201-545-2424.

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Garry Manufacturing Company now has available their new SBC 80/10 Universal Microprocessor Interface Board designed to plug directly into the Intel SBC 604 Modular Cardage/Backplane bus system with power

## We just got Mary Smith out of a bum wrap.

We gave Mary a pluggable Wire Wrap\* board that worked at a very reasonable price. Get all the facts on our line of packaging panels as well as our line of other high quality, low cost products. I.C. sockets, adapter headers, microprocessor boards, racks, cable assemblies and much more.

Call or write Garry for the name and address of your nearest distributor or factory representative.

Garry Manufacturing, 1010 Jersey Avenue, New Brunswick, New Jersey 08902. (201) 545-2424.

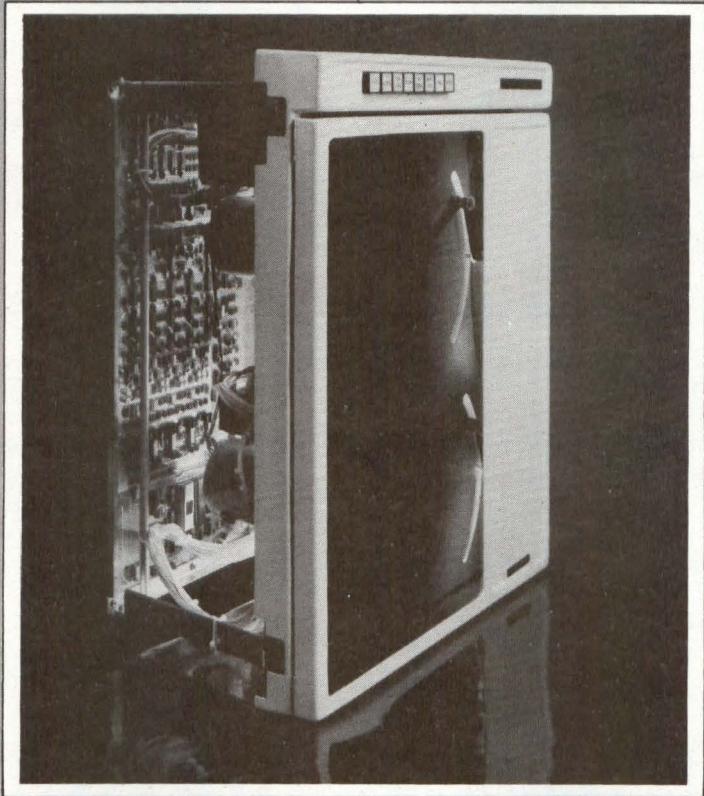
\*Registered trademark of Gardner-Denver Co.

We won't pin a bum wrap on you.

**Garry**  
Manufacturing Co.

Tandberg Data introduces a tape drive

# SO WHAT ELSE IS NEW?



## Performance. On an absolutely new level.

With the name Tandberg you expect top performance. And innovation. And being a little ahead of the competition in certain fresh and subtle ways. Ditto our new TDI 1050 Synchronous Tape Transport.

When you're a Johnny-Come-Lately with a product line you better try harder.

We did!

Your benefit? Greater reliability, maintainability, and programability as a result of our micro processor-based control logic. With its optional internal formatter, the 10½-inch-reel TDI 1050 makes your interfacing task a whole lot easier, giving unprecedented flexibility and performance when controlling the reading and writing of data.

With Tandberg's dual-format tape drive, you get both 1600 cpi PE and 800 cpi NRZI at speeds of 12.5 to 45 ips, with rewind speed of 200 ips. And there's no need for customer redesign with the in-

dustry-wide compatibility of our interface.

For those who'd like multiple-drive capability in their system, our interface enables you to hook up four drives without the need for an outside power source.

Not only is the TDI 1050 less costly at the outset, but its built-in microprocessor is likely to reduce your operating costs. Its attractive design is another appealing plus for systems builders.

Just another tape drive? Yes and no. The task it performs has been around a while. A lot of horses ran a mile and a quarter and then along came Secretariat. Refinements count a lot, regardless of the track. Check out the TDI 1050. It'll change your ideas about what a tape transport can do.

Tandberg Data Inc.  
4060 Morena Blvd.  
San Diego, CA 92117  
(714) 270-3990

**TANDBERG** =

telephone central office does not exceed the permissible level of -12dBm. The second type of connection, "fixed loss loop", operates at -4dBm. The third type, said Seppala, coming in the near future, is called a "programmable" DAA. A "programmable" DAA can control the output of any modem's transmit level from 0 to -12dBm by means of a plug inserted into the standard jack, serving as a sensor to a telephone company installed resistor. The resistor, in discrete steps of resistance, will tell the equipment that it may transmit at a given level.

Limiting the level, said Seppala, is one of the things that protective circuitry concerns itself with. Data couplers also protect circuits the following ways:

**Longitudinal Balance.** Data coupler circuitry automatically balances voltages to ground from either tip or ring connections, eliminating voltage variances in the transmission or reception of signals.

**Hazardous Voltage Protection.** Tele-

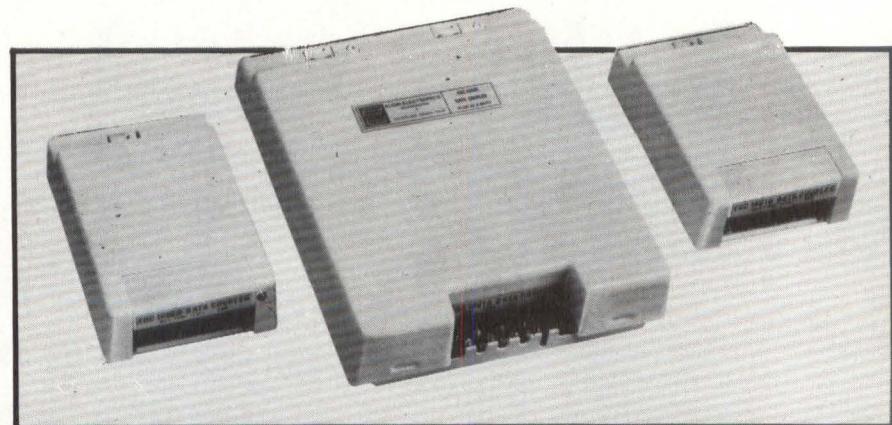


Fig 2 Elgin's three FCC registered data couplers interface customer-owned terminals, modems and the like with switched telecommunications networks for data communications.

phone companies and users are protected against hazardous voltages that can seriously damage either party's equipment.

**Excessive Signal Power.** Data couplers work to minimize excessive signal power, a main cause of signal distortion and crosstalk on the telecommunications network.

**Timing Circuits.** Timing circuits allow the telephone company's electronic

accounting equipment to determine the length of time a customer uses its circuits for transmission of data signals.

According to Montgomery and Sepala, these four essential types of protection must be built into a DAA somewhere along the line. The means to do this is changing very rapidly with modern technology and the use of devices such as microprocessors and large scale integrated circuits.

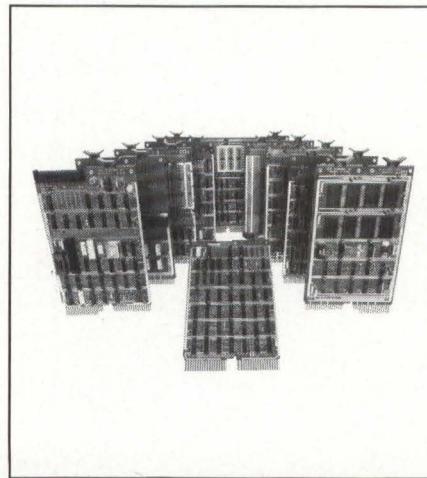
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GP Logic Modules • Peripheral Controllers • Communications Interfaces • Special Purpose Modules • Accessory Hardware

Plus: DEC's own LSI-11 Microprocessor Module.

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Card equipment  
Paper tape equipment  
Plotters
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Synchronous Serial Line



- MDB Backplane/Card Guide Assembly (8 Quad slots)  
Rack mount chassis 5½" front panel.
- Special Purpose Modules and Accessories  
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- Bus extenders/terminators.  
E-PROM and PROM modules.  
Bus connectors for backplane assemblies.

MDB Systems products always equal and usually exceed the host manufacturer's specifications and performance for a similar interface. MDB interfaces are software and diagnostic transparent to the host computer. MDB products are competitively priced; delivery is usually within 14 days ARO or sooner.

MDB also supplies interface modules for DEC PDP-11 Data General NOVA\* and Interdata minicomputers.

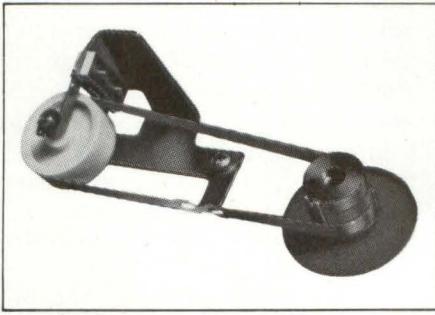
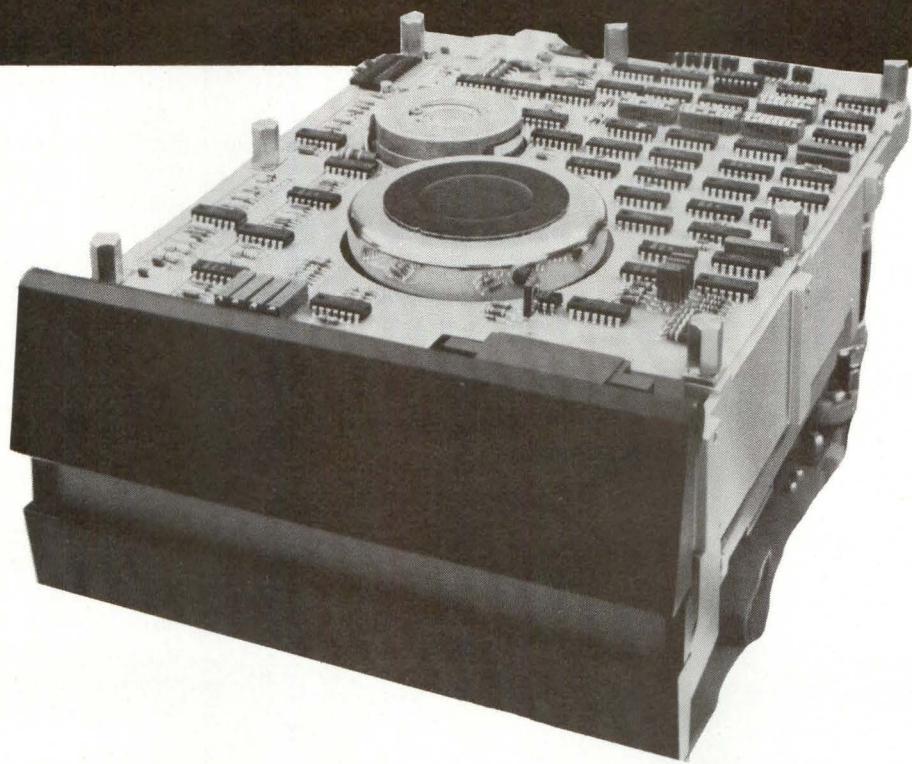
**MDB**  
MDB SYSTEMS, INC.

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\*TMs Digital Equipment Corp. & Data General Corp.

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CIRCLE NO. 90 FOR LSI-11; 91 FOR PDP-11; 92 FOR NOVA; 93 FOR INTERDATA

# MFE's Mayflower Project Brings You The World's Smallest, Double Sided, Double Density, IBM Compatible Floppy Disc.



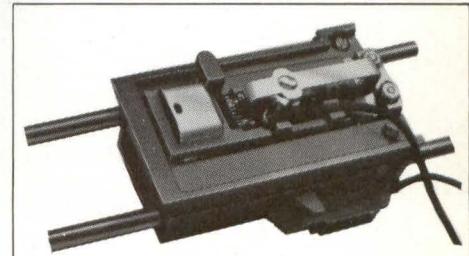
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## Data Reliability: Cartridges Compete With Floppys

The boom in minicomputers and intelligent data terminals has spurred an unprecedented demand for low-cost mass storage devices such as the 3M

magnetic tape cartridge and the floppy disk. Both media store data in magnetic form; however their operating principles are very different. In general, the floppy disk permits faster access, but according to Dale A. Spencer, President of Tandberg Data Corporation, San Diego, California, the magnetic tape cartridge is more rugged, has a higher storage capacity and usually

simplifies data formatting. He also points out that the cartridge has advantages in data reliability that make it more desirable in some applications.

Spencer puts data errors into two categories, soft (recoverable) errors and hard (non-recoverable) errors. The medium causes soft errors; controlled re-reading can correct them. Drive equipment generates hard errors; thus they cannot be eliminated by a software process.

The signal to noise ratio no longer presents a problem in modern magnetic storage devices; it is high enough to eliminate errors due to statistical fluctuations and random noise. Dropout rate depends on several factors including head to medium contact. Cartridge tape tension and disk loading problems normally insure good head-to-media contact, but dust particles can impair this contact and cause temporary dropouts.

Bit shifts occur when rewriting data; the amount of bit shift depends on write current and packing density. Tape drives hold down bit shift by operating at a constant 1600 bpi, but, Spencer says, variations in packing density cause bit shifts with disks.

Variations in drive unit sensitivity require maintaining a minimum signal level to ensure reliable data interchange when writing on one drive unit and then reading on another. The dual-gap, read-after-write head found on cartridge drives permits an immediate level check, so that software-generated re-write occurs if the level is insufficient. According to Spencer, floppy disk drives cannot ensure a minimum signal level because a single gap head is used. Thus, he says, data that was checked read after one disk revolution will not necessarily reproduce well on a different drive. He claims that a cartridge drive has a typical error rate of 1 error per  $10^{12}$  bits, and that floppy drive error rates range between 1 per  $10^{11}$  and 1 per  $10^{12}$ .

Spencer points out that error rates should be kept in their proper perspective. Soft errors pose different problems than hard errors; a high soft error rate does not decrease reliability because it can be corrected by repeated reading. A high hard error rate decreases data reliability because it cannot be corrected.

## CITIZEN SERIES 8000 PRINTERS

**heavy-duty  
132 Columns  
250-720 LPM  
Chain Printer  
Excellent  
Quality  
and Price**

Manufactured by  
**CITIZEN WATCH CO.**  
Tokyo, Japan

Interior view of printer mechanism



Font train

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THAN CCD! -- FASTER THAN DISKS!!!**



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MEMORY FROM AMPLEX THAT DOESN'T SPIN.  
A COMPACT ARRAY OF RELIABLE CORE ELEMENTS,  
MEGASTORE WON'T WEAR OUT, BURN OUT OR LOSE  
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CIRCLE 25

## ENHANCING MINI CAPABILITIES

EMU

The speed at which information can be accessed in a computer system affects its system performance. Increase the speed of access and the increase in system performance is immediate and obvious. Using complex software such as real-time or time-shared operating systems may obscure the exact restriction in accessing information: is it the front-end communications interface, the processor, the overhead of swapping tasks, the latency in accessing commonly-used operating system utilities, latency in accessing user programs and data or the inability to address sufficient information in main memory?

Most potential bottlenecks involve latency in accessing information or the inability to access enough information at or near processor speeds ( $1 \mu s$ ). Dr. Robin Lake of Monolithic Systems Corp., Englewood, CO and of Department of Biometry, Case Western University points out one solution to many system performance bottlenecks: provide a large increase in the processor's mass memory — memory which accesses information with little latency and transfers information near processor speed. The Extended Memory Unit (EMU, a trademark of Monolithic Systems Corp.) says Dr. Lake, provides exactly this capability for DEC's PDP-11 Unibus computer systems.

The EMU is a solid-state, plug-replacement for the DEC RF/RS-11 fixed-head disk. Computer systems

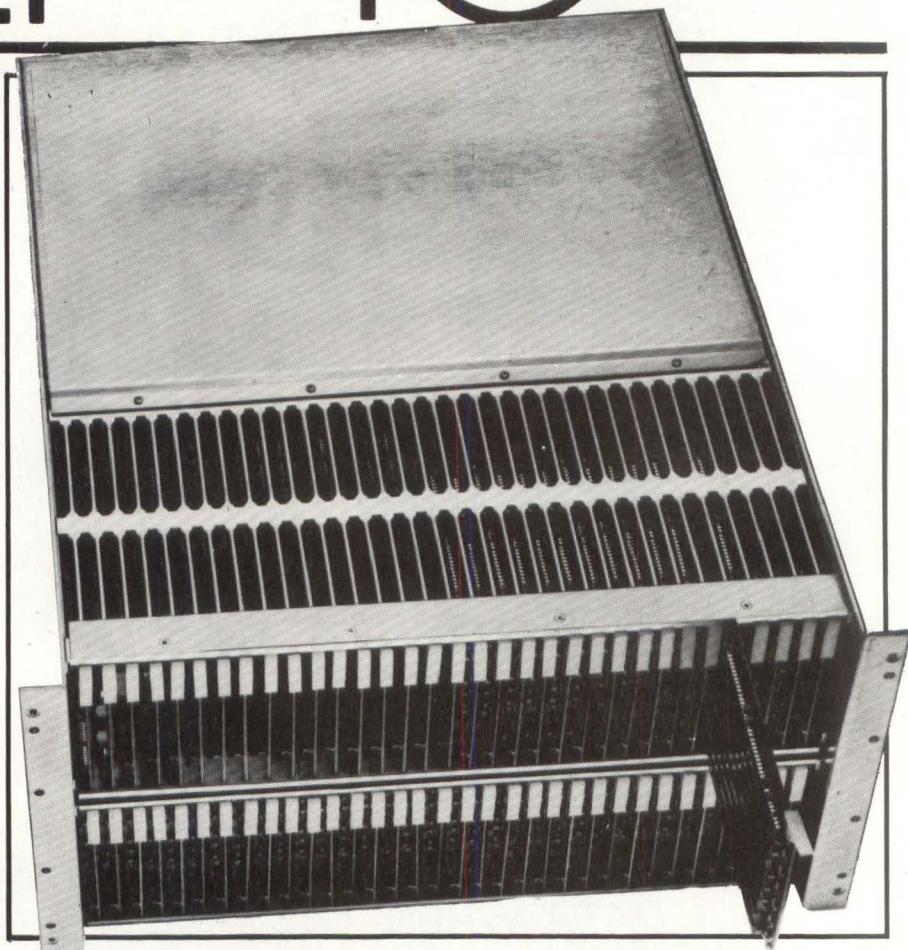


Fig 1 The solid-state EMU, manufactured by Monolithic systems, replaces fixed-head disks in PDP-11 systems.

typically include a fixed-head disk to reduce the latency (average time to access desired information) from the 55 ms rotational and positional latency of moving-head disks down to the 8.5-17 ms pure rotational latency of a fixed-head device. According to Dr. Lake, the

EMU completely eliminates this rotational latency. When accessing information is stored in the EMU, delay is the 2.1  $\mu s$  required to set up EMU control registers and initiate the transfer of information to/from the main memory. Dr. Lake says that not only is the EMU

Another first for ISS

# THE INDUSTRY'S MOST ADVANCED FIXED HEAD DRIVE

Announcing another in a long line of industry firsts for ISS—the ISS 550—the first fixed head disk drive to employ Winchester technology.

ISS is not only an innovator, but also one of the world's foremost manufacturers of OEM disk products, with all that means in the way of service back-up, spares, and technical assistance.

But at ISS, being first alone is not enough. The new ISS 550 has truly outstanding performance. Field upgradable capacity from 12.8 to 51.2 megabits. Average access time of 8.3 milliseconds. Sector formatting to meet individual requirements. And advanced technology that results in extremely low error rates.

Data transfer rate is 12MHz, and if that's too fast, you can slow it down with our data rate buffering feature.

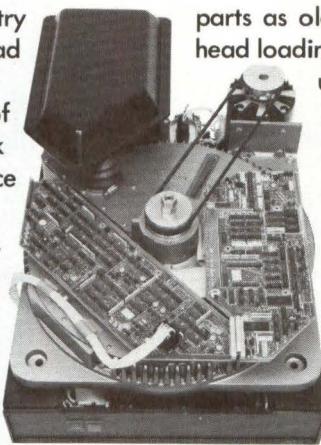
But even high performance isn't everything. The new 550 is exceptionally reliable. It has only 25% as many

parts as older technology fixed head drives. There's no head loading mechanism. DC power supply is built in. The unit is self clocked. And the design incorporates interchangeable modular subassemblies for quick and easy maintenance.

All this performance and all this reliability go into a compact package that occupies just 14.5 inches of rack space.

*But when all is said and done, the most significant statement we can make about the 550 is this: the price-performance ratio is twice as good as that of fixed head drives using older technology.*

Get full details on this ISS first. ISS is an operating unit of Sperry Univac bringing technological leadership for the generations ahead. Write or call OEM Marketing, ISS, 10435 N. Tantau Avenue, Cupertino, California 95014, Telephone (408) 257-6220.

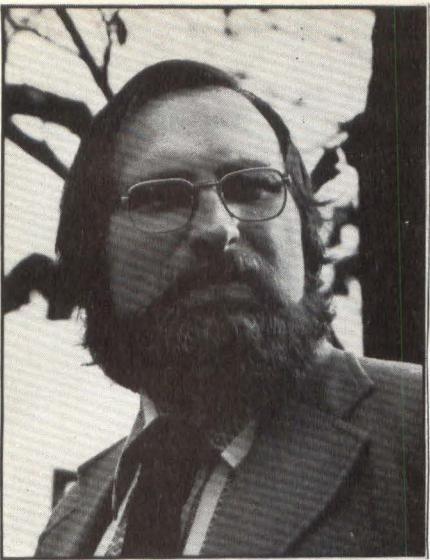


**ISS 550. Twice the performance.**

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CIRCLE 26



## Dr. Robin Lake: A large increase in the minicomputer's mass memory clears up many system performance bottlenecks.

4,000 to 8,000 times faster than a fixed-head disk with respect to latency, but the EMU transfers information at a 1  $\mu$ s data rate — 16 times faster than the RF/RS-11 and 4 times faster than the RJS-04 disk.

Dr. Lake points out that the increases in system performance offered by such a device may be manifest in many ways:

- More users and faster response time in time-sharing systems;
- Faster assembly and compilation in program development;
- The ability to handle more communication lines per processor in data communications systems;
- Faster access to information in data base management systems;
- Higher sampling frequencies possible in data acquisition systems;
- Higher control loop bandwidths in process control systems;
- The ability to handle huge (1024 by 1024) data arrays at near processor speed with BASIC, FORTRAN and other high-level languages;
- The ability to use disk operating systems in harsh environments where rotational devices are precluded by shock, vibration or high particulate atmosphere.

Indeed, Dr. Lake claims, the EMU may provide years of added productive life to a PDP-11 system which appears

to be overloaded — time that may be of great importance to the user contemplating a system upgrade but faced with extended delivery delay for a new system.

### Application

Dr. Lake provided us with the following details of enhancements extended memory units offer in some application areas.

**Time-Sharing Systems.** Many time-shared operating systems use highly paged program segments. A single PDP-11 instruction may require as many as five program segments for its execution: one each for the instruction, two indirect addresses and two operands. Each additional program segment could require system access to the paging device — with a rotational latency of 8,500 to 17,000  $\mu$ s. An extended memory unit eliminates this latency, reducing system overhead and increasing the

## Most potential system bottlenecks involve latency in accessing information.

throughput of the operating system. According to one model of time sharing performance, the EMU will yield a 79% decrease in mean wait time for each user. In fact, even greater increases occur in operating systems which encounter additional disk latency overhead when creating files, accessing utility programs overlaying program segments, accessing data files and performing system accounting.

**Program Development.** Modern compilers typically make seven to fifteen passes through a source file and the intermediate files generated. Compiler references to symbol tables, macro code segments and compiler program overlays require many disk accesses.

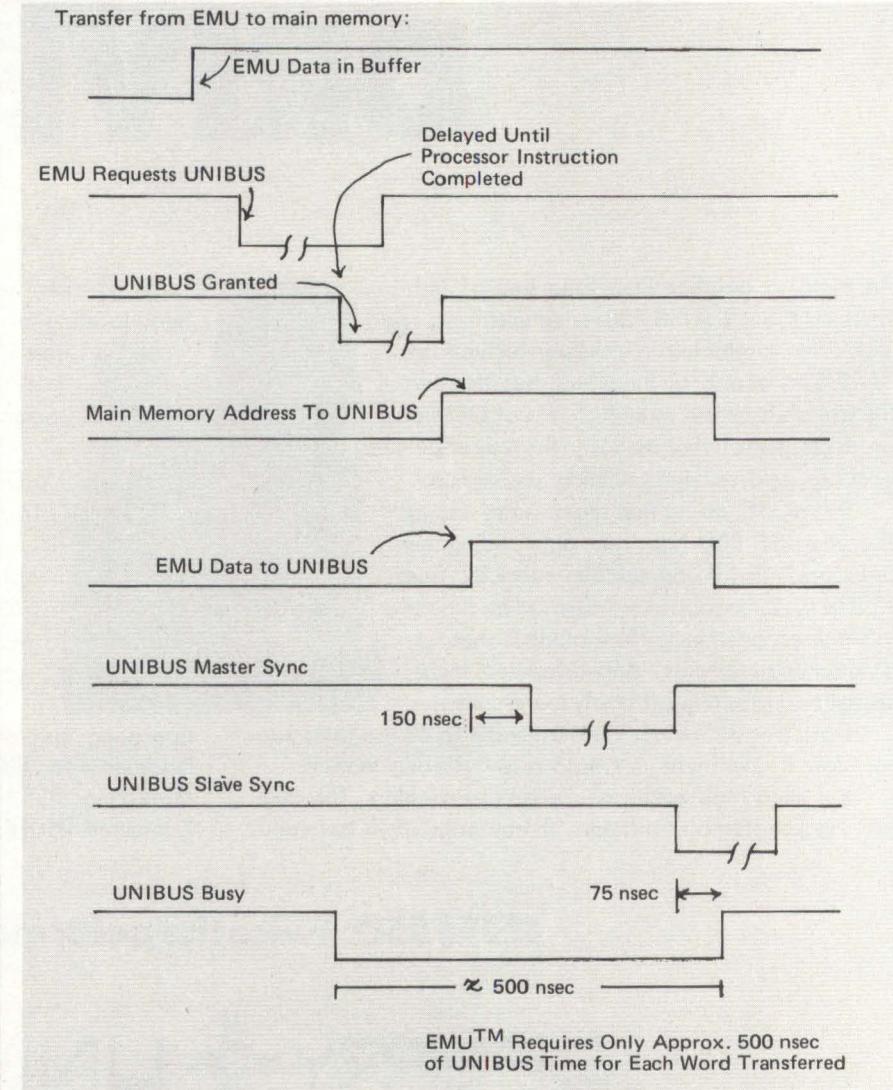


Fig 2 The EMU in a single-port configuration.

# NOW, LEAR SIEGLER AND BURROUGHS ARE ON SPEAKING TERMS.



You're probably very happy with your Burroughs mainframe.

But you'd undoubtedly like to have the versatility and dependability of Lear Siegler terminals. If only they were compatible with your present system.

Now they are. Complete with standard Burroughs polling and address line disciplines.

What's more, the ADM-2B's forms mode capability is compatible with the TD-820.

The ADM-2B gives you full text editing capabilities. Including erase to end of line/field/page. Insert and delete character and line. Blinking and blanking fields. And tabbing.

Just flick a switch and you can convert the ADM-2B to a standard ADM-2 with Burroughs line discipline.

Line diagnostic mode is switch selectable—which makes it extremely valuable for troubleshooting.

Of course, there's all the support that Lear Siegler is famous for. Throughout the United States and in many foreign countries.

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That's the full price. Including serial printer port. Numeric keypad. 24x80 character screen. 16 function keys. 110-9600 baud. RS232 interface. Burroughs two-wire direct connect is available as an option.

The fact is, Lear Siegler's new ADM-2B terminal gives you the best of both terminals. So you can use it right alongside your present Burroughs terminals and mainframe.

So rest easy, Burroughs users. Because now Lear Siegler speaks your language.

For more information contact: Lear Siegler, Inc., E.I.D./Data Products, 714 N. Brookhurst St., Anaheim, CA 92803; (800) 854-3805. In California (714) 774-1010.



**THE ADM-2B.  
SMART TERMINAL.  
SMARTER BUY.**

The linker program also has high I/O requirements as program and library code segments are selected, relocated and written out as object files. Reduction in file access latency by use of an EMU to store compiler scratch files and other similar files should reduce compilation and linkage times.

**Data Base Management.** Data base management systems, notorious for their high use of disk storage, require high rates of disk access as a data item is pursued through disk-based links and pointers. Elimination of rotational latency by storage of data-base access keys, pointers and links in an EMU promises more rapid access to the DBMS data items.

**Data Communications.** In data communications, store-and-forward message switching and time-sharing front-end processors, one system design consideration is the amount of main memory available to buffer messages awaiting transfer to a mass storage device. The EMU wastes no time waiting for rotational latency, permitting a processor to handle many more communication lines and lines of higher data rates for a given main memory capacity. The

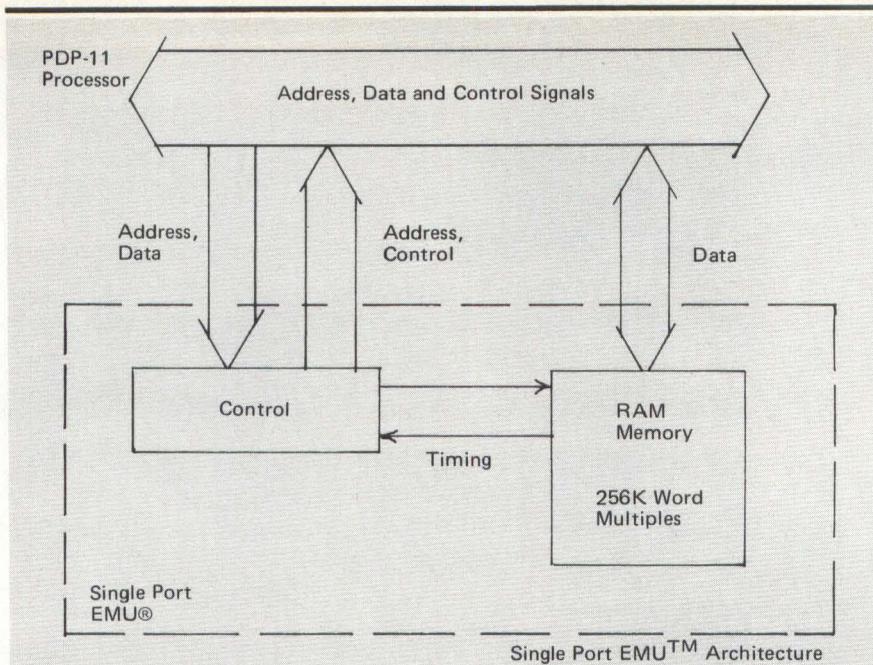


Fig 3 The EMU requires only 500 ns of Unibus time for each transferred word.

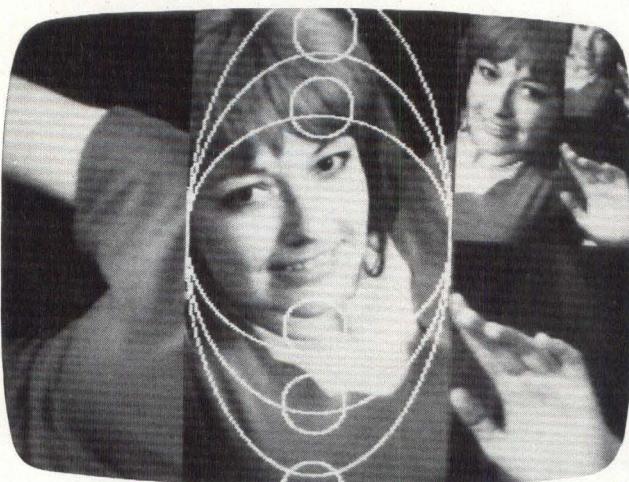
word addressability of the EMU permits message strings to be processed at their natural length without blocking into 512 byte sectors.

**Data Acquisition and Control.** Computer system performance in time-critical acquisition and control systems can

be considered in terms of processor and memory bandwidths. PDP-11 processor bandwidths range from less than a thousand floating-point fetch/execute cycles per second in the PDP-11/05 up to approximately 130,000 cps in the PDP-11/70 with floating-point proce-

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- Converts digital data to standard 525-line television format
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Video Instruments for Data Acquisition, Processing, Transmission, Display

sor. For compute-bound systems, mass memory will help only in that I/O time for access to data arrays is reduced markedly. Main memory bandwidth ranges from approximately 1.1 million in the PDP-11/05 to approximately 2.4 million words/second in the PDP-11/70 cache memory. Mass memory band-

width for the RF/RS-11 fixed-head disk is 30.3 1K-word blocks/second; the RJS-04 FHD 80 1K-word blocks/second; and the EMU 1000 1K-word blocks/second. Where data acquired must be transferred to or from mass memory for storage and analysis, the EMU offers a 12-fold to 33-fold in-

crease in mass memory bandwidth.

**FORTRAN Data Analysis.** Data analysis problems which exceed the 32K word data space of PDP-11 FORTRAN tax many PDP-11 computer facilities. In the PDP-11/04 through 11/40 and in the PDP-11/60, only 32K words of main memory are accessible to FOR-

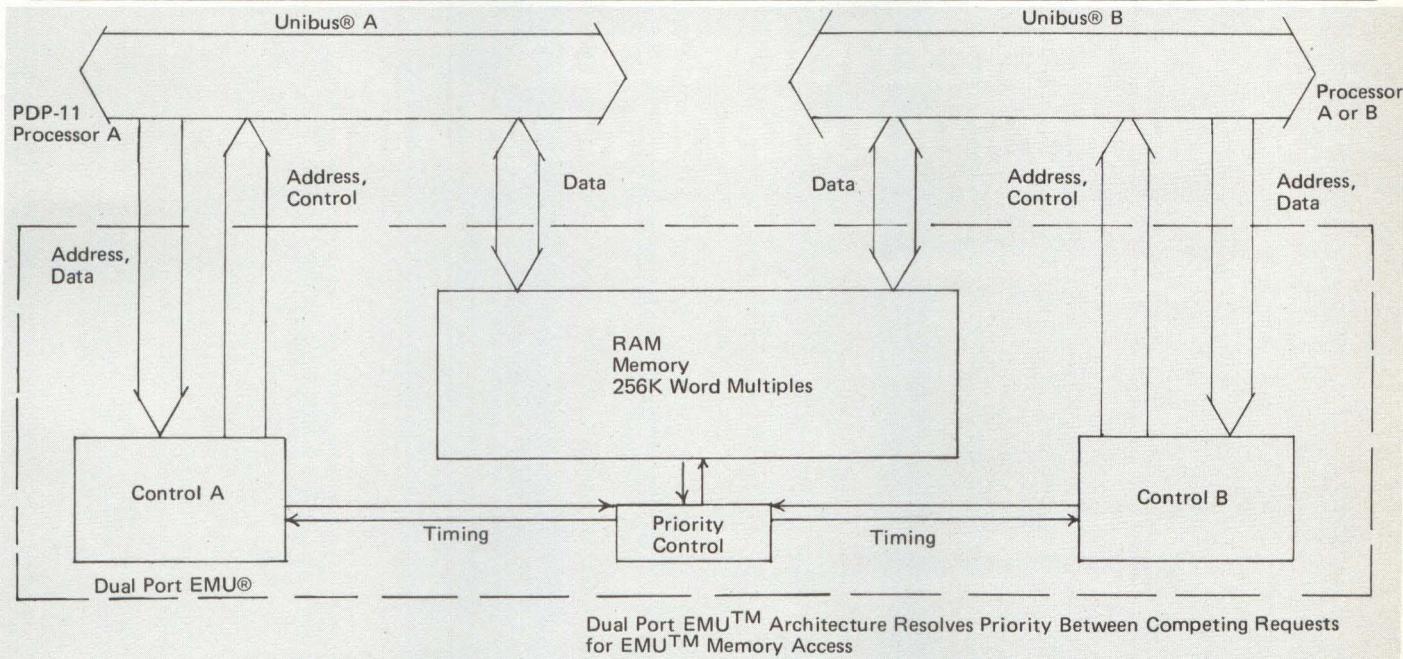
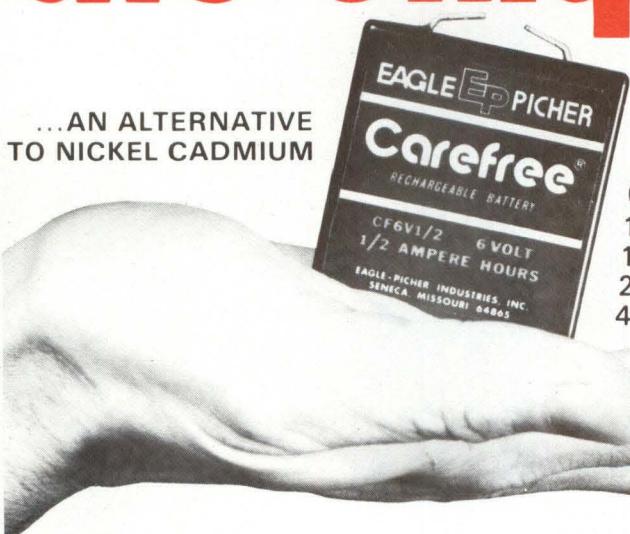


Fig 4 The EMU in a dual-port configuration.

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CIRCLE 29

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MODEL NUMBER	RATING		REGULATION		OVP MODEL SUFFIX	PRICES-ALL MODELS		
	Vdc	Amps	Line	Load		QTY	POWER SUPPLY	OVP UNIT
APS 5-3*	5	3	$\pm 0.05\%$	$\pm 0.1\%$	3mV	OV1-53	1-4	34.00
APS 6-2.5	6	2.5	$\pm 0.05\%$	$\pm 0.1\%$	3mV	OV1-63	5-9	33.15
APS 12-1.6*	12	1.6	$\pm 0.05\%$	$\pm 0.1\%$	3mV	OV1-122	10-24	32.20
APS 15-1.5*	15	1.5	$\pm 0.05\%$	$\pm 0.1\%$	3mV	OV1-152	25-49	30.70
APS 20-1	20	1.0	$\pm 0.05\%$	$\pm 0.1\%$	5mV	OV1-201	50-99	29.20
APS 24-1*	24	1.0	$\pm 0.05\%$	$\pm 0.1\%$	5mV	OV1-241	100-249	27.00
APS 28-0.8*	28	0.8	$\pm 0.05\%$	$\pm 0.1\%$	5mV	OV1-281	250-499	25.20

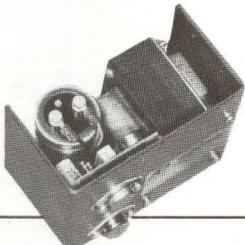


DIMENSIONS: 4" x 2.75" x 4.87"

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MODEL NUMBER	RATING		REGULATION		OVP MODEL SUFFIX	POWER SUPPLY PRICES			
	Vdc	Amps	Line	Load		QTY	APS 48-1	ALL OTHERS	OVP PRICES
APS 5-6+	5	6.0	$\pm 0.05\%$	$\pm 0.1\%$	OV2-56	1-4	68.00	55.00	15.00
APS 6-5	6	5.0	$\pm 0.05\%$	$\pm 0.1\%$	OV2-65	5-9	66.70	53.65	14.85
APS 12-4+	12	4.0	$\pm 0.05\%$	$\pm 0.1\%$	OV2-124	10-24	64.75	52.10	14.40
APS 15-3+	15	3.0	$\pm 0.05\%$	$\pm 0.1\%$	OV2-153	25-49	61.75	49.65	13.75
APS 20-2.4+	20	2.4	$\pm 0.05\%$	$\pm 0.1\%$	OV2-203	50-99	58.75	47.25	13.05
APS 24-2.2+	24	2.2	$\pm 0.05\%$	$\pm 0.1\%$	OV2-245	100-249	55.15	44.35	12.25
APS 28-2.1+	28	2.0	$\pm 0.05\%$	$\pm 0.1\%$	OV2-284	250-499	50.75	42.00	11.30
APS 48-1+	48	1.0	$\pm 0.05\%$	$\pm 0.1\%$	OV2-481	500-999	49.60	40.00	11.05

\* RIPPLE: (PK/PK) 5mV. All others 3mV.



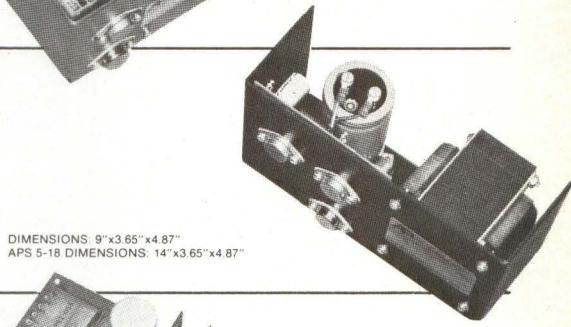
DIMENSIONS: 5.62" x 3.40" x 4.87"

## 50 TO 120 WATT "BLACK BEAUTY" SERIES. \*U.L. Recognized (File No. E58512)

MODEL NUMBER	RATING		OVP MODEL SUFFIX	POWER SUPPLY PRICES					OVP PRICES
	Vdc	Amps		QTY	APS 5-9	APS 5-12	APS 5-18	ALL OTHERS	
APS 5-9	5	9	OV2-510	1-4	71.00	85.00	108.00	75.20	15.00
APS 5-10*	5	10	OV2-510	5-9	68.75	82.95	104.50	73.40	14.85
APS 9-12*	9	12	OV2-512	10-24	66.74	80.55	101.45	71.30	14.40
APS 9-15*	9	15	OV2-518	25-49	63.90	76.80	96.70	67.95	13.75
APS 12-7*	12	7	OV2-127	50-99	61.05	73.00	91.95	64.60	13.05
APS 15-6*	15	6	OV2-156	100-249	57.30	68.55	86.35	60.65	12.25
APS 24-5*	24	5	OV2-245	250-499	52.75	65.00	79.45	55.80	11.30
APS 28-4*	28	4	OV2-284	500-999	51.60	57.90	77.70	54.60	11.05

REGULATION LINE -0.05% Load +0.1% RIPPLE (PK/PK) 3mV on 5, 12, 15V models 5mV on 24, 28V.

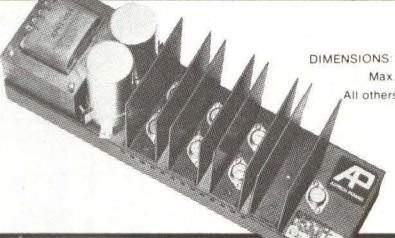
DIMENSIONS: 9" x 3.65" x 4.87"  
APS 5-18 DIMENSIONS: 14" x 3.65" x 4.87"



## 125 TO 250 WATT "BLUE MAX" SERIES.

MODEL NUMBER	RATING		REGULATION		OVP MODEL SUFFIX	POWER SUPPLY PRICES				
	Vdc	Amps	Line	Load		QTY	APS 5-9	APS 5-12	APS 5-18	OVP PRICES
APS 5-25	5	25	$\pm 0.05\%$	$\pm 0.1\%$	OV3-525	1-4	163.00	158.00	25.00	
APS 5-30	5	30	$\pm 0.05\%$	$\pm 0.1\%$	OV3-530	5-9	159.25	154.40	24.50	
APS 6-22	6	22	$\pm 0.05\%$	$\pm 0.1\%$	OV3-622	10-24	145.65	149.95	24.25	
APS 12-17	12	17	$\pm 0.05\%$	$\pm 0.1\%$	OV3-127	25-49	145.65	149.95	23.75	
APS 12-15	12	15	$\pm 0.05\%$	$\pm 0.1\%$	OV3-1515	50-99	140.20	136.90	22.00	
APS 20-16	20	16	$\pm 0.05\%$	$\pm 0.1\%$	OV3-2011	100-249	131.65	127.60	20.65	
APS 24-10	24	10	$\pm 0.05\%$	$\pm 0.1\%$	OV3-2410	250-499	121.10	117.40	19.00	
APS 28-9	28	9	$\pm 0.05\%$	$\pm 0.1\%$	OV3-289	500-999	118.50	114.85	18.80	

RIPPLE (PK/PK): 3mV on 5.6, 12, 15V models 5mV on 20, 24, 28V models.



DIMENSIONS: 16.72" x 4.87" x 6.60"  
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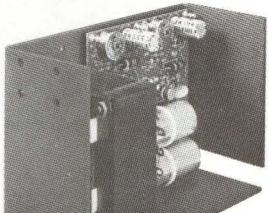
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MODEL NUMBER	RATING		OVP MODEL SUFFIX	QUANTITY PRICES					OVP PRICES
	Vdc	Amps		1-4	5-9	10-24	25-49	50-99	
DAPS 5.8	+5	0.8	43.00	41.95	40.70	39.80	38.00	36.80	33.00
DAPS 9-12.5	+9-12	0.5	43.00	41.95	40.70	39.80	38.00	35.80	33.00
DAPS 12-7.5	+12	0.75	43.00	41.95	40.70	39.80	38.00	35.80	33.00
DAPS 15-60	+15	0.06	43.00	41.95	40.70	39.80	38.00	35.80	33.00
DAPS 5112.5	+5	1.0	43.00	41.95	40.70	39.80	38.00	35.80	33.00
	-12	0.5							
DAPS 12-1.5	+12	1.5	59.00	57.60	55.90	53.30	50.65	47.60	43.80
DAPS 15-1.3	+15	1.3	59.00	57.60	55.90	53.30	50.65	47.60	43.80
DAPS 53121.5	+5	3.0	59.00	57.60	55.90	53.30	50.65	47.60	43.80
	-12	1.5							

REGULATION: +0.05% Line, +0.1% Load. RIPPLE (PK/PK) 3mV.



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### TRIPLE OUTPUT "TAPS" MICROPROCESSOR/GENERAL PURPOSE SERIES

MODEL NUMBER	RATING		OVP MODEL SUFFIX	QUANTITY PRICES					OVP PRICES
	Vdc	Amps		1-4	5-9	10-24	25-49	50-99	
TAPS 1	5V	4.0	94.15	91.85	89.20	85.05	80.85	75.90	71.00
TAPS 2	$\pm 9-12^*$	0.5	107.00	104.60	101.60	96.85	92.10	89.00	87.50
TAPS 3	$\pm 9-12^*$	1.0	137.00	134.00	129.80	127.80	125.00	123.75	113.85
TAPS 4	$\pm 9-12^*$	1.5	163.00	159.00	154.45	151.50	149.00	148.00	147.00
	$\pm 9-12^*$	3.0							

\* Also available with +12-15V output. Specify if desired. REGULATION: +0.1% Line, +0.1% Load. RIPPLE (PK/PK) 5mV.

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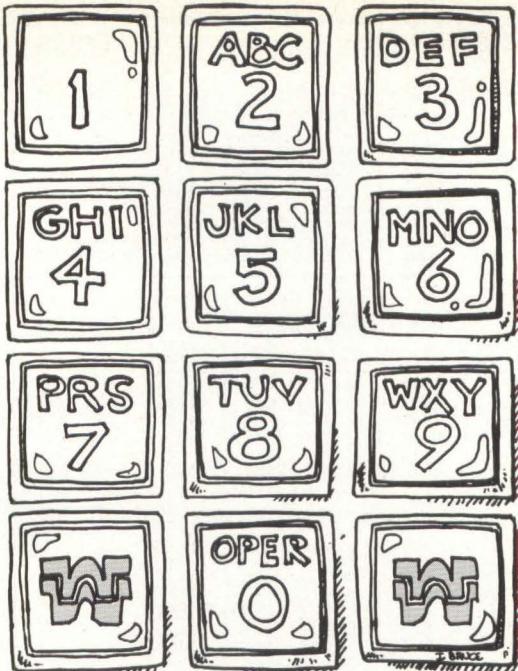
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TRAN for both program instruction codes and data. With the PDP-11/45 and 11/70 memory management units, separate 32K words of instruction and 32K words of data may be accessed by a FORTRAN program. With the EMU and its word-addressability, a PDP-11 can access 2 million words of data at a speed only slightly less than that of main memory, permitting FORTRAN data arrays of 1,024 by 1,024 floating-point words. The EMU allows the PDP-11 minicomputer to approach problems that currently challenge the storage capacity of the larger mainframe computing centers.

**GeoData.** In geophysical and oceanographic data processing, correlation, convolution and Fourier transformations of signals are performed directly, without the additional software nuisance of data blocking and unblocking. Using the EMU for acquisition of data and signals in the field permits higher data acquisition rates with some portion of the increase in system performance allocated to pre-processing of the acquired data. Pre-processing in the field assures data quality and yields preliminary impressions before extended data processing provides finer detail. Dr. Lake emphasizes that aboard ship, where reliability in data acquisition weighs heavily, the dual-port EMU offers fail-soft capabilities. In a single-processor data acquisition system, both EMU ports may be on the single Unibus at different device addresses. Should a port fail, the EMU may be accessed immediately through the second port. If a second processor is available for back-up, its Unibus may be attached to the EMU via the second port for data pre-processing while the first processor performs the primary task of data acquisition. The EMU memory is sufficiently faster than the Unibus that both processors appear to have simultaneous access to the EMU memory.

The modular design of the EMU, he points out, provides fail-soft reconfiguration and low mean-time-to-repair. Each RAM memory board contains 64K by 9 bits; all memory boards are interchangeable. Each 16K RAM chip is socketed for immediate replacement should an EMU parity error lead to identification of a bad bit. EMU memory banks may be logically interchanged by swapping the two timing control

## An Extended Memory Unit eliminates the rotational latency of a fixed-head device.

boards — assuring that contiguous EMU addresses are immediately available if the EMU is reconfigured into a fail-soft condition. DIP switches for each EMU port select control register and interrupt vector addresses. Write protection for the EMU contents may be controlled by hardware and/or software.

With a mean-time between failures of 38,000 hours (4 years), reconfiguration of the EMU is unlikely. Nonetheless, Dr. Lake claims that the design reflects thoughtful consideration for the user who must maintain computer system operation.

### System Design

The design criteria of utility, modularity, high mean-time-between-failures, low mean-time-to-repair and low cost are best demonstrated in the dual-port EMU design. The dual-port system contains two full Unibus interfaces which may reside at different addresses on a single Unibus or each at the same address on the Unibus of different processors. Nine card modules (4.5" x 8") comprise each Unibus interface port. Each port occupies the left hand side of one row in a 10.5" dual row card cage. Each card module interchanges with the one above it.

EMU memory modules are the same size as Unibus cards; each stores 64K by 9 bits using 16K MOS RAM memory chips. Any two memory cards interchange without re-addressing. Memory blocks of 256K words reside above and beside each other on the right hand side of each card cage row. Separate DC power connections, available for the top row and bottom row, permit redundant power supplies. Timing and control modules determine logical addresses within the EMU. Interchanging timing and control cards permits rapid reconfiguration of a multi-256K block EMU to prevent contiguous logical addresses. A single priority arbitration card provides apparent simultaneous access for both ports. Switching permits immediate forced assignment of the entire EMU memory exclusively to either port.

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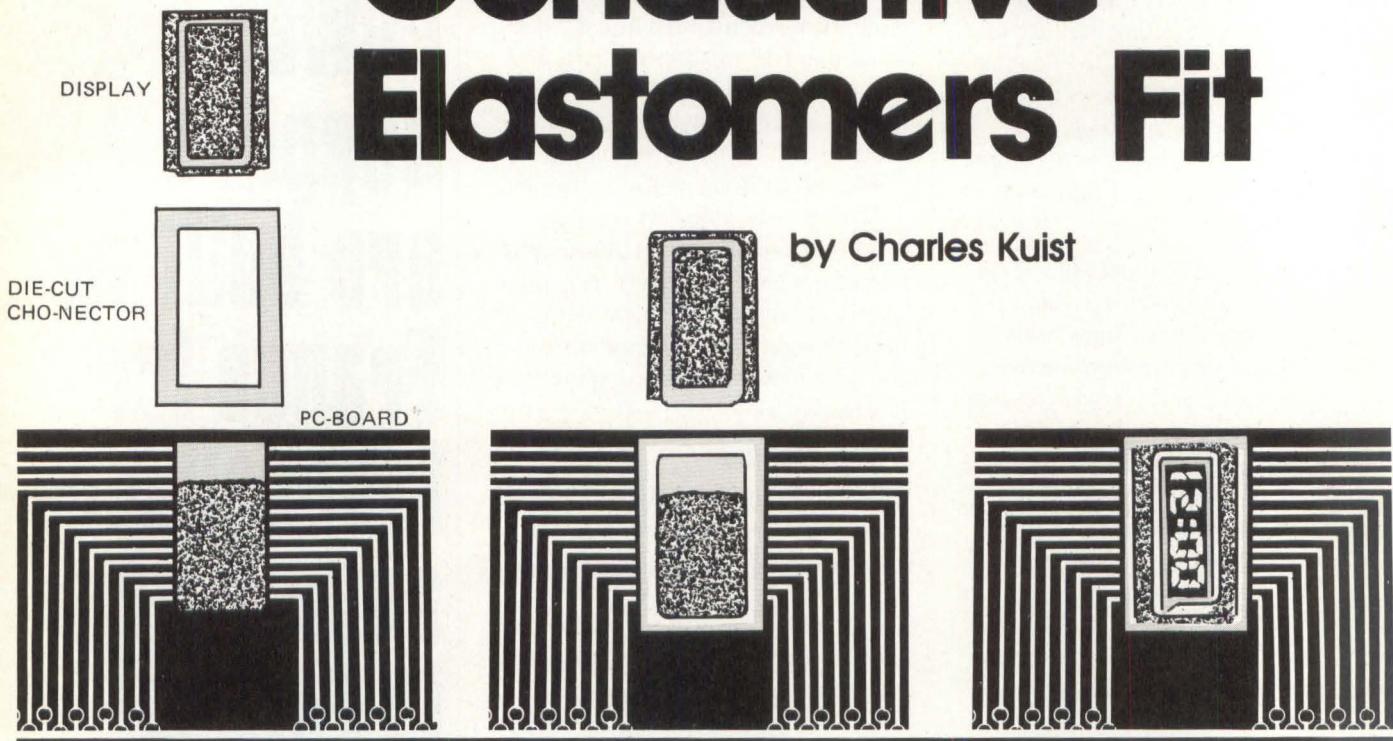
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CIRCLE 32

# Where Conductive Elastomers Fit



by Charles Kuist

**A**s materials, electrically conductive elastomers are not new. They have been in use for some time as signal measurement and transmission probes, RFI shields and static arrestors. As circuit parts, however, they have only recently come into their own, but they have already added new looks and dimensions to package configurations.

These elastomers serve mainly as replacements for mechanical switches and connectors in electronic circuits and devices and as connectors between PC boards and LEDs, flat packs, leadless ICs and other PC boards. What makes them remarkable is that they can provide 7000 or more interconnections per sq in — a fact that has started a trend away from the traditional space-consuming practices of arranging connectors in a linear pattern and bringing sets of PC connectors to an edge tab.

Thermally conductive elastomers are somewhat newer materials and are being used to electrically isolate power transistors, diodes, SCRs, Triacs, plastic and ceramic dual/in-line packages, and even whole circuit boards from heat sinks. They are important because, as packaging densities push ever higher, they offer an effective means for reducing temperatures in and around heat-sensitive chips.

The most impressive feature of conductive elastomers is their ability to be blended to meet a range of electrical, thermal and mechanical properties.

## Inside conductive elastomers

Most electrically conductive elastomers are blends of usually insulating elastomers, or matrix materials, and minute particles of metallic or nonmetallic conducting fillers. The filler densities are such that the particles constantly touch each other and form discrete, low-resistance paths from one surface of the materials to the other.

The most popular matrix material is silicone rubber, which remains stable at temperatures ranging from -100° to 400° F and resists moisture, oxygen, ozone and ultraviolet light. Other matrix materials include polyethylene, EDPM, butyl rubber, neoprene, and vinyl, all of which offer certain advantages for specific applications.

Filler materials are selected for their resistivities and include carbon (the most popular and least expensive but also the least conductive), silver or silver-plated materials, gold, nickel and others. The filler accounts for up to 85% of the compound's weight and offers a thermal conductivity many times that of the matrix material.

Elastomers for electrically conductive applications can be made into sheets, films, rods, and foams of various sizes, thicknesses, and densities. You can even precision-mold or extrude them into practically any configuration to provide conductivity wherever needed.

Fig 1 (above) No special orientation of the high-density interconnector is required for good electrical contact between the 26 pads of the display and the 26 lines on the PC board.

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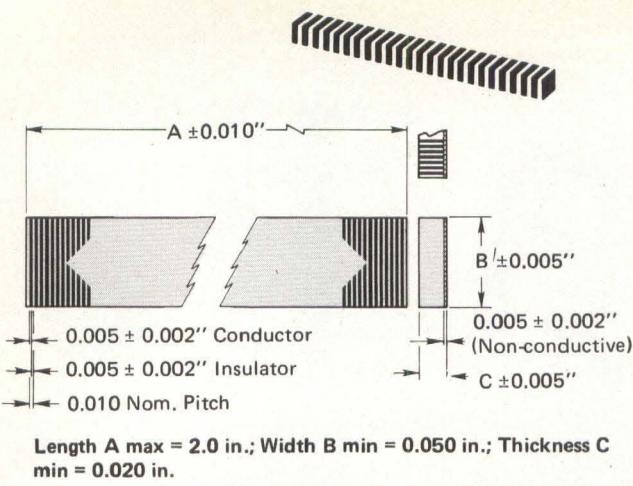
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**Fig 2** Strips of conductive and nonconductive silicone rubber are bonded alternately to form this one-dimensional, discrete-path conductive elastomer. Length A max = 2.0"; width B min = 0.050"; thickness C min = 0.020".

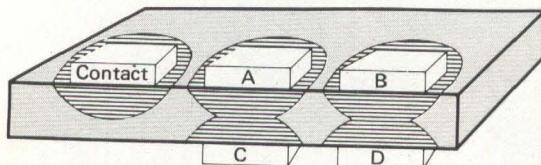
The material conforms to contacting surfaces and, unlike point contact connectors, it carries current in all areas of contact. While a dirt particle will keep rigid surfaces apart, rubber surfaces conform around the particle and ensure continued electrical contact. You can flex the material almost indefinitely without changing its mechanical or electrical properties, and it is soft enough to be used for shock and vibration damping in many applications. The elastomers resist corrosion, and many of them when torn or punctured close tightly enough to seal out adverse elements.

Thermally conductive elastomers blend silicone rubber and crystalline ceramic powders, which provide heat-transfer characteristics. They offer flexibility and conform well enough to allow for minor surface irregularities without thermal grease. Eliminating thermal grease has proved a major assembly advantage. These elastomers usually come in sheet, gasket and washer form, but you can mold them into a variety of shapes as required.

### Applications for conductive elastomers

Electrically conductive elastomers in widespread use include switch-element materials, display-mounting materials and high-density interconnection material.

Made from silicone rubber and conductive metal powders, switch elements are spongy, nondiscrete-conductive-path elastomers that you can sandwich between circuit contacts to function as switches. In this application, the elastomer pads replace beryllium-copper spring fingers in a digital



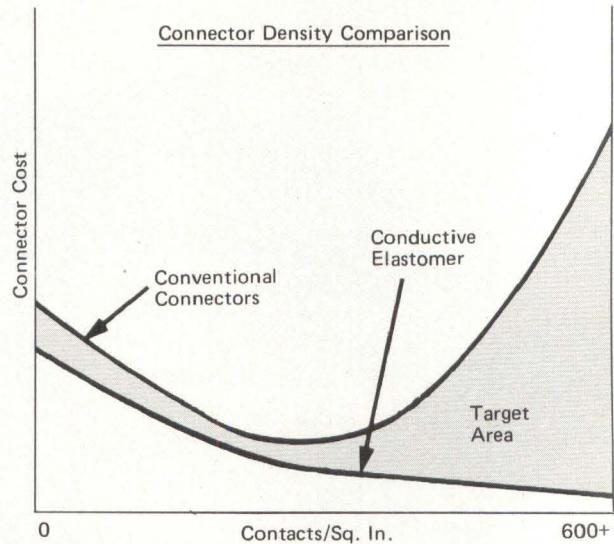
**Fig 3** Low-resistance paths are created through, but not across, the elastomer when metal contacts are placed on opposite surfaces. Between points A-C and B-D, resistance is less than 1Ω. Between points A-B, C-D, C-B and A-D, the resistance exceeds 1000 MΩ.

watch. The pads are retained in slots in the plastic housing, but for other applications, you can laminate the elastomer to metal surfaces or bond it with adhesive. While pads cost more than metal connectors, they eliminate so much solder labor that they reduce overall package costs.

This conductive elastomer has also attracted attention from computer manufacturers, who have become more aware of what electromagnetic interference (EMI) does to systems and peripherals. Because the material was developed originally for use in EMI shielding and easily molds into gaskets, it provides a means for eliminating noise problems.

A one-dimensional discrete-path conductive elastomer mounts displays close to an outside surface to improve the appearance of digital panel meters and other products. Such upfront mounting proves difficult if not impossible to achieve with conventional spring connectors. The elastomer also connects flexible circuits, calculator displays and PCBs.

Termed Cho-Bra, this display-mounting material is made by alternately laminating 0.005"-thick conductive and non-conductive silicone rubber sheets (Fig 2). The conductive elements offer low resistance and are closely controlled during manufacturing for straightness, width and inter-element spacing. The connector also contains a nonconductive edge to prevent shorting against metallic surfaces. Cho-Bra is flexible, self-gasketing and easily compresses to as much as 15%



**Fig 4** In high-density applications, the cost per contact decreases as the number of contacts increases.

of its relaxed thickness. For all practical purposes, the laminate consists of a single piece and will not come apart at the seams even under extreme pressure conditions. It also withstands shock and vibration — a characteristic that makes it ideal for packaging applications.

In applications requiring high-density interconnections, a conductive elastomer called Cho-Nector offers the greatest potential. Cho-Nector consists of a silicone matrix in which spherical metal particles of carefully controlled diameters are dispersed to form very small clusters. As a result, the elastomer exhibits short-range conduction, i.e., when die-cut parts or sheets of the material are sandwiched between opposing contact arrays and subjected to just enough pressure to ensure surface contact, conductive paths form through, but not across, the material (Fig 3).

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CIRCLE 71

The advantage of using Cho-Nector as an electrical interconnection is that you can create any configuration of independent contact pairs as long as they are separated by a distance slightly greater than the thickness of the elastomer. Under these conditions, the resistance through the material will usually prove less than  $1\Omega$ , and the resistance between contact pairs (circuit isolation) will exceed  $1000\text{ M}\Omega$  (Fig 3).

Another advantage offered by this high-density interconnector is that it requires no particular orientation at assembly. Because of its flexibility, those contacts which are not coplanar still connect within the practical limit of the rubber's deformation. The flexibility of the silicone also allows it to follow any thermal expansion or contraction of the substrates.

Cho-Nector easily handles 6-mil contacts on 12-mil centers. Thus, you can make some 7000 connections per sq in. Another version of this material handles more than 16,000 contacts per sq in (128 x 128 discrete bits of data) for use in an array or parallel processing computer. In this application, the material will be used for assembling chips containing up to 16,000 array elements whose 4-mil contacts will be spaced on 8-mil centers. In such high-density interconnection applications, the cost per contact decreases as the number of contacts increases (Fig 4).

Cho-Nector conducts statistically in that the contact area and spacing in high-density applications directly affect the certainty with which all multiple connections will mate. If you probe the surface of the material with a point contact, you find many small areas that do not conduct. The larger the probe, the fewer areas you find. With a minimum-sized probe, you find no areas of nonconduction.

Although typical applications of Cho-Nector involve interconnecting electronic devices and substrates, the material has received serious consideration as an alternative to conventional IC wire bonding. If it proves successful, it will not only reduce package costs by eliminating gold wire and associated labor, but it will also allow you to salvage a package if an assembly proves defective — something that cannot now be done economically, if at all.

For applications requiring efficient heat transfer and electrical insulation, interface materials like Cho-Therm are used. These materials combine the best properties of conductive ceramics and thermal greases but have none of their drawbacks. Nontoxic Cho-Therm conducts heat as well as or better than greased beryllium oxide, greased hard anodized aluminum and aluminum oxide, and greased mica.

### Solutions in search of problems

As you continue to learn how to use conductive elastomers, you will see some radical departures from traditional design concepts. Whereas the trend toward miniaturization of electronic circuits and devices followed an almost predictable path because of practical limitations, the trend toward device interconnection and component packaging will go the way of the designers' imaginations. No longer will designs be shelved because of the lack of interconnection methods. On the contrary, conductive elastomers will provide even greater design freedom because of their almost limitless potential.

*Charles Kuist is VP of Chomerics, Inc., Woburn, MA.*

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# VIEWPOINT

## Are Engineers Really Different?

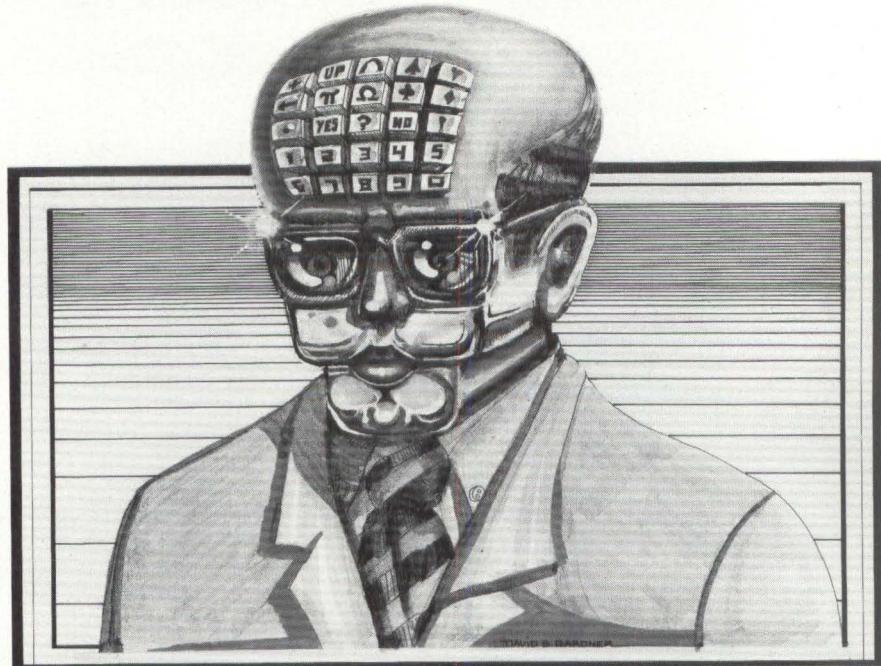
by Herbert F. Spire

As an outsider — today — my viewpoint can't help but be conditioned by many years as a design engineer and a manager of engineers. What is lost in objectivity may be gained by a full understanding of both the technology and the unique pressures under which engineers perform their remarkable work.

About half the students and seminar attendees that I meet are engineers; my contacts go beyond the classroom and involve career and education counseling. What is common both to engineers and the others is a desire to manage, to manage better or to advance in the managerial hierarchy. Engineers (or for that matter, financial analysts) who are happy carrying out the purely technical functions do not meet me in discussion or class.

These contacts have led to a viewpoint about engineers as a group. Not a statistical study, but a purely personal, possibly inaccurate set of generalizations. Hopefully many of you will take the challenge and comment on the weaknesses and strengths of these generalizations; to the extent that the issues are opened, they may be of value to engineers. On the other hand, my viewpoint is a mirror in which the engineer can see his reflection as it is perceived by non-engineering management and executives, for that is the way I now look at the working world. Here are some of the general characteristics of engineers seeking greater knowledge of management; characteristics in which I perceive them as differing from the

**Herbert F. Spire** is Professor of Management and Administrative Science in the MBA Program of the University of Connecticut at Stamford, Conn. His publications in the field of continuing education for engineers (*The Engineering Manager Game Seminar, Financial Management for Engineers, etc.*) have been adopted by the IEEE and over 20 other engineering/professional societies.



### " . . . The engineer seems to seek absolutes in all things including human relations . . . "

financial analysts, the marketing personnel, the claims adjusters, the trust officers and so forth:

**Rational decision-making.** The ability and willingness to formulate decision-making situations in unemotional terms facilitating tradeoff analyses based on quantified criteria. This quality goes beyond the expected skill in mathematical manipulation; it involves the ability (and again, willingness) to categorize, to sort, to measure.

**Lack of "give" in human relations.** The engineer seems to seek absolutes in all things including human relations. Business life is marked by a continuing series of gives and takes: manager A does a favor for manager B and someday B will return the favor to A. The fact that the corporate policy did not require A to do this favor will not distress the business-oriented manager — it simply raises the value of the favor. The engineering-oriented manager argues that he doesn't have to do the favor, so why should he? In some cases, discussions of real-life instances arouses overt hostility from engineers against the concept of calculated "trades" in working situations.

**A belief that taking human nature into account is "manipulation".** Salespeople know it instinctively, most teachers

learn it sooner or later, but only engineers seem to put a negative value judgement on a sensitivity and responsiveness to the other person's feelings. If you want someone to do something for you or to learn something from you, you don't deliberately offend them, putting artificial barriers in the way. All people have some "turnoffs" and it is only good management to learn what they are and to be sensitive to them in personal contact. If the chief draftsman is known to be offended by bare feet, then don't pitch him for a rush design job putting your sandaled feet on his desk. Yet in cases like this, I've had engineers (never any other profession) argue that to put shoes on to talk to the chief draftsman would be "manipulation," "being untrue to myself," "presenting a false image," and so forth. They don't seem to understand what is being said to the other person: I don't give a damn about you!

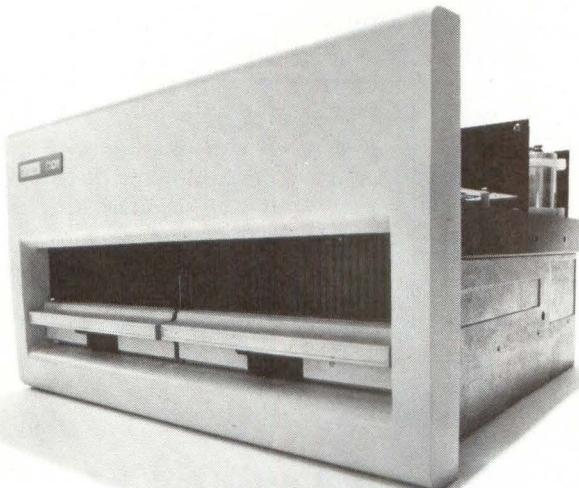
**Easily mobilized anxieties.** The occupational psychologist named this (through extensive studies) characteristic of engineers many years ago. Engineers worry not only about their own jobs; they worry about the success of the organization as a whole. In their suppression of their own self-interest in

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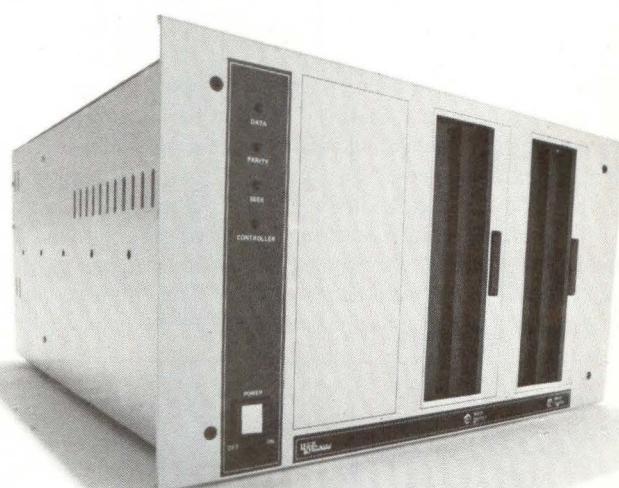
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<b>NO</b>	Front panel system status indicators	<b>YES</b>
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## VIEWPOINT

the interests of the needs of the project and the organization, they are truly outstanding among professional groups. It accounts for a lot of the conflict they experience with other groups. Years ago, after riding back from Washington in a plane with two of my engineers, the Director of Personnel of a large corporation said, "Your engineers are too highly motivated." They cared about the company; I thought this was great, but many members of organizations do not see beyond their own self-aggrandizement. Of course this quality has its negative aspects — for the engineer. What other group with so little long-term security works so much overtime without pay, and without even requesting pay? To have five engineers work all weekend, all you have to do is say that the job must be done by Monday; most others at a similar level expect and get time-and-a-half.

**A lack of education in management.** Great advances have been made in recent years in knowledge of the behavior of people in working organizations in the fields of behavioral science, leading to such areas as organizational development and useful models. Similar gains

### "...To have five engineers work all weekend, all you have to do is say that the job must be done by Monday . . ."

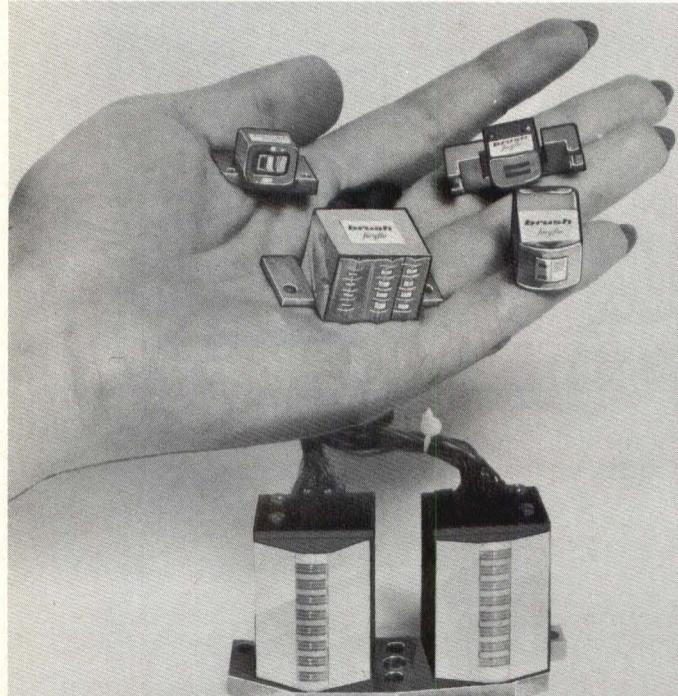
have been made in the scientific sides of management, in decision making, quantitative methods, operations management. Accounting (especially cost accounting) is as essential to the engineering manager as the general manager. I have observed not only that the engineers have had little exposure to these areas in formal studies; they do not seek continuing education in these areas as avidly as other upwardly-mobile professions. Of course, we can't rule out the effect of their employers. Many engineering employers are still refusing reimbursement to engineers for non-technical courses, to their own disadvantage. Whatever they are afraid of costs them dearly!

**A naivete about the essential conditions of employment.** Being an employee is, in large part, a strictly business deal. The employee has something the employer wants (skill, effort, knowledge,

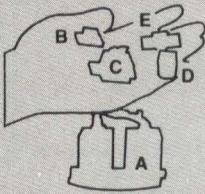
potential) and the employer has something that the employee wants (money, fringe benefits, security, opportunity for self-actualization). The employer pays so much for what he wants; the employee wants so much for what he has. A deal is made — an agreement — and a business relationship is made. When one or the other sees their needs differently, the situation is subject to change. It isn't a moral issue; it is simply a matter of trade. Years ago the manager of an employment agency told me, "Engineers are the only people who think that when they get a job they are married to the company." And, like many other infatuations, such "marriages" are subject to quick disillusionment and subsequent bitterness.

More could be said from this viewpoint, but one page isn't much to deal with the most important profession in our post-industrial society.

*Do you see changes that should be made, trends that your colleagues haven't recognized, needs that aren't being met in your field? Digital Design would like to publish your viewpoint; just send it to Viewpoint Editor, Digital Design, 167 Corey Road, Brookline, Massachusetts 02146.*



Selected heads shown include: (A) Reel-to-Reel Head, 1-inch, 14 tracks, interlaced; (B) Mini-Cartridge Data Head, full width, read/write; (C) Cartridge Data Head, 4 tracks, read-after-write, selective erase; (D) Credit Card Head, track 2 (ABA) — read; track 3 (thrift) — read narrow/write wide; (E) Cassette Digital Head, 2 tracks, read/write, with integral tape guide.



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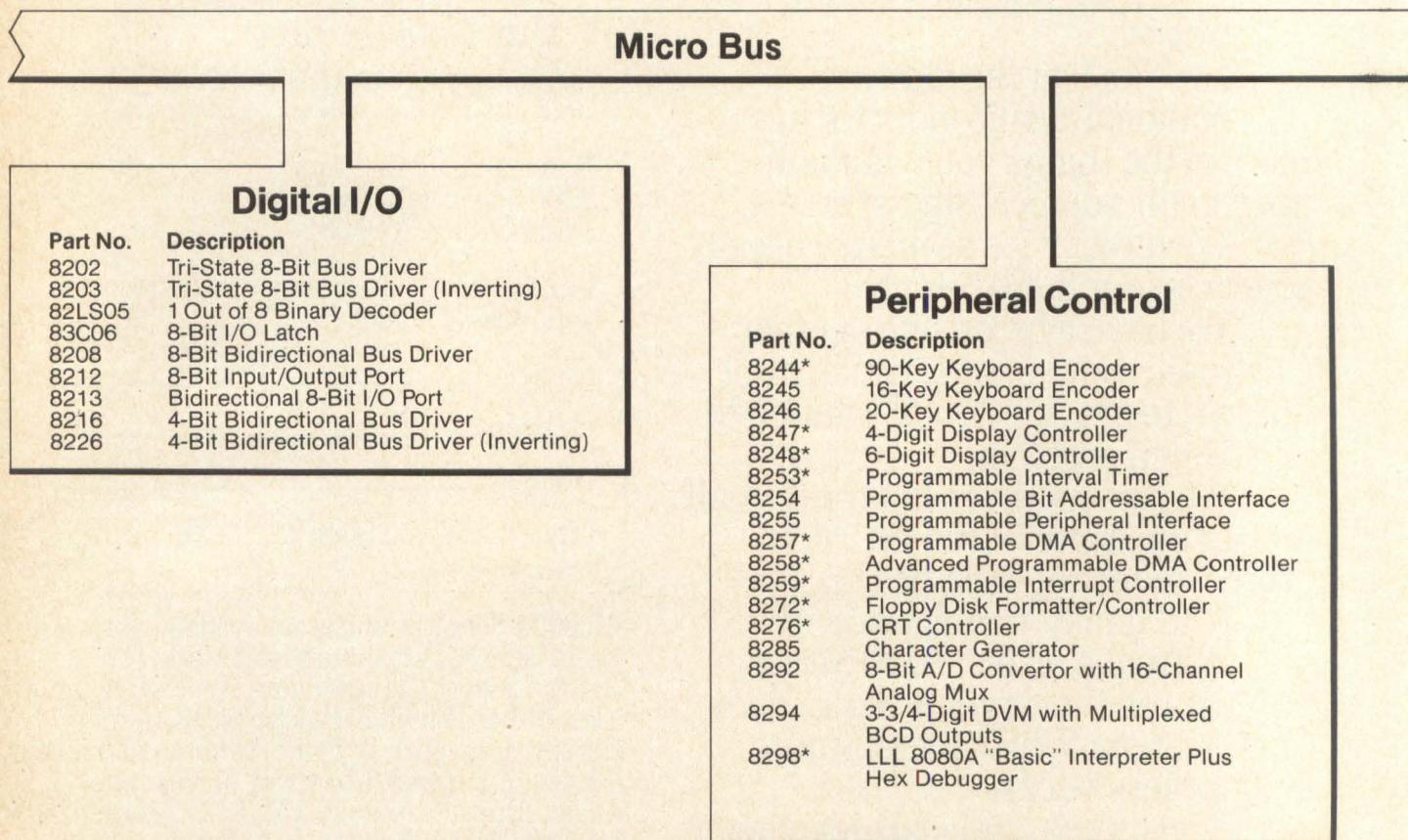
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# The 8080A diagram

At this writing, National Semiconductor is offering 60 support products for its 8080A microprocessor. (Most are off the shelf; all are compatible with National's standard MICROBUS™ and with microprocessors of the future.)



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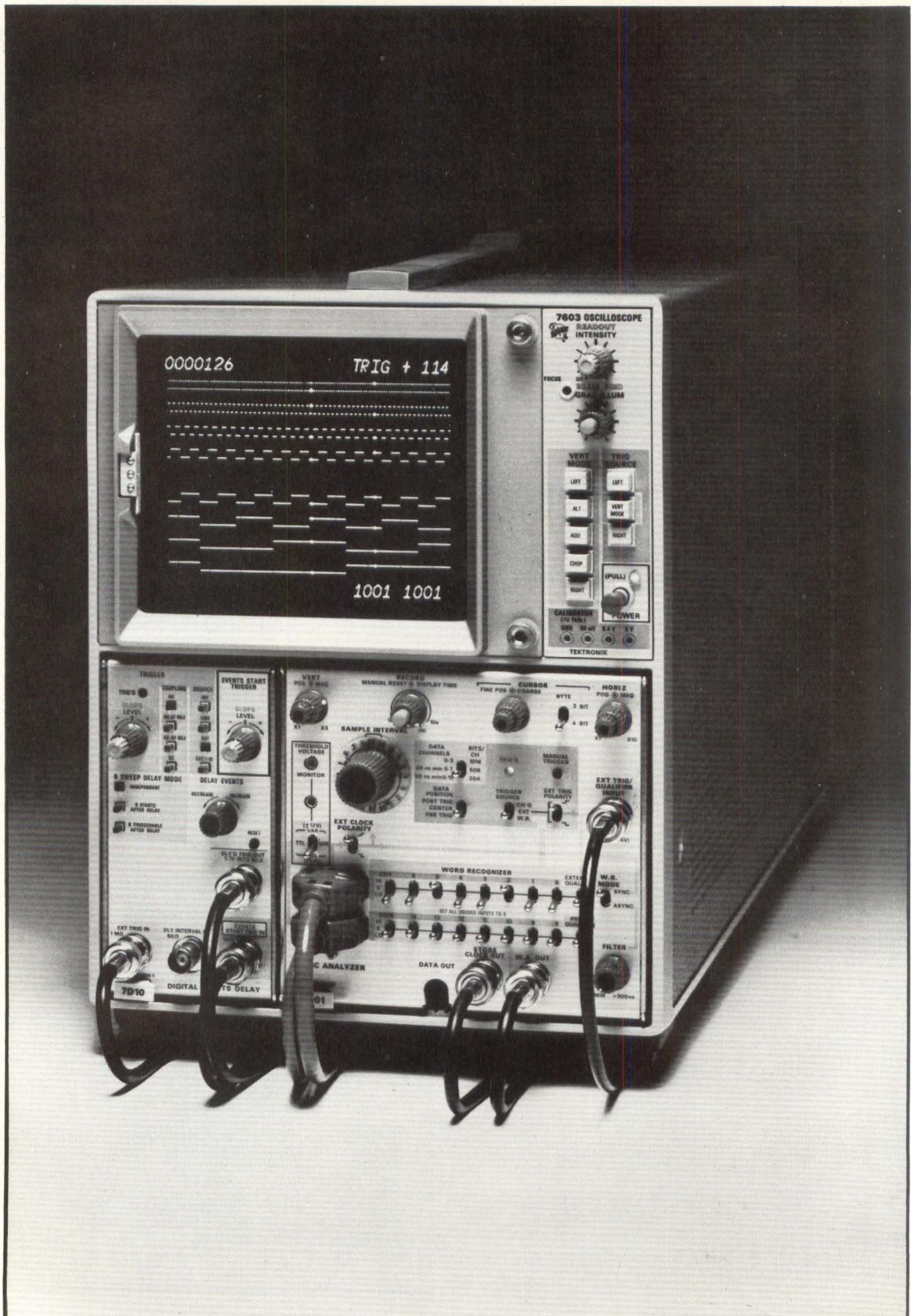
## Communications

Part No.	Description
8250	Asynchronous Communications Element
8251	Programmable Communications Interface
8252*	Advanced Programmable Communications Interface
8261*	Programmable Communications Subsystem
8274*	Multi-Protocol Communications Controller-SDLC, ADCCP, Bisync, DDCMP
8283*	Advanced SDLC, ADCCP Protocol Controller

## Memory

Part No.	Description
8356	2048X8 ROM, 128X8 RAM I/O
8154	128X8 Static RAM with 16-Bit I/O
8364/	8192X8 MOS Mask ROM
8364E*	(E is 2708 Compatible)
8316A/E	2048X8 MOS Mask ROM
8332E	4096X8 MOS Mask ROM (2708 Compatible)
1702A	256X8 EPROM
8704	512X8 EPROM
2708/8708	1024X8 EPROM
8101A-4	256X4 Static RAM with Separate I/O
8111A-4	256X4 Static RAM with Common I/O
8102A	1024X1 Static RAM
74C920	256X4 CMOS Static RAM with Separate I/O
74C921	256X4 CMOS Static RAM with Common I/O
74C929	1024X1 CMOS Static RAM
2114	1024X4 Static RAM
MM257	4096X1 Static RAM
DM87S296*	512X8 Bipolar PROM
5290	16K Dynamic RAM
8316A/E	Mask ROM (2708 Compatible)
DM74S472*	512X8 Bipolar PROM/20-Pin DIP
MM5204	512X8 EPROM

\*Available soon.



# WHAT DO LOGIC ANALYZERS DO?

by Ken Pines

**W**hat the oscilloscope is to the analog world, the modern logic analyzer is to the digital world. In fact, the logic analyzer might better be called a logic scope, digital event storage scope or more simply, logic recorder. Logic or microprocessor analyzers as we know them today capture and store a number of digital channels and present them in some type of visual display for analysis. Since all analyzers perform the same basic functions, you can have a difficult time selecting a unit from the two dozen or more available at prices from \$300 to \$20,000. And we all know that the usefulness of any equipment, including logic analyzers may or may not depend upon the price of the unit or prestige of the manufacturer.

The satisfaction you will receive from an analyzer will be directly related to the usefulness in your particular application(s). Here, we'll give you a grounding by breaking down the analyzer into its basic components and discussing its features in detail. In this article, we will consider these basics; next month we will explore some actual field applications in which features of a particular machine were required to solve a problem. When we are through, you should have more insight into the choice of your next logic analyzer.

## The Mouse in the Machine

When faced with an ever increasing number of highly complex logic and microprocessor analyzers, you should understand the basic concept of what will be called the "mouse" in the machine. Everyone who produces an analyzer must use a mouse from essentially the same source as anyone else who produces analyzers. Some of the mice run faster and some are bigger, but all come from the same sources such as Signetics, National, Motorola and others. As you may have guessed by now, the mouse is the memory, and all analyzers begin with a memory as the basic integrating factor. Every logic and microprocessor analyzer produced performs the same basic function: to "trap" or record a set of digital inputs, usually by sampling input data and storing it in a memory that varies in length from

16 to 2048 bits. The analyzer begins and ends the recording process and saves and outputs data of interest in some convenient manner for analysis. This is what a logic analyzer does and this is all it does. We will now begin to explore why and how analyzers perform these functions.

## The Logic Analyzer vs. The Oscilloscope

The logic analyzer does not replace the oscilloscope, but functions as a companion device available for viewing several lines of digital data simultaneously. The major benefit derived from the use of the logic analyzer is the ability to freeze a low frequency or single event pattern that would not sweep the scope often enough to write a clear picture. Further, logic analyzers can stop the recording so as to save prior trigger information. In the analyzer, the trigger can be used to stop the record; in the scope, the trigger can only begin the recording or sweep of data. Short of expensive multichannel storage scopes that use glass delay lines, the logic analyzer is the answer for going back and viewing a multi-source sequence of digital events.

## Basic Features

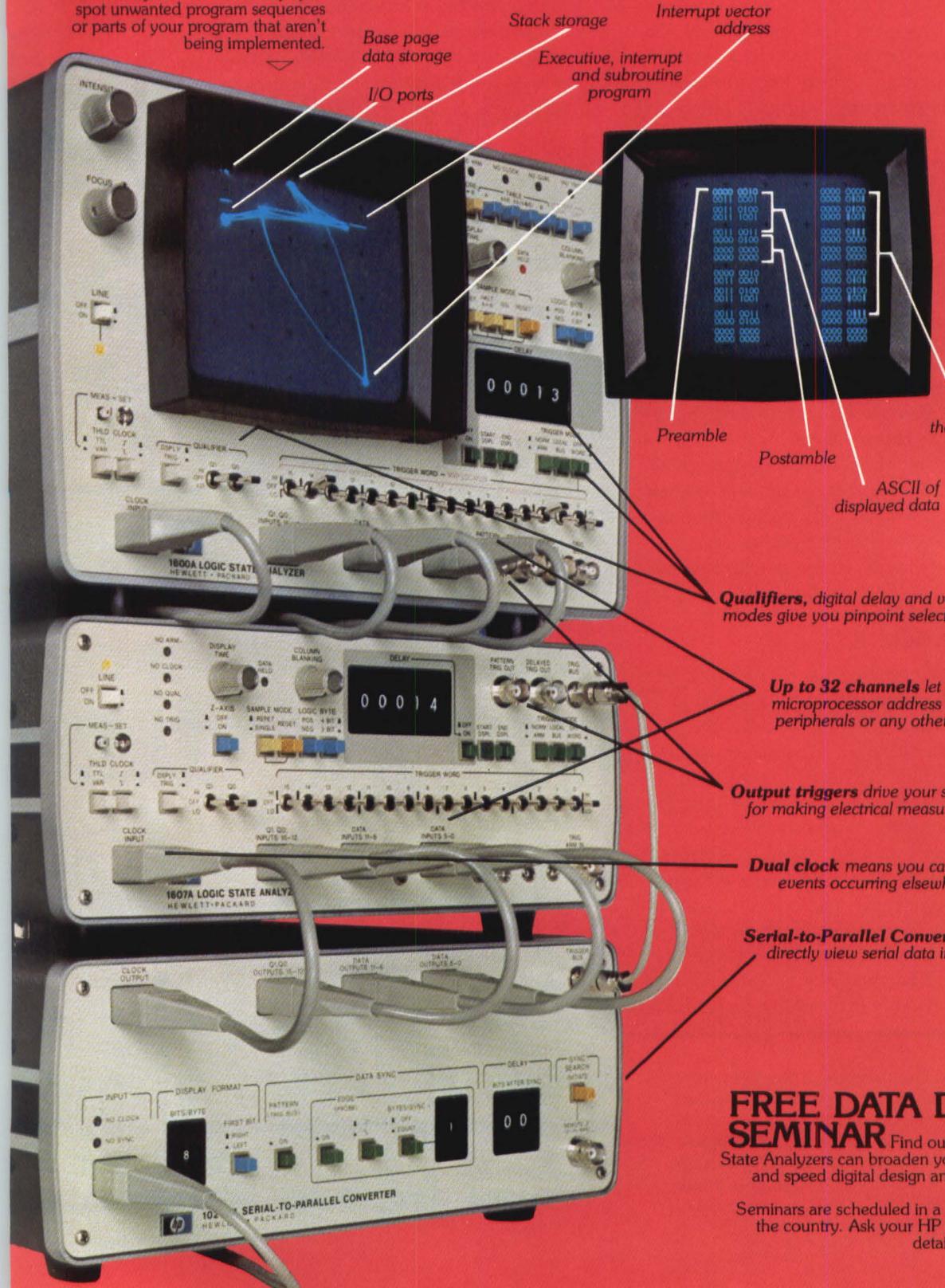
**Threshold.** Threshold detection at the input to the analyzer defines the logic states to be stored in memory. Available units are either fixed at a RTL, DTL or TTL level or else they allow adjustment throughout some range. Here the distinction between general purpose and special purpose machines begins to take place. A unit offered as a general purpose analyzer may have a number of fixed, switch selectable settings as well as a continuously variable range of from  $\pm 2.5V$  to  $\pm 15V$ . Variable thresholds have two major benefits: the first is the ability to work on many different logic families and the second is that you can vary the thresholds about the specified value to check for marginal data transitions. For example, a TTL signal may be swinging close enough to the threshold to give intermittent results. Setting the analyzer thresholds to a value such as +2V would clearly show if a signal is properly overdriving the +1.4V TTL threshold. The general purpose analyzer can also set one group of channels at one threshold value while setting another group at a different value, thus allowing you to analyze two different logic families simultaneously.

**Sampling.** Logic analyzers use sampling for storing the input data into the memory. Based upon the information available at the threshold detectors, a high or low (1 or 0) representation is stored in memory on a periodic sample basis. The data stored for analysis is only a representation of the input data; your choice of analyzer will depend on the suitability of that representation to handle your requirements.

◀ Fig 1 A general purpose oscilloscope in the Tektronix 7D01 instrument shown here displays information for logic analysis. This analyzer can sample data asynchronously at rates up to 100 MHz or synchronously at up to 50 MHz and can format the 4096 bits in memory as 4 channels x 1016 bits, 8 channels x 508 bits or 16 channels x 254 bits. A digital events delay provides additional triggering flexibility.

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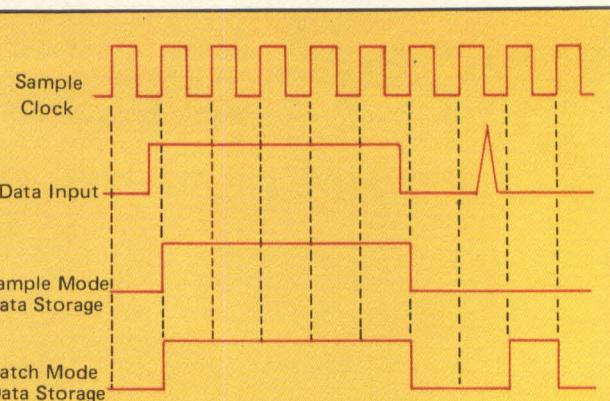
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The available analyzers range in sample frequency from a few megahertz to 200 Mhz. The faster the analyzer, the higher the price, on what is almost a logarithmic scale. Analyzers in the range of 5 to 10Mhz generally sell from \$1000 to \$2000 range. 50Mhz analyzers run \$3500 to \$6000, while the 200Mhz entry hovers right around \$20,000. While slower units can cost more due to other features, in general "higher speed equals higher price". The question to focus upon when making a choice is how much speed will your application require.

Before we go any further on the question of speed, we should pause and explore the difference between the synchronous and asynchronous analyzer. The synchronous analyzer contains no clock of its own, and thus depends upon the system clock to drive its sample circuitry. This means that stored data will represent only the sequence of system logic occurring in synchronization with either the positive or negative edge of the system clock. The record contains no information about the relative timing or between-clock behavior of the signals. On the other hand, an asynchronous analyzer contains its own clock and can store timing and between-clock signal behavior as well as the sequence of system logic events. In order to clearly show the data and the timing information, asynchronous analyzers usually have memories many times longer (256 to 2048 bits) than the synchronous units (16 to 64 bits). The longer memory allows enough resolution of the stored data to clearly sort out anomalies (such as ringing and glitches) from the actual system data bits. For this reason, the synchronous units have a greater use in software applications whereas the asynchronous machines are more desirable for hardware debug. Fig 2 shows a situation where both synchronous and asynchronous analyzers captured the desired logic event with the asynchronous analyzer giving more insight as to the cause of the problem. It is important to note that all



**Fig 3 Comparison of data storage in sample and latch modes during asynchronous data recording.**

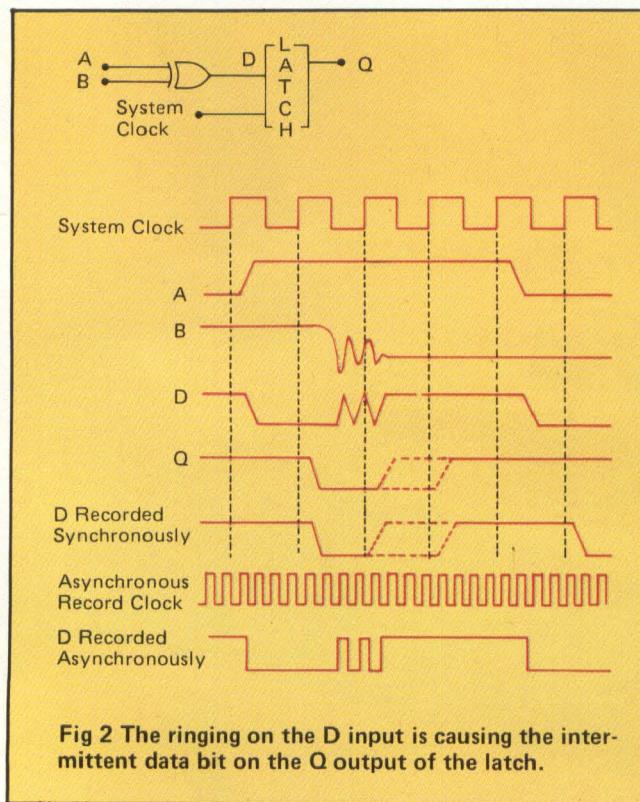
asynchronous analyzers can also operate synchronously from the system clock.

Now, we will go back to the question of how much speed is required. On a synchronous analyzer, the frequency limit need be only as high as the fastest system clock encountered. You need only make an estimate as to what you expect to see in system speeds over the next few years and choose accordingly. On the other hand, more thought is required when choosing an asynchronous analyzer.

Theoretical limitations of sampling data with an asynchronous clock require a minimum of two samples per data cycle. Practically, this limit is somewhere above four samples per cycle, and for good resolution of the data, the ratio can run as high as 10 or 20. The reason for the high multiples is that the one bit recording error associated with sampling becomes a much smaller percentage of the data, thus giving a much better visual representation when sampling at higher multiples. You can easily see the effect that a sample recording error would have on data sampled at 4 times per cycle and data sampled at 10 times per cycle. The general rule of thumb in purchasing an asynchronous logic analyzer should be to purchase as high a frequency as the budget allows with a minimum of somewhere in the range of 4 times the data frequency to be sampled.

**Latch Mode.** One item included in many asynchronous logic analyzers that you should examine closely is commonly known as latch mode. Latch mode allows an analyzer to capture data spikes or events that are narrower than the sample clock interval; latch mode can thus effectively increase the bandwidth or sample frequency of the analyzer. To better visualize the use of latch mode, see Fig 3. The narrow data spike would ordinarily be missed with a straight sampling technique since it appears after the clock edge and disappears before the next clock edge. The sampling circuitry would never know that the spike occurred. The latch mode circuitry captures the transition and holds it until the next clock cycle. In this way, the analyzer captures the high speed anomaly or glitch and stores it in its proper time sequence in relation to the rest of the data.

Latch mode has two major benefits to the user. The most obvious is the ability to capture high speed data anomalies, more commonly called glitches. The second, not quite as obvious, relates to extending the bandwidth capability of a unit when operating at slower speeds. An exam-



**Fig 2 The ringing on the D input is causing the intermittent data bit on the Q output of the latch.**

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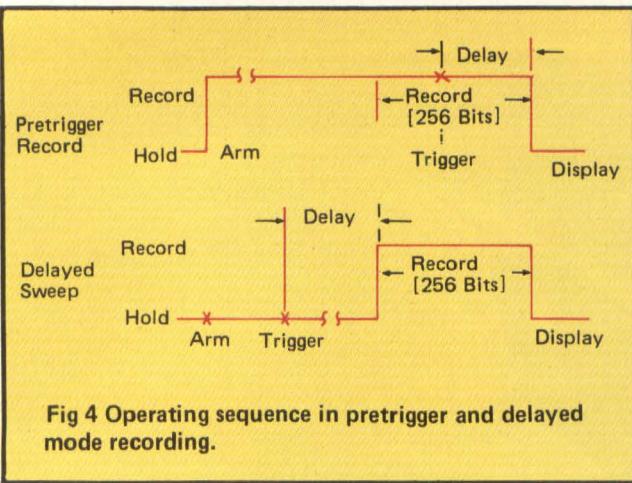
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CIRCLE 40



**Fig 4 Operating sequence in pretrigger and delayed mode recording.**

ple of this might be the desire to check timing between two 100ns pulses that occur in a system every 50 to 100ms. To see a full 100ms of recording, the sample interval might have to be as wide as 500ns. Without latch mode, you would not be certain of capturing the pulses of interest since they are five times narrower than the sample clock interval. This ability to capture data with certainty while running the clock at intervals wider than the data bits should be considered very carefully. It is probably the most important feature in a logic analyzer.

**Record Modes.** What we have explored so far, shows you that the logic or microprocessor analyzer is a very simple tool that records data in a snap shot fashion. In other words, what the analyzer does is take a picture of data that allows you to view the events for analysis. We will now look at the viewfinder of the data camera. The viewfinder allows you to focus in on precisely the time sequence of interest and ignore that which is not useful to your analysis.

As was stated earlier, all the available analyzers incorporate the ability to look at prior trigger data, a feature commonly known as pretrigger recording. The available variations allow setting the trigger at the beginning, middle or end of the record, or in some, at any location along the X-axis. Most analyzers also have a delayed mode feature whereby the sweep of data can be held off for 10,000 to 100,000 clock samples after a trigger event. This mode is very closely analogous to the delayed sweep mode in an oscilloscope and is very useful when looking at data that is delayed in time from some synch event or start bit. Fig 4 is a visual representation of the sequence of events in pre-trigger and delayed mode recording.

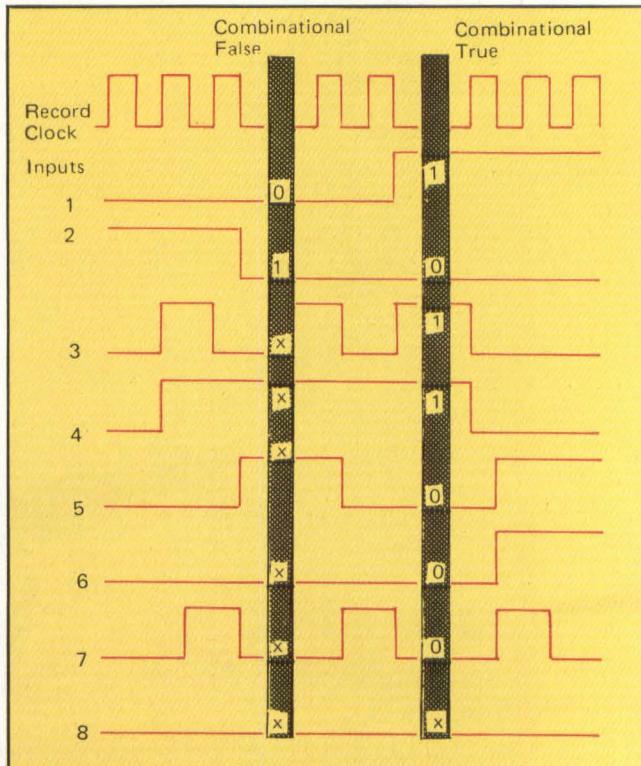
Since pretrigger mode, given enough delay, could accomplish everything that delayed mode can accomplish, you might justifiably ask why include delayed mode on the logic analyzer? Including delayed mode lets you to put the unit in a mode most often called delayed repeat.

Delayed repeat mode operates so that after recording a sweep of data, the analyzer automatically re-arms, or resets; it is then available for a new trigger or synch event. This is sometimes referred to as a pseudo real time mode. The necessity for having a delayed mode in order to do the repeat type recording is because in pretrigger mode, the stored data begins to disappear immediately upon arming or re-setting. In that case, automatically rearming the unit at the end of record would ensure that no data would be held

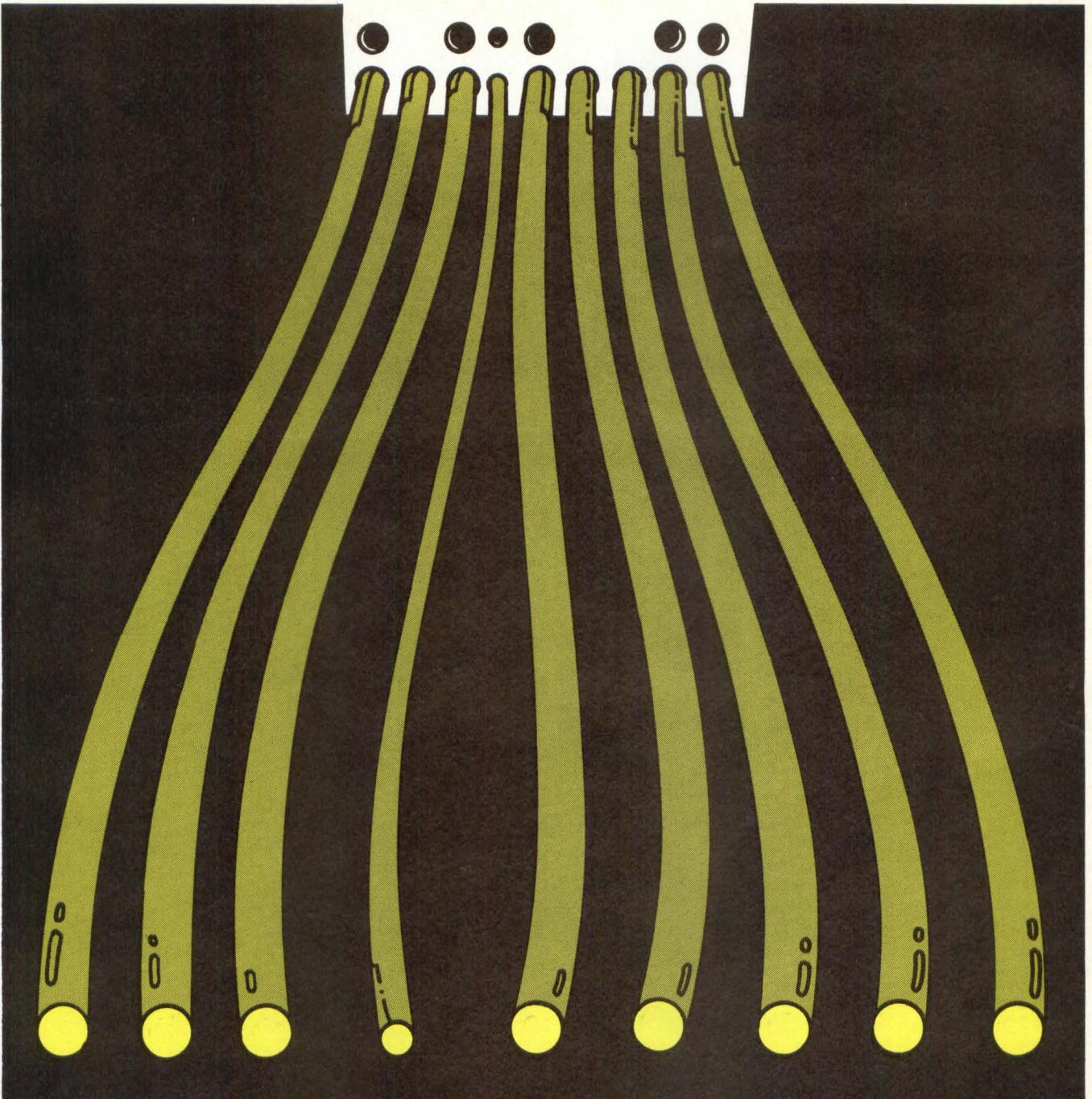
in memory. In the delayed repeat mode, the old data is held upon rearming until a new trigger event occurs and the delay is counted out. At that time, the memory is refreshed with a new sweep of data. The stored information is always based upon the last event that triggered the analyzer.

Implementation of delayed repeat occurs in one of two basically different manners. In the first, the rearming process does not occur until the data has made a complete sweep of the output display. In this way, by watching the screen you can see that data jump if a pattern based upon a given event changed during one of the sweeps. This mode, although very esthetically pleasing, leaves the analyzer unavailable for data capture for a large percentage of the time that the analyzer is used, since the scope sweep takes more time than is required for filling the memories. The second manner of implementing delayed repeat is to re-arm the machine immediately upon the end of record. Thus the machine becomes available immediately after recording for a new trigger input. The esthetics of this type of implementation are somewhat less pleasing because the scope picture will appear scrambled during trigger cycling unless the triggers appear at a rate of a few hundred hertz or less. The benefit is that the machine is unavailable for triggering only during the delay count and recording process; the statistical probability of capturing the data based on the last repeating trigger event is much higher than in the first manner.

In the delayed sweep mode, the analyzer can count synch events. In some systems two levels of triggering might be required to see the data of interest that lies some given number of synch events from another start event. With an analyzer that allows event delay, the unit could be armed upon the start event and the synch events counted out before the data sweep was taken. This feature usually lets



**Fig 5 This diagram illustrates an example of conditions for combinational false triggering. (Courtesy of Biomation)**



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CIRCLE 41

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you look at a memory full of data prior to, or after the last counted synch event.

**Triggering.** To further carry on the analogy of a logic analyzer to a camera, we will now look at the shutter of the camera or the manner in which we generate synch or trigger events. Virtually all the analyzers in the marketplace have what can best be described as combinational trigger. This feature allows the selection on each data input of a 1, 0 or don't care status when making up the trigger event. The simplest way that this works is that when the data matches the setting of the combinational trigger, the machine receives a trigger event input. The availability of qualifiers and the selection of a make true or make false trigger enhances the combinational trigger.

Qualifiers allow you to look at a data bus location where different devices may put similar data. To use it for this purpose, you set the trigger to respond to a given address on the bus only when a particular device is transferred on the bus. The make true, make false conditioning allows the user to set the triggering in an "and" combination or an "or" combination of the trigger settings. Note in Fig 5 how the make true trigger responds when the set word ap-

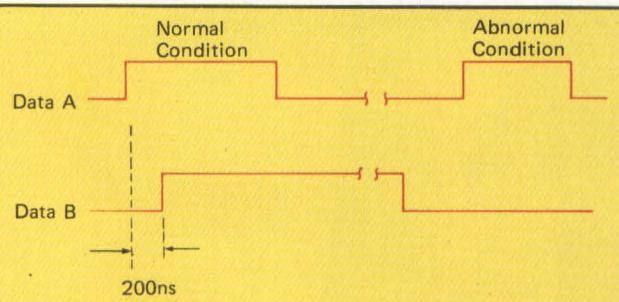


Fig 6 Comprised of a '1' on channel A and a '0' on channel B, the trigger word necessary to capture the abnormal condition appears for 200 ns during the transition to the normal condition.

pears at the inputs, while the make false trigger responds when that word goes away. The make false triggering is often used when a change in any one of several control lines is desired as a trigger.

One major variation on the combinational trigger is the ability to trigger on events that are not being recorded. This seems to be more and more available as an adjunct to the logic analyzer, and not necessarily built into it. This approach finds favor because more often than not the desired trigger word is much wider than the data of interest. Auxiliary combination trigger boxes include all the other trigger features found in the logic analyzers themselves such as qualifiers, true/false conditioning and delay.

If you are considering the purchase of an asynchronous unit, one item to consider with some care is the ability to insert delay in the trigger. For an analyzer to capture a single or low frequency event based on a given word combination, anomalies in the data which might otherwise make up that combination must be "delayed" from or screened out of the trigger. Trigger delay is currently offered in two different manners; the first allows the insertion of up to 300ns of analog delay, while the second allows some maximum number of sample bits of delay. Fig 6

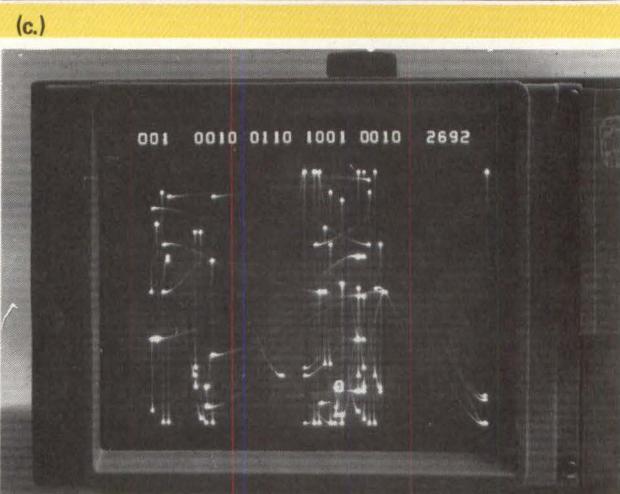
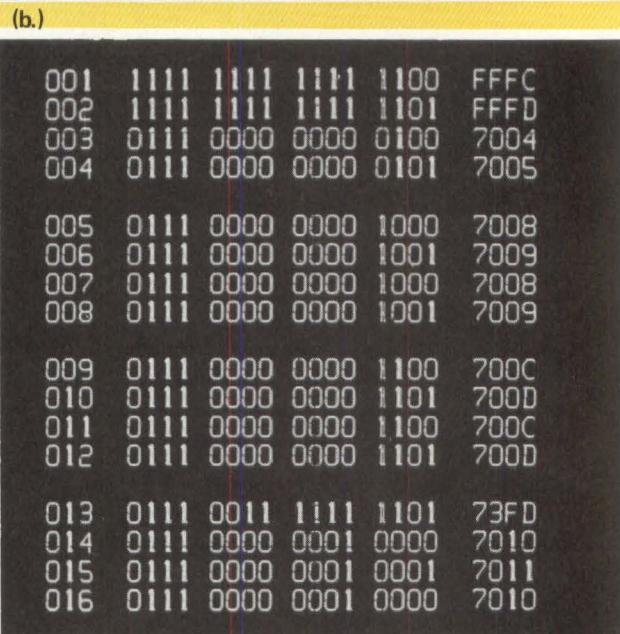
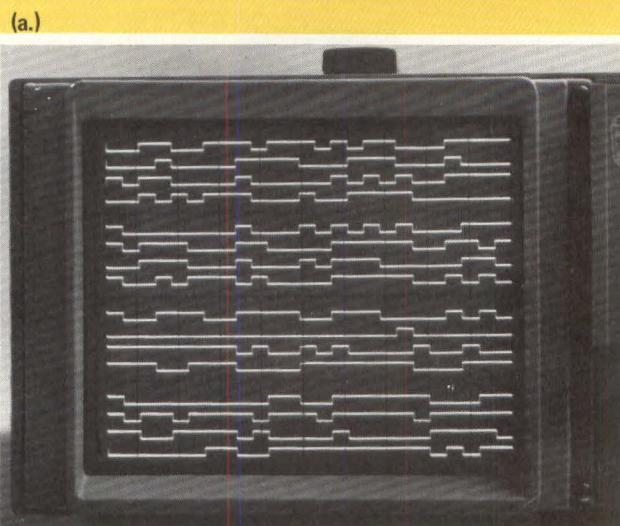


Fig 7 (a) Typical time domain readout of a 16-channel logic analyzer. (b) Data domain display with memory address shown by the three digits on left and hex conversion shown by the four digits on the right. (c) Typical map mode with 8 channels of data on X axis and 8 channels of data on Y axis. The display consists of 64,000 discrete locations.

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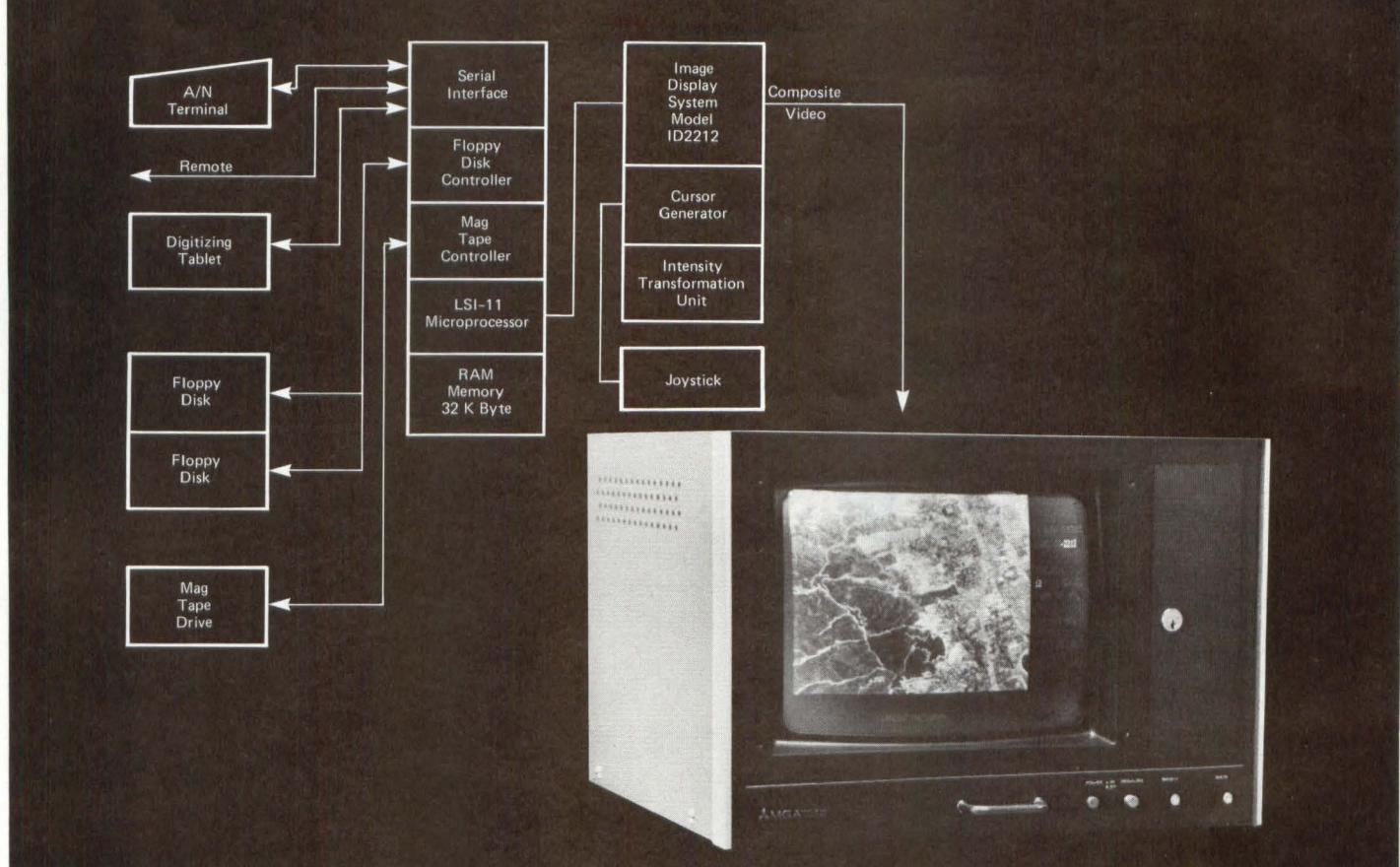
shows what happens when triggering on a microprocessor bus that has anomalies occurring on device transfer that might otherwise trigger the analyzer. Without a delay of 200ns or greater, the normal condition that occurs many more times than the abnormal condition would continually trigger the analyzer and make it virtually impossible to see what occurred at the abnormal condition. In the example shown, the analog delay would work as well as the digital

delay. You should look, however at your particular application and see if 300ns suffices for all applications. In one application discussed in the second part of this article (appearing next month), an example will be shown where 300ns of delay is not nearly enough. Digital trigger delay in an asynchronous analyzer should be considered carefully since its value in the ease and certainty of data capture rivals that of the latch mode discussed earlier.

## Logic Analyzing Instruments

Manufacturer	Model No.	No. of Channels	Maximum Frequency (MHz)	Memory Format	Asynch (Internal Clock)	Latch Mode	Domain State	Timing State	Type of Display
BP Instruments	20D	8	20	8 x 256	Yes	Yes	Yes	No	Separate Scope or XY Display
	50D	8, 16 (optional)	50	8 x 512 (Dual)	Yes	Yes	Yes	Optional	Separate Scope or XY Display
Biomation	810-D	8	10	8 x 256	Yes	Yes	Yes	No	Separate Scope or XY Display
	851-D	8	50	8 x 512	Yes	Yes	Yes	Optional	Separate Scope or XY Display
	920-D	9	20	9 x 256	Yes	Yes	Yes		Separate Scope or XY Display
	1650-D	16	50	16 x 512	Yes	Yes	Yes	No	Separate Scope or XY Display
	8100-D	8	100	8 x 2048	Yes	Yes	Yes	No	Separate Scope or XY Display
	8200	8	200	8 x 2048	Yes	Yes	Yes	No	Built-in
Davco	DM 230	32	4.2, 11 (optional)	32 x 256	No	No	Yes	Yes	Separate Scope; Built-In Hex LED Display
Digital Broadcast	80-M	8	20	8 x 1024	Yes	Yes	Yes	No	Separate Scope or XY Display
Digital Labs	DSR-505	2	10	2 x 512	Yes	Yes	Yes	No	Separate Scope
E-H Research	1320	2 to 16	50	100/channel	Yes	Yes	Yes	No	Built-In
	1330	8	20	8 x 1000	Yes	Yes	Yes	Yes	Built-In
Hewlett-Packard	1600A	16	20	16 x 16	No	No	No	Yes	Built-In
	1607-A	16	20	16 x 16	No	No	No	Yes	Separate Scope or XY Display
	1602A	16	10	16 x 64	No	No	No	Yes	Built-In LED Display
	1610A	32	10	32 x 64	No	No	No	Yes	Built-In
	100A	8, 24 (optional)	8	8 x 16	No	No	No	Yes	Separate Scope or XY Display
Paratronics	150	56	no information available at press time						
	LC-32A	8	4	8 x 64	No	No	No	Yes	External or Built-In
Tektronix	LA 501W	up to 16	up to 100	4 x 1016 8 x 50B 16 x 254	Yes	No	Yes	No	Built-In
	7 D01	up to 16	up to 100	4 x 1016 8 x 50B 16 x 254	Yes	No	Yes	No	Built-In (Binary)
	7 D01F	up to 16	up to 100	4 x 1016 8 x 508 16 x 254	Yes	No	Yes	Yes	Built-In (Display Formats, Binary, Octal or Hexadecimal)
	Vector	1625A	16	25	16 x 256	Yes	Yes	Yes	Optional
									Built-In

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Applications for the IEC 2212:

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CIRCLE 44

## How Are Logic Analyzers Going to Change?

During the next two or three years, industry requirements will lead manufacturers who build logic analyzers to market 3 types of models, according to Dave Parmley, Tektronix. One model will be aimed at testing microprocessors, a second will test specialized complex devices and the third will be a more sophisticated general-purpose instrument. These three categories will fall into a new class of test and measurement equipment called logic measurement and development products.

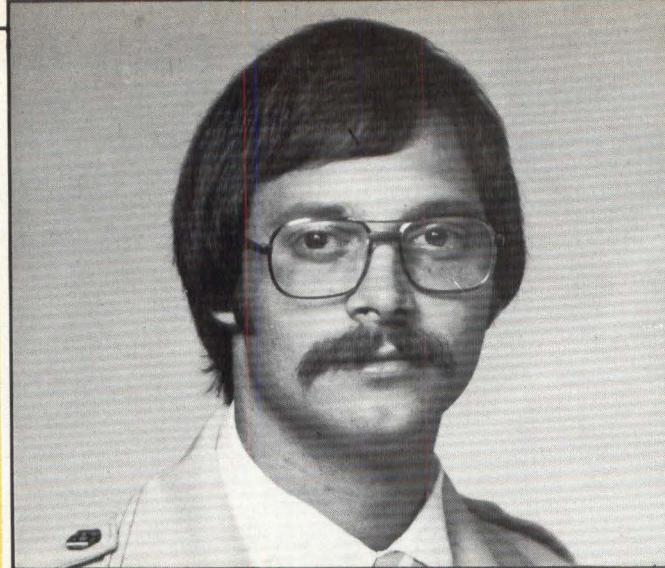
Microprocessor analyzers will evolve in two directions: noninteractive, dedicated analyzers, and interactive analyzers, such as the Tektronix 8002 μProcessor Lab (which is already available), dedicated totally to microprocessor development.

Likewise, vendors will develop instruments dedicated to specific applications and classify them as logic analyzers. These instruments (for example, signature analyzers) will become more numerous as more industries use digital components in their systems.

A group of logic analyzers will become even more general-purpose than the general-purpose logic units on the market today, Parmley continued. The need that exists today for synchronous and asynchronous data sampling with large formattable memories will stay. As memory chip prices come down, larger logic analyzer memories will be available for markets that require high speed sampling rates or high numbers of data channels. Logic analyzers will be general-purpose enough to be used as a design tool and as a service instrument. Although the designer will continue to use logic analyzers, he will transfer troubleshooting more often to the service technician. Therefore, the designer will have to supply such data as timing diagrams and state tables in the system documentation, for the technician to compare the information with what it should be. In a similar manner, a logic analyzer with a reference memory could supply quick and easy data on the manufacturing line.

Producers of microprocessor analyzers place much emphasis on triggering. Typically, microprocessor analyzers are recorders of the synchronous type and are set up to meet the triggering needs of the microprocessor designer. The microprocessor analyzer is set up to trigger on break points in the program, at the beginning or end of loops, or at the beginning or end of a set number of loops. This latter ability is typically related to triggering on "nested loops". In choosing between a microprocessor analyzer and a logic analyzer, you should avoid the pitfall of the "mystique of the microprocessor". Often the general purpose analyzer will have all the trigger capability necessary to capture the data of interest while having far greater capability for debugging the peripheral circuitry.

**Compare Memories.** Many units now available contain dual or compare memories that allow the user to compare a new recording against a stored or held recording. Analyzers do



Dave Parmley, Marketing Product Specialist for Tektronix in Beaverton, Oregon.

To be useful as a service or manufacturing technician's tool, a logic analyzer must do the job without requiring extensive operator training in its use. Improved interfaces must do away with a large assortment of dials, switches and knobs to a more simplified method of selecting the logic analyzer parameters. Therefore, new logic analyzers will be smarter and more straightforward to operate; they may be programmable or preprogrammed, declared Parmley.

Logic analyzer triggering will become more sophisticated. The operator of a logic analyzer will be able to preselect the series of events that must happen before a trigger occurs. Triggering will be programmable and based on such measurements as the length of time between events happening, a number of events, software routine conditions (number of branches), and pulse width, duration, and speed.

More instruments will talk to each other through standard interfaces, such as the IEEE general-purpose interface bus (GPIB). Standard interfacing techniques will allow logic measurement and development products from more than one manufacturer to communicate directly with these instruments, predicted Dave Parmley.

this in two different ways: one method sends the output through an exclusive OR, showing a 1 where the memories are different and a 0 where they are the same; the other method flashes back and forth between the two memories where the changing patterns or numbers on the screen indicate the difference. A further variation on the compare memory, halt upon non-compare mode, allows the unit to capture data, compare it against the stored data and rearm if they are the same. In this manner, captured data that differs from stored data causes the unit to go into display and show the areas where the data differs. The use for the compare memory seems obvious, yet another less obvious use seems to be generating much interest. This is where the fault condition can be captured and saved and the machine put back into recording for an attempt to capture it again. Thus the engineer doesn't have to draw out the erroneous pattern for reference.

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#### SPECIFICATIONS

##### Status Signals:

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(Read-While-Write)

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.150, ± .005 inch.

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##### Read and Write Rate:

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100 inches per second,

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##### Start Distance to ± 5% of 20 Inches Per Second:

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##### Start Distance to ± 5% of 100 Inches Per Second:

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##### Stop and Settle Time:

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CIRCLE 45

## Manufacturers' Guide to Logic Analyzers

All the manufacturers listed below market some form of logic analyzer; Biomation, Hewlett-Packard, Systron Donner and Tektronix also make analyzers designed specifically for use with microprocessors. Contact them directly or use the circle number on one of our reader service cards.

**BP Instruments, Inc.**  
10601 De Anza Blvd.  
Cupertino, CA 95014  
(408) 446-4322

**Circle 189**

**Biomation Corp.**  
10411 Bubb Rd.  
Cupertino, CA 95014  
(408) 255-9500

**Circle 190**

**Davco Mfg. Co.**  
169 Ridgedale Ave.  
Morristown, NJ 07960  
(201) 267-4990

**Circle 191**

**Digital Broadcast Sys.**  
Box 381  
Madison, AL 35758  
(205) 837-2183

**Circle 192**

**Digital Laboratories**  
600 Pleasant St.  
Watertown, MA 02172  
(617) 924-1680

**Circle 193**

**E-H Research Labs.**  
515 11th St.  
Oakland, CA 94607  
(415) 834-3030

**Circle 194**

**Hewlett-Packard**  
Garden of the Gods Rd.  
Colorado Springs, CO  
80907  
(303) 598-1900

**Circle 195**

**Paratronics, Inc.**  
150 Tait Ave.  
Los Gatos, CA 95030  
(408) 354-7766

**Circle 196**

**Scanoptik**  
P.O. Box 1745  
Rockville, MD 20850  
(301) 977-9660

**Circle 197**

**Systron-Donner Corp.**  
10 Systron Dr.  
Concord, CA 94518  
(415) 676-5000

**Circle 198**

**Tektronix, Inc.**  
Box 500  
Beaverton, OR 97077  
(503) 644-0161

**Circle 199**

**Vector Associates**  
685 Station Rd.  
Bellport, NY 11713  
(516) 286-9000

**Circle 200**

**Data Output.** The most popular method for outputting the data is via an oscilloscope or CRT-type display. The two major categories of displays fall into what is termed the timing domain and the data domain. In the timing domain display, data is written across the scope in a pseudo waveform representing a timing diagram of the captured data. Enhancement of this mode can include a marker at the trigger and a movable cursor marker around which the data can be expanded. Further, readouts are available that give the distance and sample bits between the two markers.

The data domain display exhibits data on the oscilloscope or XY display in a truth table-type format — the data is shown in both binary form and a user-chosen converted form. The converted data can be shown in hex, octal or decimal coding. The data domain display, although derived from exactly the same data as the timing diagram display, finds favor with the microprocessor designer.

In summary, we take a memory and some method of stopping and starting a recording and add a way to visualize what is in the memory and we then have a logic analyzer: a very simple device used to capture data related to a specific event or set of events. In Part II (appearing next month), we will explore some actual field experiences and applications where the microprocessor or logic analyzer was used to solve a particular problem.

## Logic Analyzers: Untangling the Terminology

Do you know the difference between a logic state analyzer and a logic timing analyzer? Many systems designers don't, and the extent of their confusion has increased steadily during the last four years, says Bruce Farley, a product marketing manager for Hewlett-Packard's Colorado Springs, CO, division.

Farley blames much of the problem on the logic analyzer manufacturers themselves, who he admits have not always used the terms "logic state analyzer" and "logic timing analyzer" as accurately as they should have in characterizing their products.

To help clarify some of the muddled terminology, Farley recently visited Boston where he enumerated what he feels are some of the main differences between these two types of testing instruments. Speaking during a demonstration of the Colorado division's two latest logic state analyzers — the models 1610 and 1602 — Farley explained that the phrase "logic analyzer" is a generic term and can refer to either a logic state analyzer or a logic timing analyzer. Whether an instrument qualifies as a state or a timing device depends primarily on the type of clock it uses. A logic state analyzer has an external, synchronous clock; a logic timing analyzer, an internal clock, he says.

Depending on the type of clock, a logic analyzer performs one of two basic kinds of tests. With its synchronous timing device, a state analyzer traces the flow of electrical signals through a digital system's data bus. A timing analyzer, on the other hand, examines sequences of multi-channel or asynchronous events like handshaking, erase conditions or glitches, Farley explains.

More specifically, designers performing state analysis try to answer questions like the following:

- During tests, did a piece of digital equipment produce the sequence of electronic events predicted by the designers' algorithms?
- If not, in what respects did the observed output differ from the expected results?

In timing analysis, by contrast, typical questions asked by systems designers include the following:

- Did two or more events occur when they were supposed to?
- Did one event trigger a second event within the time limit specified by the designers?

Because of the type of data they sample, timing analyzers usually have no more than eight channels. If the number of channels were much higher, systems designers probably could not reliably interpret their test results, Farley explains.

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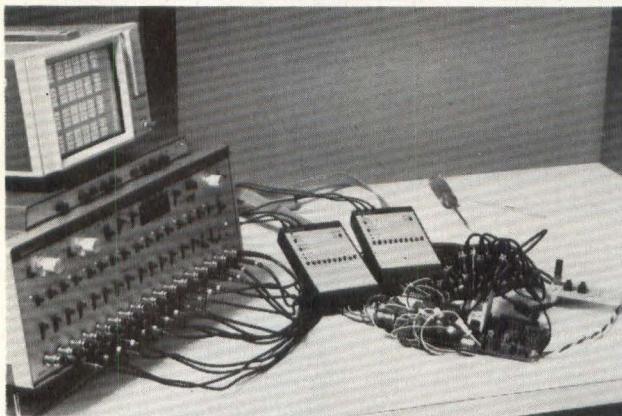
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CIRCLE 46

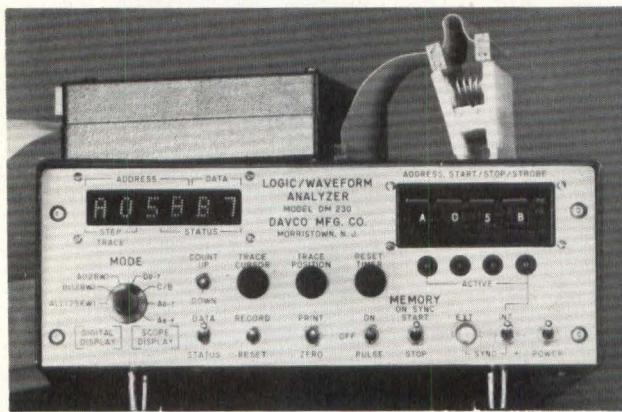
# LOGIC ANALYZERS: WHAT YOU CAN BUY



## Biomation 1650-D

Biomation's Model 1650-D logic analyzer, combined with a 116 display control unit, a 10-TC probe pod and a 10X probe set, can detect and analyze malfunctions in many microprocessor systems. Even though the design team has assembled and verified the software for the microprocessor system on a development unit, problems can occur. By observing program flaws in the system under test, the instrument detects and analyzes failures.

Circle 179



## Davco DM 230

The DM 230 waveform analyzer from Davco Manufacturing turns a standard single-channel oscilloscope into a 32-channel measuring tool for detecting marginal or defective ICs and system software in computing systems. A fast memory option increases throughput rate from 4.2 to 11 MHz and an optional RS-232 interface allows the user to connect a video terminal to the analyzer.

Circle 180

## Hewlett-Packard 1602-A

About the same size as an average briefcase, Hewlett-Packard's Model 1602-A weighs 10 pounds. Equipped with an F8 microprocessor and a 16 bit wide by 64 word deep memory, it can capture 64 events — 63 words following, preceding or surrounding the event designated as trigger. It automatically

tests itself every time it's turned on and through its keyboard, it interacts with its user by pointing the way through every operation. The manufacturer offers an op-



tional programming capability via the HP interface bus; this capability makes the analyzer entirely programmable and able to dump, on command, its 64-word memory store onto the bus for analysis by the controlling computer.

Circle 183

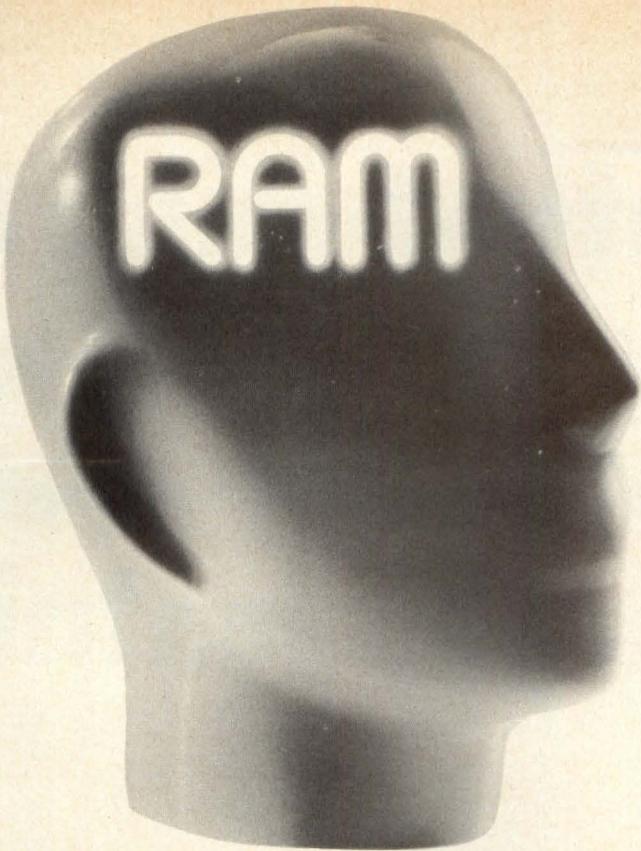


## Digital Broadcast Systems 80-M

Memory of the Model 80-M logic analyzer, marketed by Digital Broadcast Systems, stores a 1K-bit record of digital waveforms under test. The unit continuously monitors and records data on up to 8 input lines at user-selected sampling rates. When the 8-bit word recognizer detects the proper event, the system stops recording after a delay period, which determines the trigger position. This mode of operation can capture any false data condition programmable into the word recognizer.

Circle 181

(Continued on page 77)



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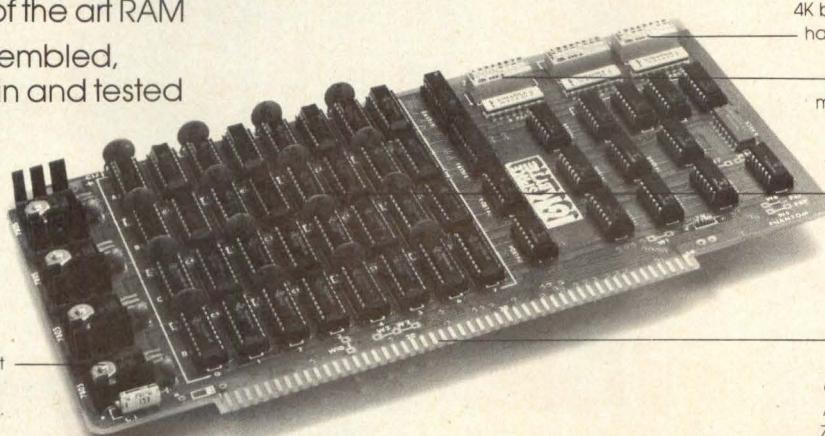
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CIRCLE 47

# Introducing the SPACE BYTE 8085 A self-contained

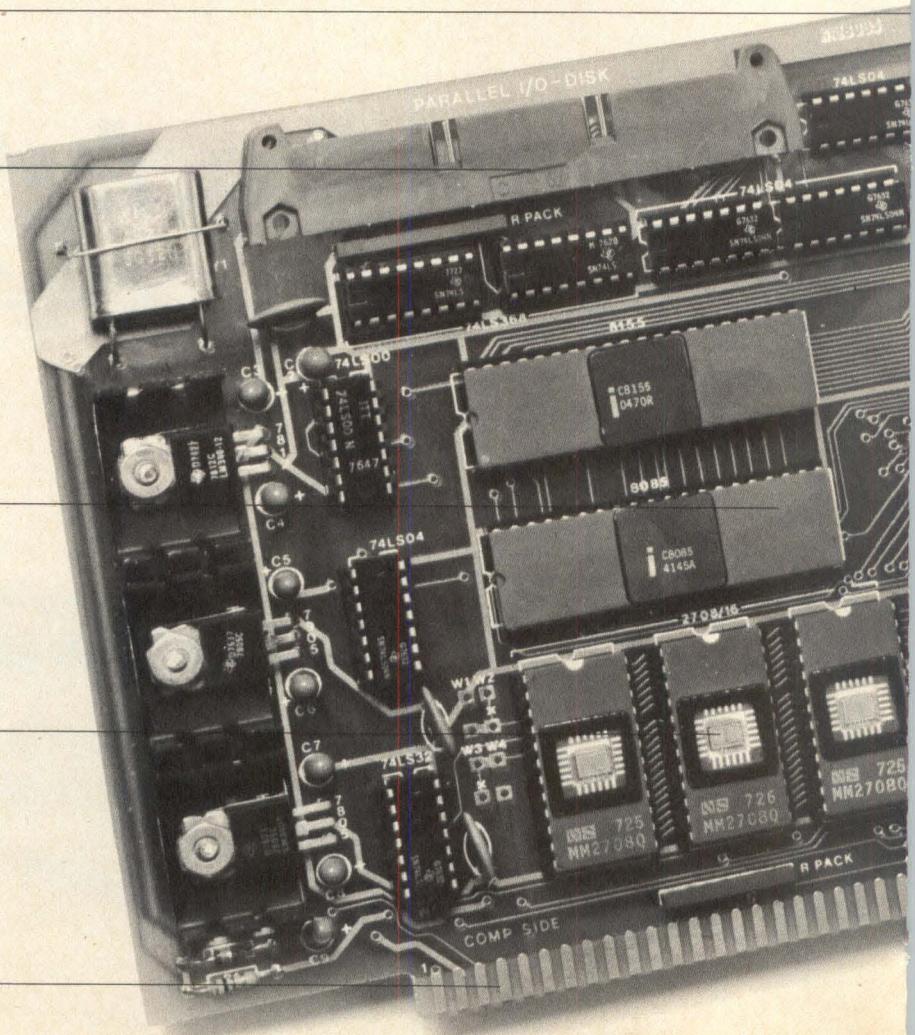
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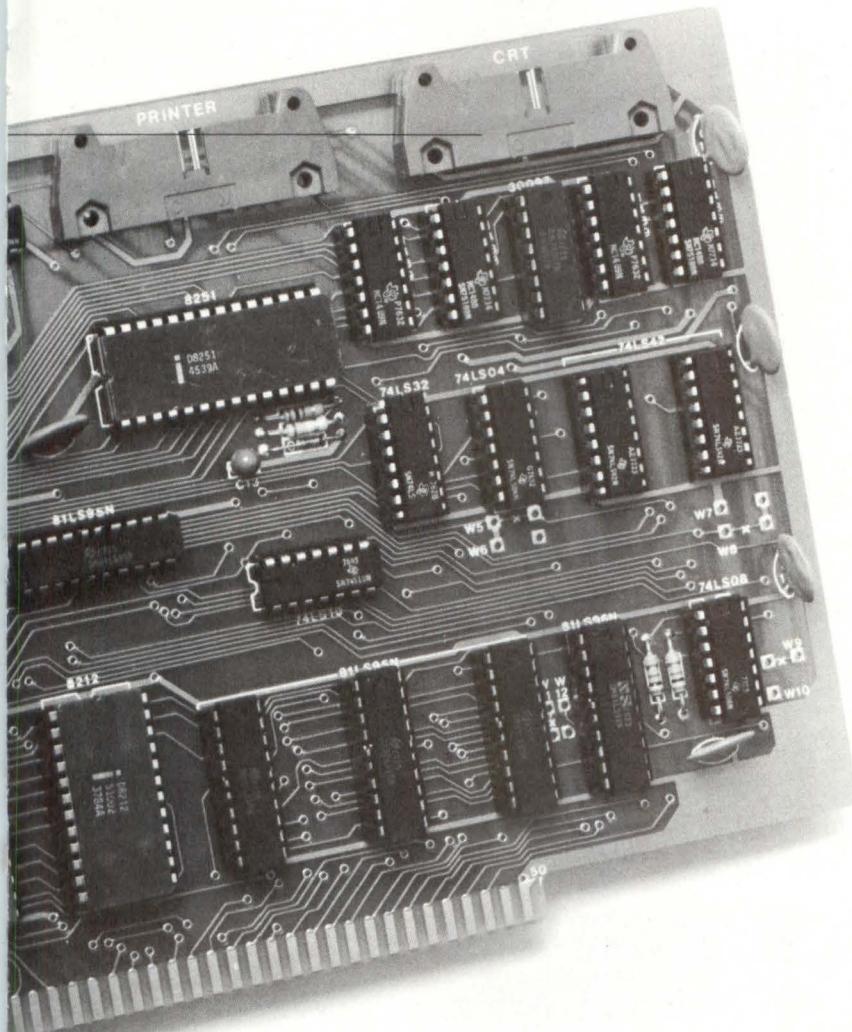
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CIRCLE 49

## The SPACE BYTE 8085 CPU- As the dedicated controller with its own software development system\*

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Additionally, the SPACE BYTE 8085 CPU will serve as the heart of its own software development system when installed in a S-100 type mainframe. With the optional SPACE BYTE 2708/2716 EPROM PROGRAMMER, application firmware can be developed and tested on the very device for which it was conceived.

By inserting programmed EPROMS in the sockets on board the SPACE BYTE 8085 CPU, the dedicated controller can now be tested "as itself," while still installed in the S-100 mainframe.

The SPACE BYTE 8085 CPU and increments of 16K SPACE BYTE fully static memory offer perhaps the most innovative, versatile and cost effective software development system in the industry.

**The SPACE BYTE 8085 is:**  
**a self contained computer**  
**a software development system**  
**a dedicated controller**

\*A complete software development system requires in addition to the SPACE BYTE 8085 CPU, RAM (such as the 16K SPACE BYTE), an EPROM programmer (such as the SPACE BYTE 2708/2716 EPROM PROGRAMMER), floppy disk system; CRT; line printer; and mainframe.



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CIRCLE 50

## Logic Analyzers: What You Can Buy

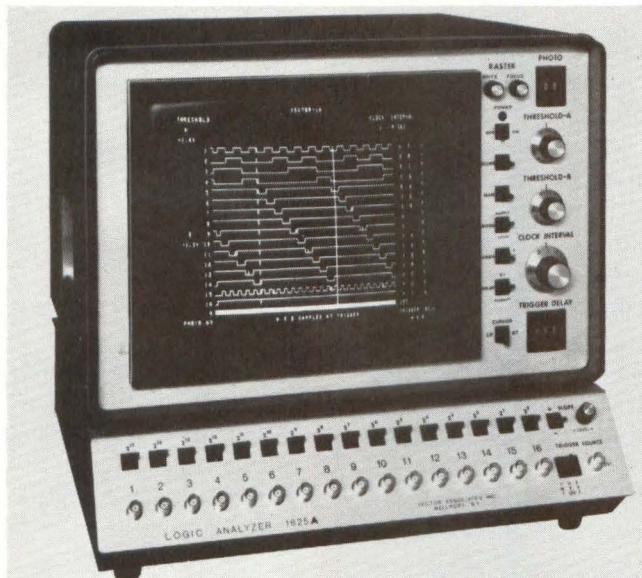
(Continued from page 72)



### Systron-Donner 50

Usable with all microprocessor families with an accessible bus structure, Systron-Donner's Model 50 analyzer provides three modes of delays: single or multiple machine cycle, instruction or loop cycle and combinations of both. Clock rate is 4 MHz; instruction cycles may include up to 8 machine cycles. In addition to displaying the address and first byte of an instruction fetch, the instrument can independently strobe and display 7 more machine cycles of data

Circle 187



### Vector Associates 1625A

Displaying 16 channels of input data when triggered by a second set of 16 inputs (address data), Model 1625A logic analyzer from Vector Associates can detect failures in most microprocessor models. The instrument includes a 12" CRT, switch register/comparator, trigger delay generator readout of all front switch positions and the 1 and 0 readouts of all data at the cursor position. Cursor operator control permits the user to look forward and backward in time in chosen increments of 0 to 255.

Circle 185



### Digital Laboratories DR-505

Hardware troubleshooting DR-505 digital signal recorder, manufactured by Digital Laboratories, provides pretrigger viewing, uses standard 10:1 probes, stretches glitches, indicates when signal is between logic thresholds and stores 512 samples per channel.

Circle 186



### Scanoptik LC-320

The LC-320 Instrument Package from Scanoptik combines the power of a 32-channel by 64 word logic state analyzer with a two channel, 15 MHz oscilloscope. Front panel switches set a 16-bit trigger address. When the logic state of the synchronous address bus agrees with the present trigger address, the analyzer will store the next 64 states of both the address and data busses. The analyzer then displays this 64X32-bit word block into a 64X8-digit hexadecimal block.

Circle 188

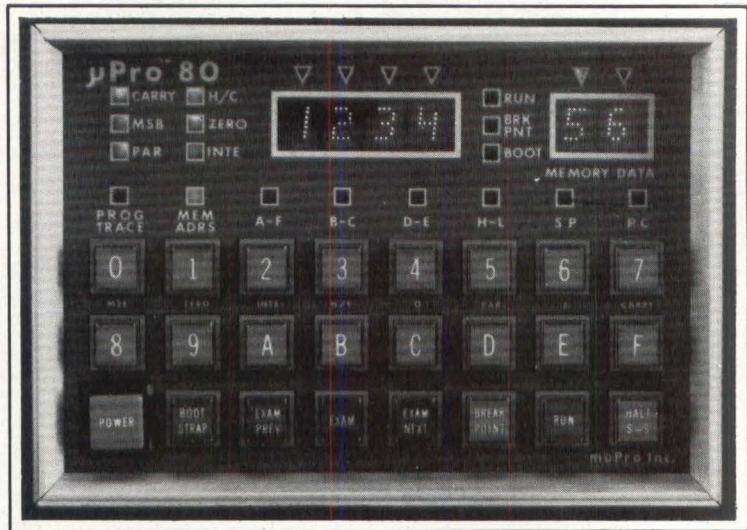


### E-H 1330

Intended for developing, testing and maintaining digital circuits and systems, E-H 1330 Series logic analyzers do pre-trigger, simultaneous multichannel and transient recording. Each logic analyzer provides alphanumeric readouts of all instrument settings on its CRT.

Circle 182

# FIELD SERVICING MICROPROCESSOR- BASED SYSTEMS



As a designer of microprocessor-based systems, you must address the problem of field servicing your products. Systems built around microprocessors present unique field service problems, problems so complex that they consume excessive engineering time, eroding corporate profits. In the past, engineers solved these problems by designing special purpose devices to use with an array of test equipment such as portable oscilloscopes, portable voltmeters and portable signal generators. But with microprocessor-based systems, problems requiring more sophisticated field service equipment occur, forcing the evolution of a new generation of test equipment. This in turn brings on a proliferation of new test concepts, procedures and documentation to support the equipment.

During the initial field installation of newly-developed microprocessor-based systems, servicing centers around locating design problems. The early period in the life of a product requires major debugging efforts by the hardware designers and software engineers. When a field failure occurs, it may not be apparent whether a hardware design error, software bug or something totally outside of the system caused the problem. Also, whenever there is an in-field product upgrading, similar problems occur. After the initial hardware and software bugs are eliminated, hardware failures cause most field problems; however, some problems arise due to external system modification that the hardware

or software can't handle. Also, system software may need changes to compensate for hardware limitations discovered after initial system installation.

The problems and constraints discussed above have several things in common, according to James B. Moon and Brent C. Olson of MuPro Inc., including:

**Cost.** The test equipment should cost as little as possible and get the system operational as quickly as possible.

**Portability.** Service personnel should be able to easily carry the unit under their arms or aboard an airplane.

**Easy to interface.** The test equipment should interface quickly and easily to the system being tested.

**Rugged.** Test equipment must survive fairly rough handling in the field.

**Transparent.** The test equipment you use should not introduce additional variables into the system being tested.

## Identifying the Problem

Moon and Olson point out that with most installations, hardware and software engineers troubleshoot the new system. These engineers must understand the conceptual design of the system and its method of operation; test gear must be flexible and powerful.

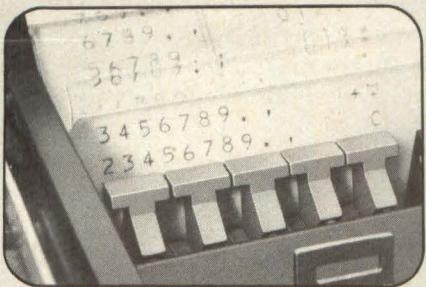
The test equipment must control and exercise the user's system; this capability should include the ability to change memory contents. If the system memory is PROM or ROM, individuals handling the troubleshooting probably prefer to first use the test equipment to find the problem and then program a new PROM to solve the problem. Moon and Olson

**The front panel (above) of muPro's 80-E emulator provides total control of the 8080-based system under test.**

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/	0	1	2	3	4	5	6
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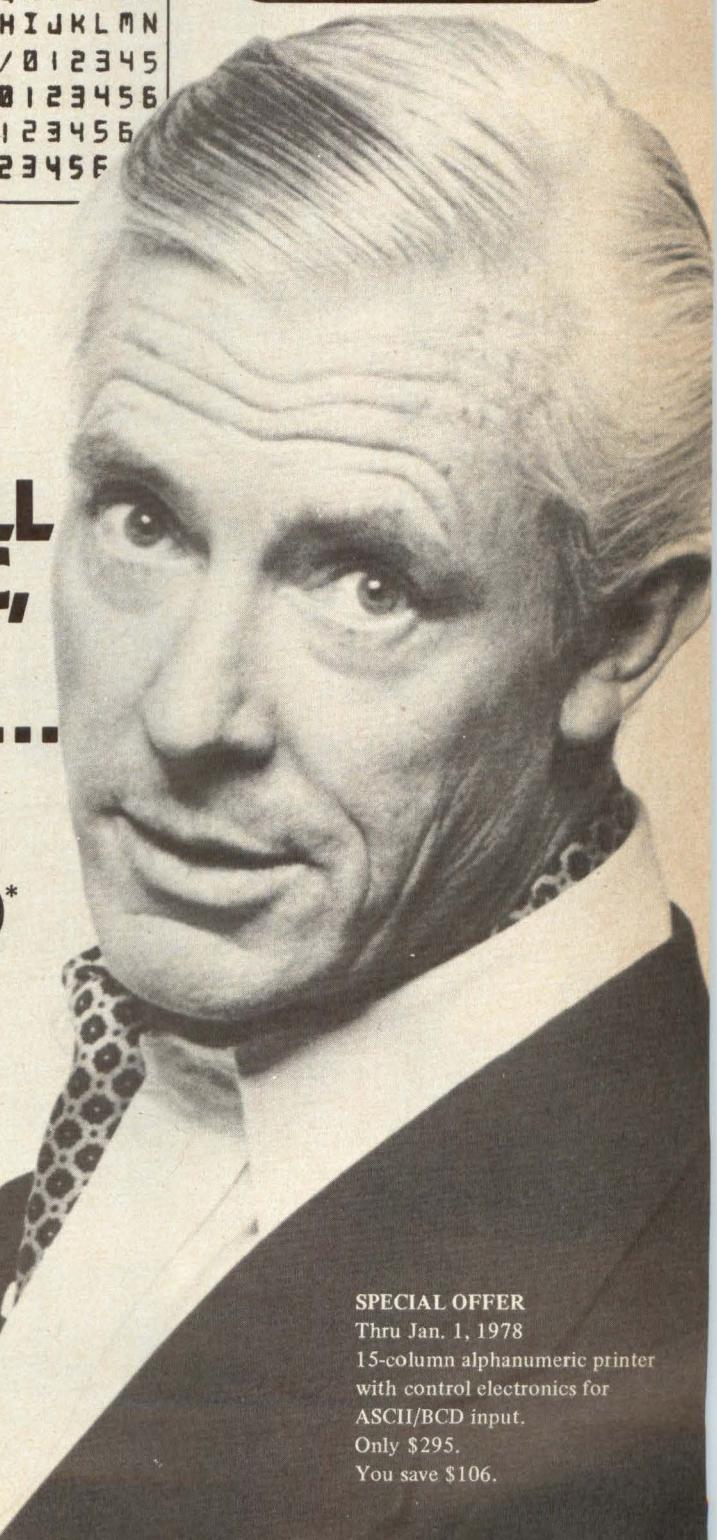
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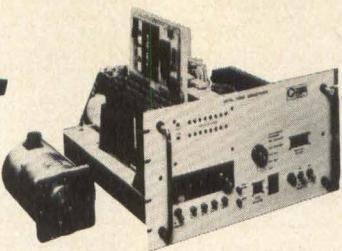
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CIRCLE 52

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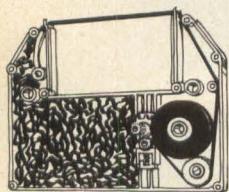


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CIRCLE 53

say that if the test equipment has the capability of programming a PROM, this feature alone could pay for the equipment if it eliminates a second field service trip. The test equipment must also control the user's system to force it to operate in those ways that isolate the problem and locate a convenient, easy solution. Also, the test equipment must display all the necessary information to indicate the type and nature of the problem.

The test equipment should have the capability to function as a completely passive monitor, rendering no effect on the user's system while monitoring. However, it should be capable of assuming control of the system when conditions dictate.

After initial installation and debugging, field service technicians take over; test equipment must allow full-capability operation by these personnel. Equipment so complex that it looks like a pinball machine crossed with a porcupine becomes useless in the hands of these technicians who usually have only a basic knowledge of electronics and system operation. Therefore, test equipment should clearly indicate proper system operation to aid in quickly separating true problems from customer errors.

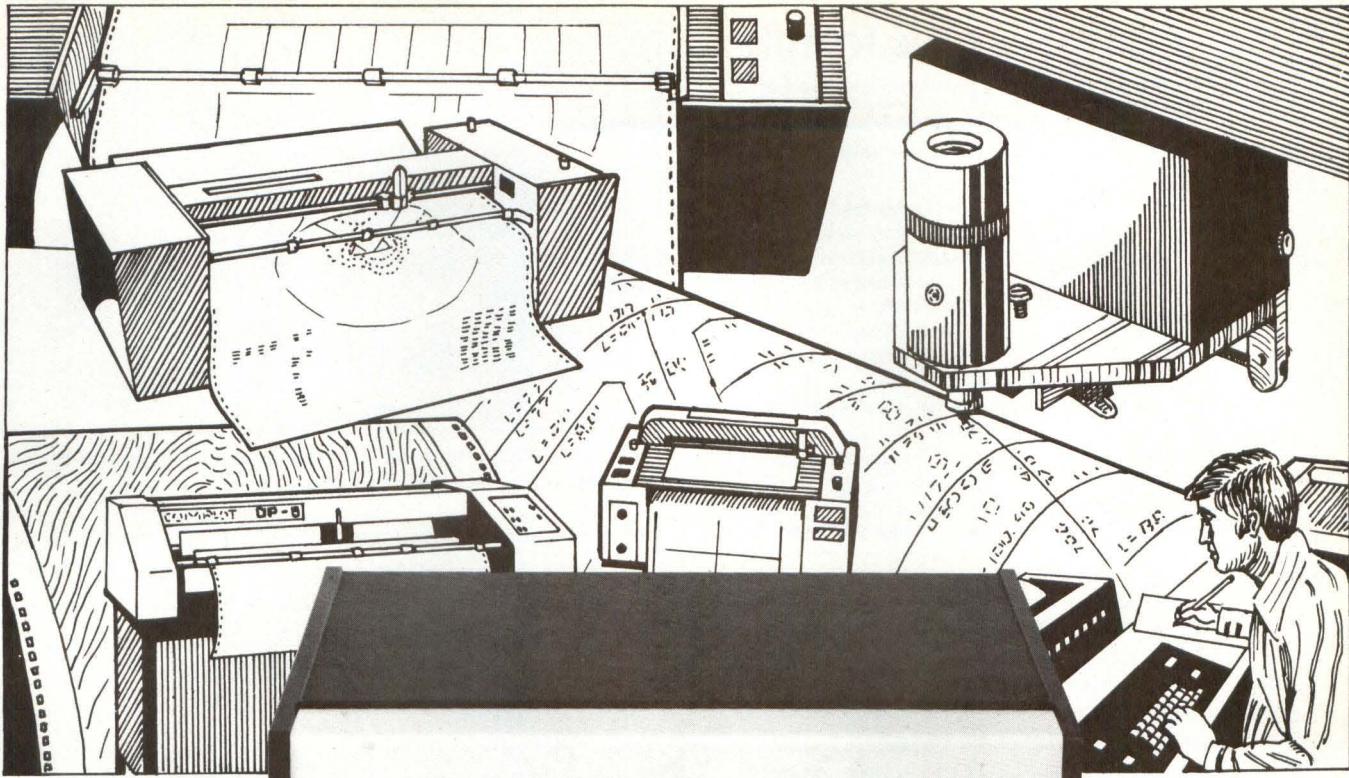
Chances are the field service technician is not the original hardware and/or software design engineer; he thus needs test flow charts, diagrams or structured test procedures and test equipment that is easy to use. The technician must be able to select test programs, modify constants and observe memory location contents.

**Today's options.** A quick look at some of the current field service methods and techniques shows how they measure up to the tasks of field service of microprocessor-based systems. Moon and Olson point out problems with several methods that have been used previously.

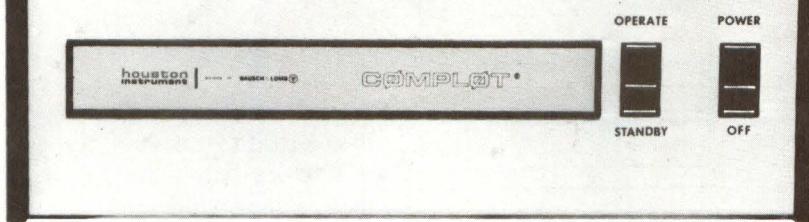
Logic signature testing works well while running a fixed test sequence of instructions for hard-wired logic or microprocessor systems. However, typical microprocessor-based systems require an exact means of duplicating the sequence of instructions used in the working model to compare to the signatures. Scope testing works for a small subset of the system, but is generally not viable due to the rapidly escalating amount of information on the display required as the problems become more complex. This technique does find use in conjunction with other test equipment, and allows you to effect looping and repetitive displays of simple signals.

Logic analyzers play a key role in initial hardware analysis and debug. They can observe sequences of events which occur only rarely, and which therefore must be captured and stored; some analyzers generate time domain, data domain, state diagrams or assembly language mnemonic representations of the events observed. All logic analyzers present in some form a "snapshot" of the system operation, although Moon and Olson claim that none of them provide the ability to observe or manipulate the CPU register contents or memory contents. They also say that logic analyzers do not provide the ability to readily modify the program itself, should a software problem need to be corrected.

Other methods that Moon and Olson feel have little use for field servicing include parametric testing and subsystem swapping. Parametric testing results require interpretation by personnel more skilled than most field service technicians;



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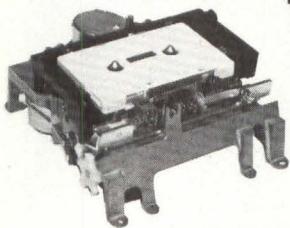
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CIRCLE 54

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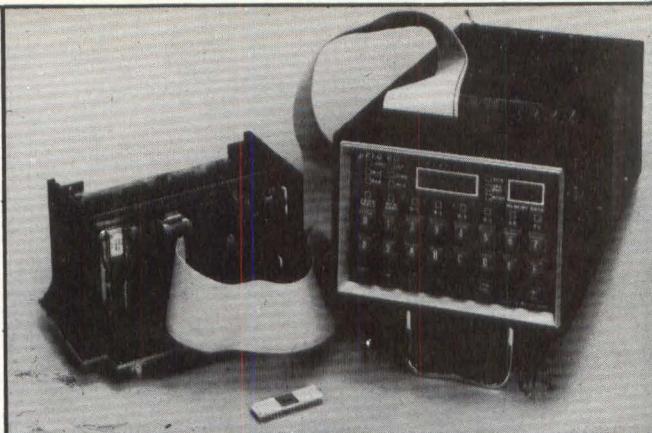
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**CIRCLE 56**



To use the 80-E, after removing the 8080 chip the user inserts a 40 pin cable header into the vacant 8080 socket.

subsystem swapping, commonly used after initial installation, enjoys limited success during the early stages of system life due to its high cost and the limited availability of swapable subsystems. Size, complexity and features of the overall system can also affect the swapping technique.

**The Alternative**

Moon and Olson point to a new class of test equipment that solves the field-servicing problem, particularly for 8080-based systems. One example of this type of device is the in-circuit emulator, which combines such features as versatility and portability with a RAM, a control and display panel and the necessary emulator circuitry. MuPro's 80-E, an in-circuit emulator that ties into the circuit under test, replacing the 8080 and fully controlling the system, allows true real-time operation without introducing extraneous wait states. The technician may change programs at will without constantly programming and reprogramming PROMs. Recent advances allow it to function as the nucleus of a multi-user, multi-task floppy disk development system; using this capability with system software can significantly speed program development.

As we are all aware, a rapid proliferation of microprocessor based systems is taking place throughout the industry. Field service personnel must tackle problems they have not seen before.

To address these problems, many organizations use traditional and time-worn field service techniques and equipment. However, as the installed base increases and new generations of systems appear, the techniques and equipment of the past grow unwieldy and cost prohibitive. Thus Moon and Olson say that management must now examine significantly different field service techniques to reduce repair time and costs. They must also examine test equipment designed specifically for microcomputers like the 8080.

The test equipment and procedures they implement must be versatile, compact, portable, rugged, easy-to-operate and relatively inexpensive. Portable in-circuit emulators such as the 80-E represent a new generation of test equipment that permits the timely, easy and economical repair of microprocessor-based systems.

**DD**

*For more information about MuPro's 80-E in-circuit emulator, circle number 178.*

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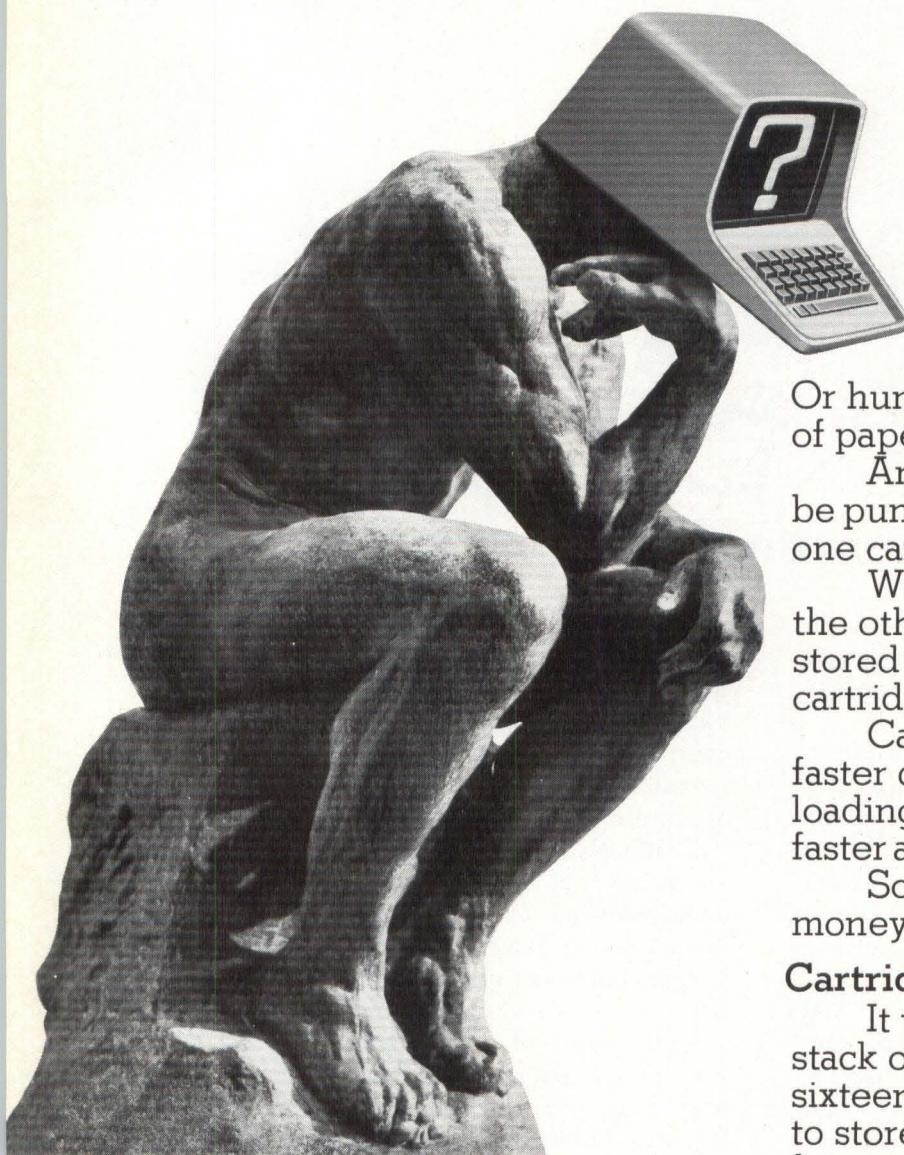
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# Is your computer smart enough



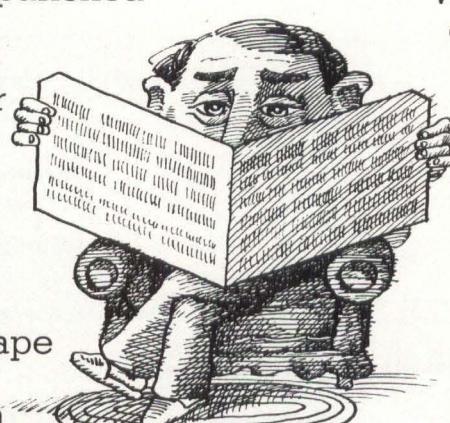
A 3M peripheral drive which uses 3M data cartridges is better than any drive which uses punched cards or paper tape.

And, if you'd take the time to ask it, your computer would probably tell you so.

It's simple logic.

## Cartridges are faster than cards.

Cards and paper tape are slow. It takes hundreds of cards for a single computer program.



*Cards must be read one at a time.*

*One DC-300A cartridge equals almost 16 feet of cards.*

Or hundreds of feet of paper tape.

And each program must be punched, verified and read one card at a time.

With our drive system, on the other hand, programs are stored on a single tape cartridge.

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So you save time and money.

## Cartridges take less space.

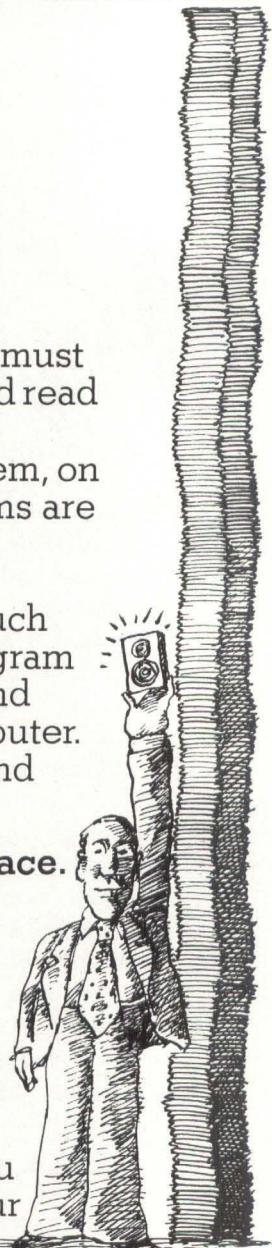
It would take a stack of cards almost sixteen feet high to store all the information you can store on a single 3MDC-300A data cartridge.

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Your filing system is simplified and overhead is greatly reduced.

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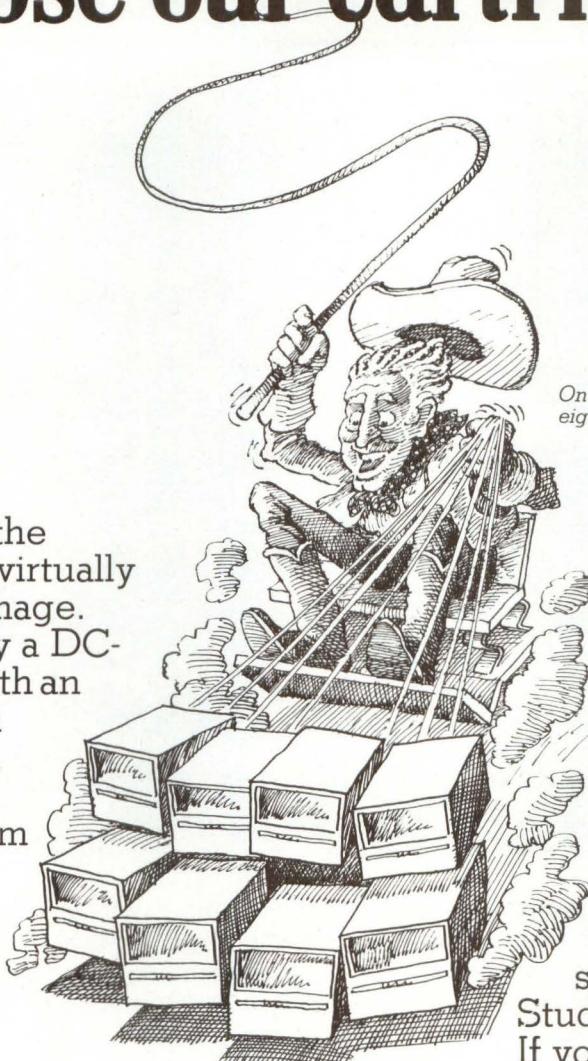
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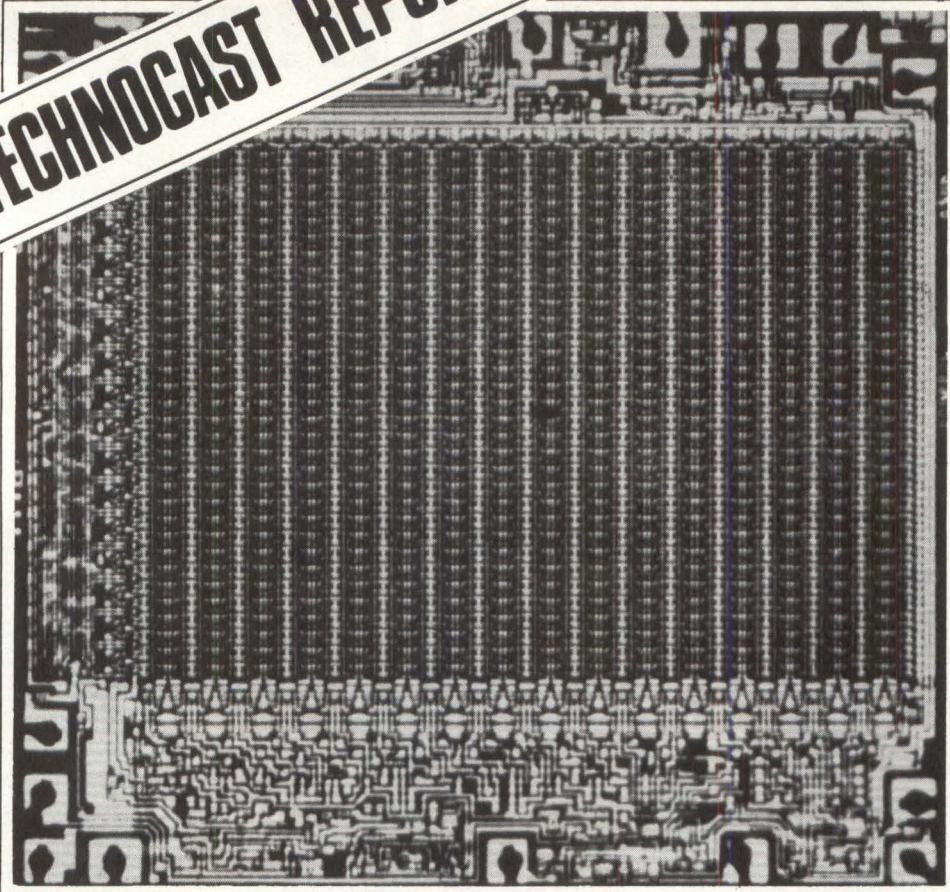


Photo courtesy of American Microsystems, Inc.

This month we complete our state-of-the-art and patent activity analysis reporting on computer memory technology. In May we covered magnetic bubble memories; in June we covered cassette, cartridge and diskette drives; July included a patent report on floppy disks; and in August, we covered charge coupled devices, core, semiconductor, CRT, and optical memories. This article discusses mag-optical, holographic, superconductive, ferroelectric, plated wire, planar film and domain tip propagation.

## COMPUTER MEMORY TECHNOLOGY: PART II

### magneto-optical memories

Magneto-optical memories optically record on or retrieve information from magnetic films by modulating the films' physical characteristics. Generally, laser beams store digital information one bit at a time on the magneto-optical medium. The information is read by sensing the magnetic field induced change in the polarization of the laser light. The physical modulating mechanisms applied on magnetic films include: thermo-magnetostrictive recording, Curie point writing, compensation temper-

ature writing, temperature dependent coercivity, Kerr effect and Faraday effect.

### Patent Activity

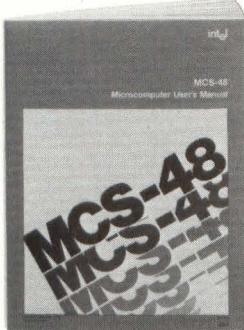
Recent patent activity has been directed to the reading and writing of data in magnetic domains by the action of a laser beam on a magnetic film. Patents issued since May 1974 include:

**3,949,387 — Beam Addressable Film Using Amorphous Magnetic Material** (Chaudhari et al, IBM Corporation) — This patent discloses a beam addressable file that uses

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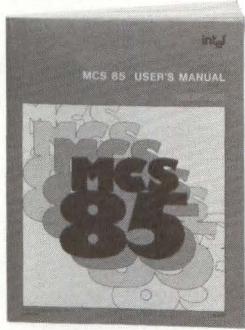
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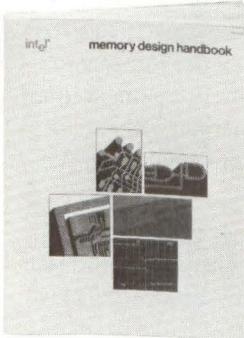
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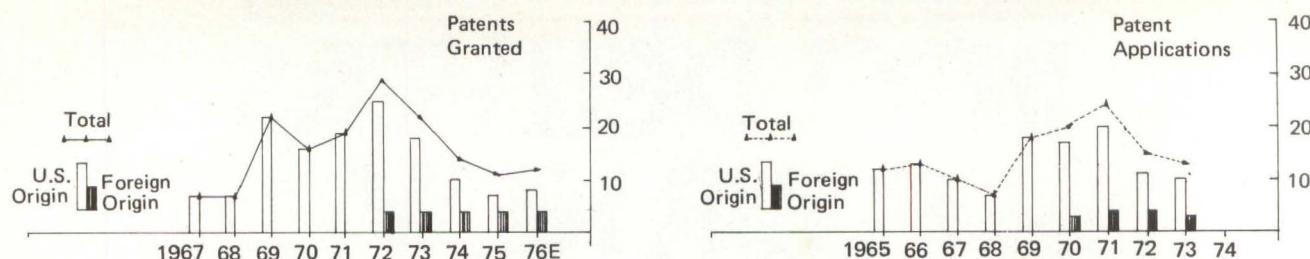
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CIRCLE 59

**Table 1 Distribution of Magneto-Optical Memory Patents**



	By Patent Grant Date										By Patent Application Filing Date											
	1967	68	69	70	71	72	73	74	75	76E	Total	1965	66	67	68	69	70	71	72	73	Total	
<b>Total Patents</b>	7	7	22	16	19	29	22	14	11	12	159	12	13	10	7	18	20	24	15	13	132	
<b>United States</b>	7	7	22	16	19	25	18	10	7	8	139	12	13	10	7	18	17	20	11	10	118	
<b>Total Foreign</b>						4	4	4	4	4	20							3	4	4	3	14
Germany						3				2	5							3				3
Netherlands						3					3							2	1			3
France						2				2	4							2				2
Finland						2				2	2							1	1			2
United Kingdom						1	1				2							1	1			2
Japan						1	1				2							1	1			2
Italy						1				1	1							1				1
Canada						1					1							1				1

an amorphous magnetic composition having uniaxial anisotropy as a storage medium. Either light beams or electron beams or electron beams can be used to write information into the storage medium with Curie point or compensation point methods. It is asserted that this method will extend the ambient temperature range of the film due to the stability of the composition.

**3,947,890 – Magneto-Optical Readout Apparatus** (Travot et al, Eastman Kodak Co.) – Discloses apparatus for retrieving magnetically recorded information by Kerr or Faraday effects. The magnetic recording is irradiated by a beam of coherent light whose plane of polarization is periodically varied. The transmitted or reflected light from the recorded medium is then analyzed for changes in polarization.

**3,944,992 – Magneto-Optical Information Storage Device Using Photoconductive Control Element** (Krumme et al, U.S. Phillips Corp.) – Discloses a device for magneto-optic memories including a storage plate of magnetizable material and a light beam for recording and retrieving information in the plate. A photoconductive layer on the storage plate is activated by the light beam and is controlled by electrodes provided thereon via a current or voltage source.

**3,899,780 – Magnetic Bubble Store Having Optical Centering Apparatus** (Otala, U.S. Phillips Corp.) – Discloses a storage system including a plate of magnetic material in which digital information can be stored in the form of domains. The domains are written and read by means of electromagnetic radiation generated by a highly coherent light source which can be modulated. The domains are maintained by a constant magnetic field, which is generated by a permanent magnetic layer.

**3,836,895 – Opto-Magnetic Memory** (De Jonge, U.S. Phillips Corp.) – Discloses the storage of data by cylindrical magnetic domains in a plate of ferric material having an easy axis of magnetization extending normal to the plane of the plate and a compensation temperature for magnetization. The size of the magnetic domains is varied by their selective

heating with a laser light source to indicate the presence or absence of data. Faster writing speeds are asserted.

**3,824,570 – Magneto-Optical Transducer Using Bubble Domains** (De Bot, U.S. Phillips Corp.) – Discloses a device for converting image information into magnetic information including a light source for projecting the image onto a plate of magnetic material capable of accommodating domains. A domain pattern is produced as the result of thermal action of the incident light. A magnetic domain displacement plate is provided for reading purposes.

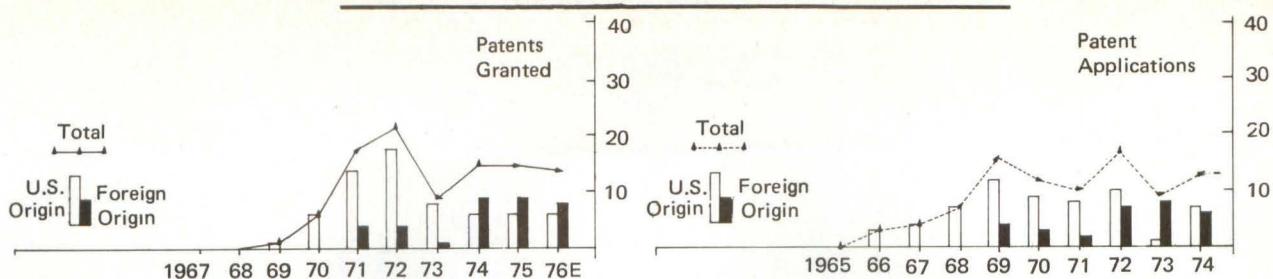
**3,815,151 – Optical Memory With Readout Beam Anneal** (Schmit, Honeywell Inc.) – Discloses optical storage of information by Curie point writing on manganese bismuth film which has multiple temperature dependent crystallographic phases. Readout is obtained by laser beam heating of the magnetized area to a temperature which removes quench crystallographic phases, yet is below the normal phase Curie temperature. The magneto-optic effect of the magnetized area rotates the polarization of the laser light in relation to the stored data. An improved readout signal-to-noise ratio is asserted.

**3,810,131 – Devices Employing The Interaction Of Laser Light With Magnetic Domains** (Ashkin et al, Bell Telephone Laboratories Inc.) – Discloses bubble and strip magnetic domains that are thermally nucleated, annihilated, captured or moved by an incident laser beam of variable power without the use of outside connections, conductor loops or magnetic elements. The laser beam is directed at the domains in a low coercivity, magnetically isotropic, single crystal of orthoferrites and ferrimagnetic garnets for heating to above the Curie point within the crystal's thermal time constant. A large storage capacity and high operating speeds are asserted.

#### holographic memories

Holographic memory systems record data by illuminating a photosensitive material simultaneously with two beams of

**Table 2 Distribution of Holographic Memory Patents**



	By Patent Grant Date								Total	By Patent Application Filing Date								Total	
	1967	68	69	70	71	72	73	74		1965	66	67	68	69	70	71	72	73	
<b>Total Patents</b>									100		3	4	7	16	12	10	17	9	78
<b>United States</b>	1	6	14	18	8	6	6	6	65		3	4	7	12	9	8	10	1	54
<b>Total Foreign</b>			4	4	1	9	9	8	35						4	3	2	7	8
Japan			2	1	1	4	7	2	17						2	1	1	4	3
Germany				1		4	2	2	9						1	2	4	7	
France					1	1		4	6						1		1	1	3
United Kingdom			2	1					3						1	2			3

coherent light; one beam illuminates an object plane and carries the data for recording, the other constitutes a reference beam. Plural individual holograms are stored on each photosensitive memory medium, each hologram representing a different data bit pattern or "page." To read out a page, a laser beam selectively illuminates a stored hologram thereby projecting a real image of the bit pattern onto a matrix of photodetectors which convert the light into electronic signals.

### Recent Activity

Recent emphasis has been on optical systems for reading and writing hologram memories. Patents issued since May 1975 include:

**3,964,032 – Optical System For Storing Information** (Barodos, Harris Corp.) – Discloses a wideband holographic information storage system which records Fourier holograms on film in rapid succession, each hologram storing 128 bits of data. The holograms are successively recorded in adjacent positions across a photosensitive film by scanning a light beam wide enough to cover two facets of a rotating polygonal scanning mirror.

**3,959,784 – High Speed Optical Read-Out Of Data Stored In An Array** (Meier, Actron) – Discloses an optical system which illuminates successive frames of holographic data with light of different wavelengths and then images the data on successive photodetector arrays. The color of light being used for illumination determines which array the image of the frame is formed on.

**3,946,370 – Method Of Making Light-Dot Distribution For The Holographic Storage Of Binary Information With The Aid Of Electronically Controlled Switching Masks** (Schmidt et al, U.S. Phillips Corp.) – Discloses a method of making light data distributions for the holographic storage of binary information through the use of an electronic switching mask. The mask has its individual elements modulated in their path length through fading of the interference structure of the hologram to transmit a constant quantity of light independent of the information distribution.

**3,936,139 – Holographic Memory Providing Both Angular And Translational Reference Beam Deflections** (Huignard et al, Thomson-CSF) – Discloses an optical system for storage and retrieval of data using a hologram incorporating

two light deviating devices. One device enables selection of an elementary area of the storage medium while the second device allows superimposed holograms to be stored within the elementary area.

**3,924,924 – Holographic Memory Utilizing A Changeable Phase Object and Coherent Subtraction** (Fukuhara, Hitachi Ltd.) – Discloses a holographic recorder which uses a pattern generator to reduce the hologram's dependency upon the incident angle of irradiated light. The pattern generator comprises plural biaxial, birefringent, irregular, ferroelectric crystals with mutually opposing planes normal to any one of the a-, b-, or c-axes and having a thickness of a half-wave plate. The crystals are arranged as a matrix on a plane perpendicular to incident light and are modulated by a threshold voltage applied to their Z-planes to phase modulate the information pattern onto a photosensitive medium and form a hologram.

**3,891,976 – Hologram Memory With Sequential Data Storage and Beam Angular Relationship** (Carlsen, GTE Laboratories, Inc.) – Discloses an optical data beam and an optical reference beam passed through deflectors to intersect and form holograms at the recording medium. Each data bit is recorded with a distinct angular relationship between the intersection data and reference beams. These relationships are used to identify the position of each data bit.

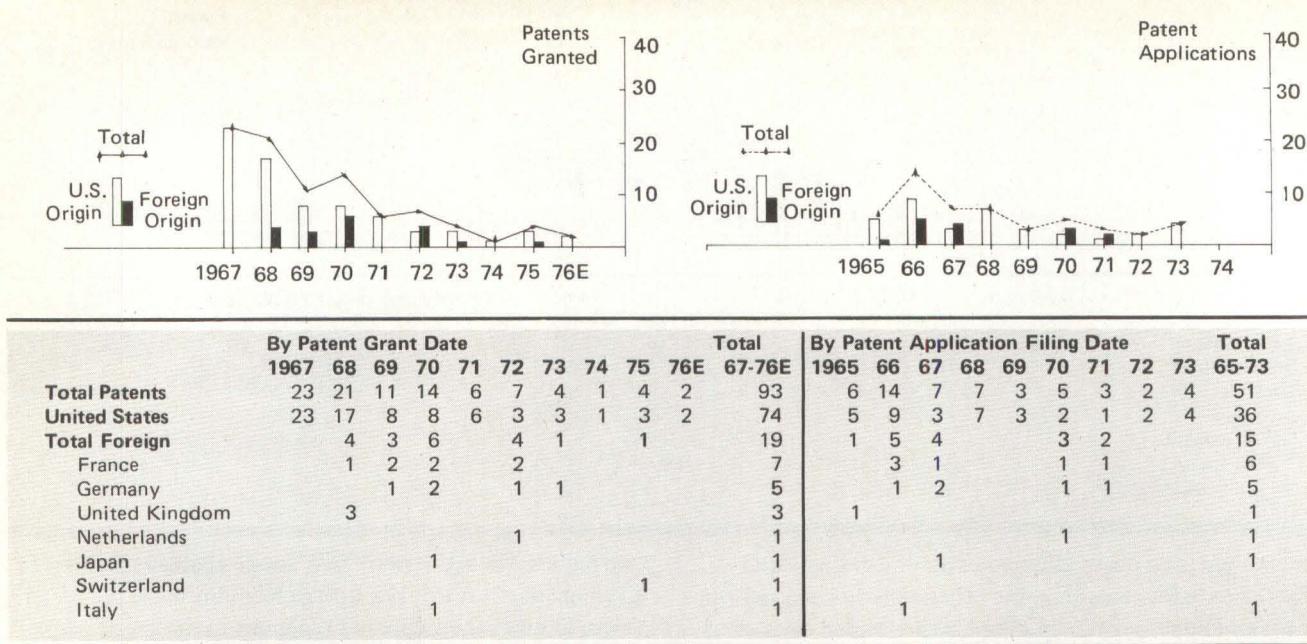
**3,833,893 – Holographic Memory Including Corner Reflectors** (Rajchman, RCA Corp.) – Discloses a holographic storage medium in which lenses are eliminated and corner reflectors are used. A laser beam is deflected to an illumination hologram to illuminate an array of controllable corner reflectors to represent binary data.

**3,883,216 – Holographic Memory Having Spherical Recording Medium** (Lee, Honeywell, Inc.) – Discloses a holographic memory in which a constant angle is maintained between the object beam and the reference beam at the memory medium. The object and reference beams are each pivoted about respective pivot points and the memory medium has a spherically curved surface, with multiple data storage locations.

### superconductive memories

Superconductive memory devices employ as the memory element an electric current in a loop of material cooled be-

**Table 3 Distribution of Superconductive Memory Patents**



low its critical point. The material has the property of losing all electrical resistance when so cooled so that the electric current persists indefinitely with no measurable attenuation. Included are Josephson junction memories consisting of one or more Josephson junctions connected in a superconducting loop. These memories exhibit extremely fast switching speed and high density.

### Patent Activity

Recent patent activity has focused on using Josephson junctions in memory devices with emphasis on material and structural features. Patents issued since February 1972 include:

**3,936,809 – Single Flux Quantum Storage Devices and Sensing Means Therefor** (Zappe, IBM Corp.) – Discloses a single Josephson tunnelling device made with two superconductive materials spaced apart by an insulator. The Josephson current density profile is characterized by a larger magnitude at the boundary portions than at the center. A sensing arrangement is also described.

**3,916,391 – Josephson Junction Memory Using Vortex Modes** (Gueret, IBM Corp.) – Discloses a memory array of Josephson junctions arranged in rows and columns of a matrix. The junction parameters are chosen so that the junctions, while remaining in their superconductive state, can assume either of two vortex modes in which, respectively, no flux quanta or a certain number of flux quanta can be trapped within the junction.

**3,825,906 – Superconductive Shift Register Utilizing Josephson Tunnelling Devices** (Hamel et al, IBM Corp.) – Discloses a two phase superconductive shift register using Josephson tunnelling devices. Included are a plurality of shift register stages energized from a DC current source wherein each stage contains a first and second branch circuit in parallel. A Josephson tunnelling device is located in each branch.

**3,705,393 – Superconducting Memory Array Using Weak Links** (Anacker et al, IBM Corp.) – Discloses memory cells containing superconductive rings capable of supporting Jo-

sephson tunnelling current. Coincident currents are used to trap flux in the rings and to release the trapped flux for readout of the memory cells.

**3,691,539 – Superconductive Device for Electronic Storage of Large Quantities of Data Using Magnetic Particles** (Erben et al, Messerschmitt-Bolkow-Blohm GmbH) – Discloses a three layered storage element made up of an insulating film sandwiched between two superconductive layers with magnetic particles applied to the upper superconductive layer. An electron beam is used to reorient the particles for storage purposes.

**3,646,528 – Self-Searching Memory Utilizing Improved Memory Elements** (Davies, TRW, Inc.) – Discloses an associative memory system using the presence or absence of a persistent current in single control superconductor devices to represent binary information. Readout is accomplished by association in comparators which may be selectively masked.

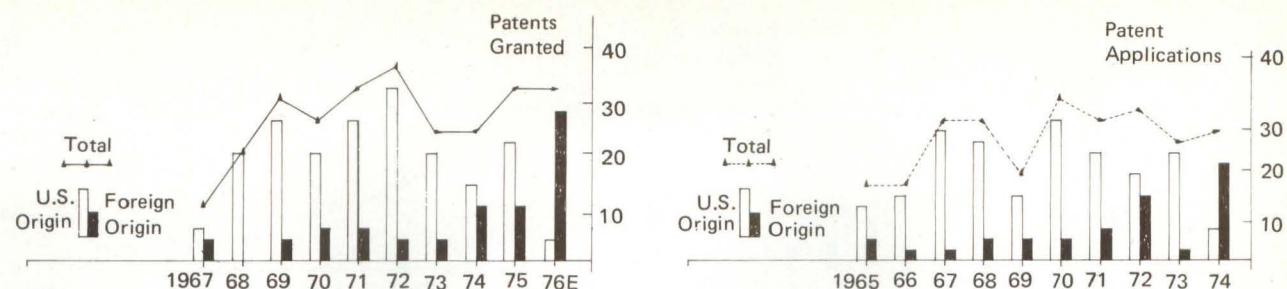
**3,643,237 – Multiple-Junction Tunnel Devices** (Anacker, IBM Corp.) – Discloses memory circuits which employ nonlinear tunnelling devices. Each device is a series arrangement of tunnel junctions causing the memory to have built in redundancy. Better reliability is asserted.

**3,641,517 – Superconductive Data Storage Arrangement** (Brilman et al, Societe Alsacienne de Constructions Atomiques de Telecommunications et d'Electronique "Alcatel") – Discloses a cryogenic device made up of an arrangement of elementary storage cells connected to an addressing device for the storage and the non-destructive reading of information. The cells are grouped so that the circuits for energizing the storage loops and the test conductors are interconnected in columns, and the writing conductors and the reading conductors are interconnected in lines.

### ferroelectric memories

Ferroelectric memories contain a ferroelectric material either directionally polarized or modified in its inherent polarization direction by the application of an electric field to the domains of collectively oriented molecules in the materi-

**Table 4 Distribution of Ferroelectric Memory Patents**



	By Patent Grant Date										By Patent Application Filing Date										
	1967	68	69	70	71	72	73	74	75	76	Total 67-76E	1965	66	67	68	69	70	71	72	73	Total 65-73
<b>Total Patents</b>	5	10	15	13	16	18	12	12	16	16	133	7	7	13	13	8	15	13	14	11	101
<b>United States</b>	3	10	13	10	13	16	10	7	11	2	95	5	6	12	11	6	13	10	8	10	81
<b>Total Foreign</b>	2	2	3	3	2	2	5	5	14	16	38	2	1	1	2	2	2	3	6	1	20
Japan			1	2	1	2	1	2	8	17			1	1	1	2	2	1	1	1	9
Germany	1	1	1	1				2	2	8		1	1	1	1	1	1	1	1	1	5
France						2	1	4		7								2		2	2
Switzerland	1									1											1
Sweden							1			1											1
Mexico			1							1											1
USSR								1		1											1
Czechoslovakia	1									1											1
United Kingdom		1								1											1

al. The electric field is typically applied through two electrodes mounted upon the ferroelectric material. Polarization modulation caused by the electric field is used to control the intensity of incident light in a binary mode, in accord with data signals. The piezoelectric properties of ferroelectrics provide an additional mode of memory operation. The magnitude and sign of the electrical charge in the materi-

al, caused by the piezoelectric effect, are used to represent binary states.

#### Patent Activity

Recent patent activity has been directed towards storing information in ferroelectric material using the different effects engendered by the electric field. Patents issued since

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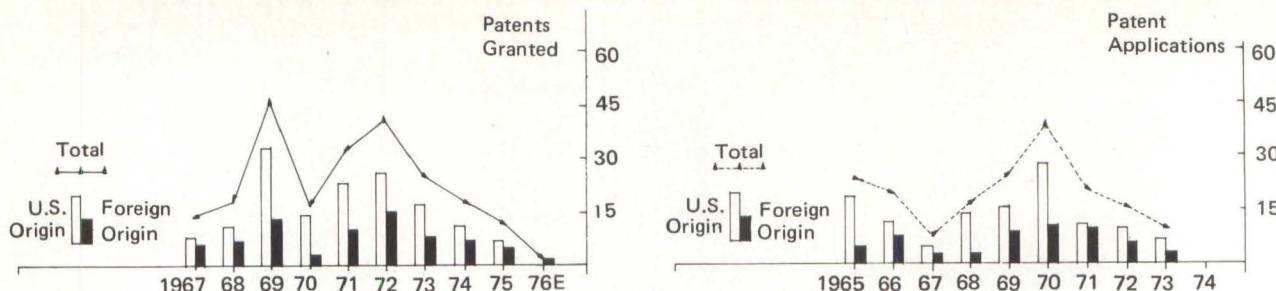
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**Table 5 Distribution of Plated Wire Memory Patents**



	By Patent Grant Date										Total	By Patent Application Filing Date										Total
	1967	68	69	70	71	72	73	74	75	76E		1965	66	67	68	69	70	71	72	73	65-73	
<b>Total Patents</b>	14	18	45	17	33	41	25	18	12	2	226	24	20	8	17	25	39	21	16	10	180	
<b>United States</b>	8	11	33	14	23	26	17	11	7		150	19	12	5	14	16	28	11	10	7	122	
<b>Total Foreign</b>	6	7	13	3	10	15	8	7	5	2	76	5	8	3	3	9	11	10	6	3	58	
Japan	6	7	13	3	9	11	7	7	5	2	70	5	8	3	3	8	7	9	6	3	52	
France					2	1					3						2	1			3	
Germany					1	2					3						1	2			3	

November 1973 include:

**3,964,033 — Electro-optic Storage Device** (Wasa et al, Matsushita Electric Industrial Co. Ltd.) — Discloses a memory storage system utilizing a transparent ferroelectric ceramic plate and a pair of erasing electrodes on the opposite edges of the plate. The writing electrodes consist of thermally sensitive transparent resistor layers.

**3,958,230 — Arrangement Including A Piezo-Ferroelectric Body** (Petersen, U.S. Phillips Corp.) — Discloses a storage electrode terminating impedance for a piezo-ferroelectric memory. The impedance reduces deleterious electromechanical variations at adjacent storage electrodes upon partial polarization or depolarization of an electrode on a piezo-ferroelectric body.

**3,930,240 — Ferroelectric Memories and Method of Activating The Same** (Hadni et al, Agence Nationale de Valorisation de la Recherche (Anvar)) — Discloses a high capacity, non-destructive memory comprising a thin plate of ferroelectric material (triglycine sulfate) cut at right angles to its ferroelectric axis and metalized on two sides. Polarization modulating voltages are transmitted through the metalized sides of the material in order to switch the ferroelectric domains in the areas where a light source (laser) has scanned. A large storage capacity, by virtue of high density of writing and reading cells, is asserted.

**3,890,604 — Selective Dipole Orientation Of Individual Volume Elements Of A Solid Body** (Schroder) — Discloses a magnetic cube containing ferroelectric particles to which intersecting elastic waves are applied so that the volume element of said body which intersects with the superimposed portions of the waves at any given time has a higher energy density than any other portion of the body. A sensing element detects the changes in dipole orientation of the ferroelectric particles.

**3,868,652 — Multi-Layer Ferroelectric Optical Memory System** (Cooper et al, IBM Corp.) — Discloses a ferroelectric optical memory system utilizing a light scanner for selectively setting the birefringent level associated with a region or storage location of the ferroelectric layer. The birefrin-

gent levels collectively set for regions of each particular storage location indicate the digital information stored.

**3,832,700 — Ferroelectric Memory Device** (Wu et al, Westinghouse Electric Corp.) — Discloses a memory element utilizing the remanent polarization of a thin, ferroelectric film to control the surface conductivity of a bulk semiconductor. When a potential of one polarity is applied to a gate electrode of the ferroelectric material and the semiconductive substrate, and then removed, a persisting inversion layer or conducting channel is formed. When a potential of opposite polarity is applied, the channel will be depleted.

**3,798,619 — Piezoelectric Transducer Memory With Non-Destructive Read Out** (Samofalov et al) — Discloses a long-term storage device with non-destructive reading of information which uses a strip of ferroelectric material with at least two piezoelectric transducers. The ferroelectric material acquires piezoelectric properties when placed in an electric field.

**3,774,174 — Polarization And Optical Switching Of Quadrable Ferroelectric Films By Singular Electrodes** (Franchombe et al) — Discloses a ferroelectric material with at least two independently reversible polarization components and single-crystal domains. At least one set of electrodes are positioned to apply electric fields to single-crystal domains of the ferroelectric material at an angle to the reversible polarization components, so that one electric field can reversibly polarize both components and a second field can reverse one of the components without reversing the other.

#### plated wire memories

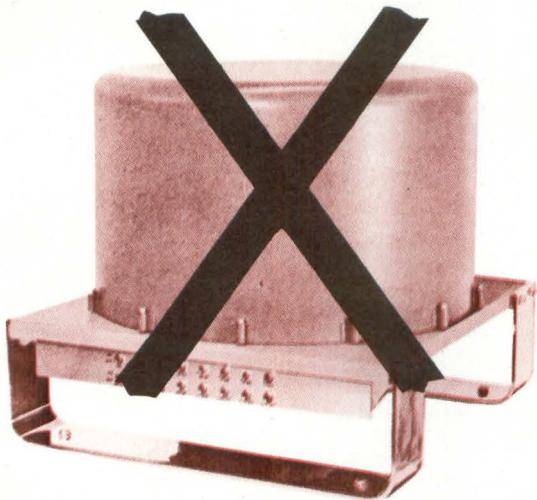
Plated wire memories are non-destructive read-out type devices composed of a cylindrical magnetic film electroplated onto a conductive wire substrate. During fabrication, easy and hard axes of magnetization are established in the magnetic film with the easy axis being able to support two stable states representing a binary "1" and "0". These axes are organized into matrices and provided with the necessary circuitry to write and sense stored information.

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## Recent Activity

Recent patent activity generally has focused on memory arrangements which allow high packaging density and on the structural features of the plated wire memory element itself. Patents issued since April 1974 include:

**3,906,467 – Plated Wire Memory** (Velishek et al, Control Data Corp.) – Discloses a plated wire memory consisting of a barrier layer between the core of non-magnetic conductive material and an outer layer of highly permeable magnetic material. The barrier layer is constructed of conductive material such as gold or gold-copper alloy that does not diffuse into the magnetic material.

**3,898,634 – Magnetic-Wire Memory System** (Yoneyama, Toko Kabushiki Kaisha) – Discloses a balanced address selecting matrix type memory system composed of a first and second memory stack each including the same number of information lines and work lines arranged in a symmetrical manner. Circuitry is provided to compensate for noise created in the information lines.

**3,895,362 – Integrated Magnetic Wire Memory** (Yamakawa et al, Oki Electric Industry Co., Ltd.) – Discloses a memory cell composed of a plurality of parallel coplanar magnetic wires enclosed by an insulating film, and a plurality of U-shaped conductive non-magnetic wires disposed in a plane parallel to the plane of the magnetic wires and in a direction normal to the projected direction of the magnetic wires.

**3,863,233 – Magnetic Memory Array** (Eddey et al, Goodyear Aerospace Corp.) – Discloses an associative processor which is a digital computer system capable of operating upon many independent sets of data simultaneously. Each data set is processed sequentially bit by bit, giving an overall effect that is analogous to a large bank of serial computers all executing the same program but on different data.

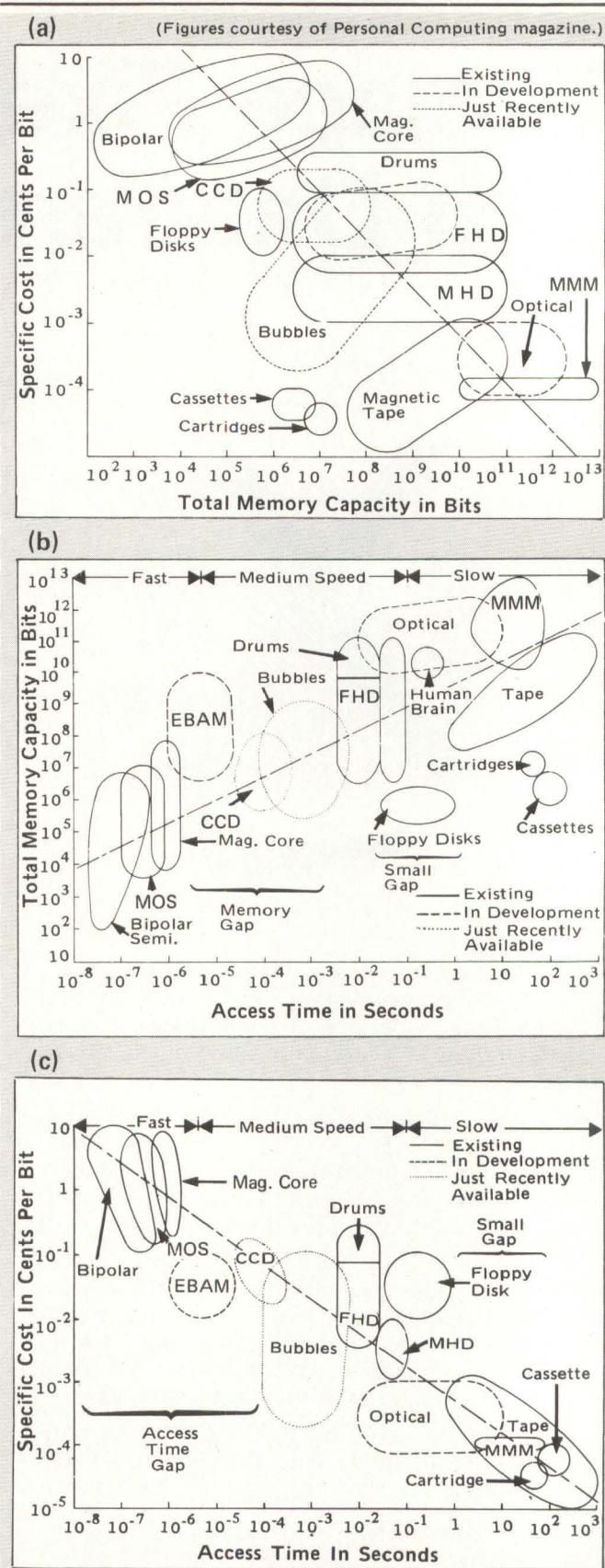
**3,852,725 – Magnetic Plated Wire Memory Device** (Ogura et al, Oki Electric Industry Co., Ltd.) – Discloses a magnetic memory device in which at least two independent memory planes are arranged on each side of a rigid base board. Readout driving current is taken from each opposing edge of the rigid base board surfaces.

**3,824,566 – Magnetic Thin Film Plated Wire Memory** (Kobayashi et al, Fuji Denki Kagaku Kabushiki Kaisha) – Discloses a memory with fewer digit drivers to attain lower cost and higher density. The memory contains a plurality of digit pair wires intersecting substantially at right angles with word wires. The digit wire pairs are grouped into a plurality of shift sense sections, each of which includes an equal number of digit pair wires.

**3,810,134 – Memory Bit Drive Circuitry Providing Common Terminating Impedance to a Sense Line** (Culp, General Electric Co.) – Discloses a matrix memory having an arrangement for providing write current to bit lines through the same wires on which output or sense signals are carried, without affecting the sense signals. Each bit is written into a storage cell which is magnetically coupled to a sense pair. A bit driver, composed of a current source, is connected across each pair.

**3,803,656 – Plated Wire Memory Plane** (Johnson et al,

**Table 6 Memory Comparisons:  
Cost, Speed and Capacity**



(a) Cost as a function of memory capacity. (b) Memory capacity as a function of access time. (c) Cost as a function of access time.  
MOS: Metal-Oxide Semiconductor; CCD: Charge-Coupled Devices;  
EBAM: Electron Beam Accessed Memories; FHD: Fixed Head Disks;  
MMM: Magnetic Mass Memory (magnetic tape automated library).



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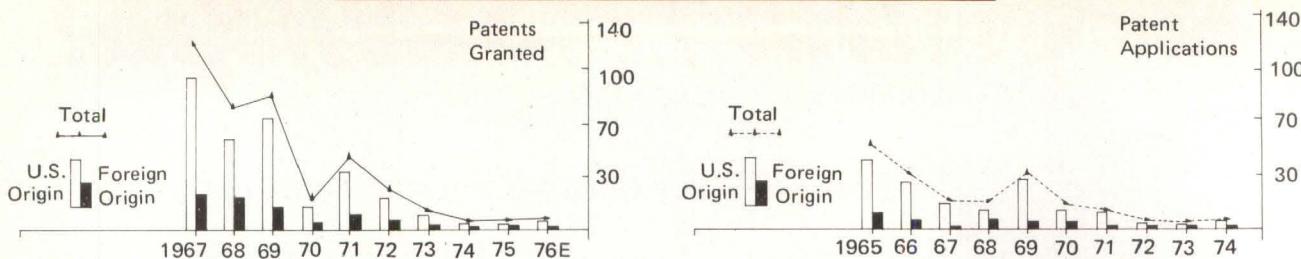
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**Table 7 Distribution of Planar Film Memory Patents**



	By Patent Grant Date										Total	By Patent Application Filing Date								Total	
	1967	68	69	70	71	72	73	74	75	76E		1965	66	67	68	69	70	71	72	73	
<b>Total Patents</b>	122	80	88	20	48	27	13	6	7	8	419	56	36	19	18	37	17	13	6	5	207
<b>United States</b>	99	59	73	15	38	21	10	4	4	6	329	45	30	17	12	32	12	11	4	3	166
<b>Total Foreign</b>	23	21	15	5	10	6	3	2	3	2	90	11	6	2	6	5	5	2	2	2	41
United Kingdom	10	6	4	1	1						22	2	1		1	1					5
Germany	6	5	2	2	2					1	2	20	3	1	2	1					8
France	1	1	2	1	5	3	1	2			16	2	1		3	3	1	2	2		14
Japan	2	5	1	1	1	2	2	2		2	16	1	2		1	1	3			1	9
Netherlands	3	1	1	1							6	1									2
Switzerland	1	2	3								6	1									1
Canada		2									2	1	1								2
Indonesia	2										2										

Xerox Corp.) – Discloses a plated wire memory plane which includes a support member, an insulator having a plurality of parallel grooves, a plated wire, an annular magnetic coating uniformly deposited in all of the preformed grooves and a substantially U-shaped word drive laminate. The preformed grooves facilitate insertion of the plated wires into the insulator.

### planar film memories

Planar film memories use anisotropic magnetic films of permalloy which contain a preferred axis of magnetization, called easy axis, and a perpendicular axis, the hard axis. The magnetic vector of the film aligns itself with the easy axis when no external magnetic fields are present. Magnetic fields generated by passing a current through a conductor mounted close to the film rotate this vector towards the hard axis. The realignment and rotation of the magnetic vector is the basis for two distinguishable, reversible states. Typically, planar films are classified according to their four major modes of construction: single plane film; coupled planar films; bicore elements; and mated-film elements.

### Patent Activity

Recent patent activity has been directed towards more efficient planar film memory systems, such systems allowing for higher densities and lower power consumption. Patents issued since February 1973 include:

**3,962,690 – Thin Film Magnetic Storage Device** (Koenig et al, BASF Aktiengesellschaft) – Discloses a ferromagnetic thin film with areas of differing coercive forces and electric conductors extending in planes parallel with the film's support, and at right angles to strip-like channels having low coercive force. The conductors produce magnetic fields required for propagation of magnetic domains in the low coercive force channels.

**3,922,651 – Memory Device Using Ferromagnetic Substance Lines** (Imamura, Kokusai Denshin Denwa Kubushiki Kaisha) – Discloses a word-selection memory comprising a plurality of non-magnetic lines arranged in parallel to one another and a plurality of memory lines. The magnetic lines

utilize ferromagnetic thin film orthogonally arranged with the nonmagnetic lines. Each of the memory lines is formed from conductive, ferromagnetic material having an axial easy magnetization axis.

**3,798,623 – Quad Density Solid Stack Memory** (Kaske et al, Sperry Rand Corp.) – Discloses an electrically alterable random access memory system which contains mated film elements as memory cells. The memory cells are arranged on each two-dimensional memory plane along two parallel running sense digit lines. A single word line, passing orthogonally through the stacked, superposed memory planes, is inductively coupled to a pair of memory cells, each cell associated with each sense-digit lines on each memory plane.

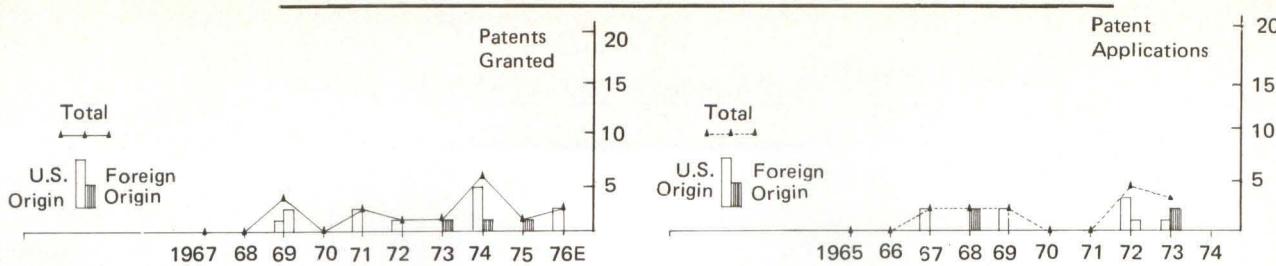
**3,786,444 – Magnetic Thin Film Memory Packaging Design** (Sly, U.S. Army) – Discloses a memory store unit made by aligning film core areas and bonding them in pairs on either side of a single piece of printed wire overlay which supplies word and common sense lines. Top and bottom insulators, apertured to receive the film core arrays are applied to the overlay for support and to maintain a uniform distance between the overlay and ground planes.

**3,742,467 – Sense-Digit Line Selection Matrix For Memory System** (Benrud et al, Sperry Rand Corp.) – Discloses a circuit for addressing a sense-digit line of a group of such lines that form part of a selection matrix of a ferroelectric thin film memory system. The group addressing circuit is a matrix of eight FET transistors for gating one of eight associated active sense-digit lines and one FET transistor for gating an associated dummy sense-digit line for reading and writing.

**3,727,199 – Static Magnetic Memory System** (Lekven, Signals Galaxies, Inc.) – Discloses a static magnetic memory which includes individual binary storage members that are afforded directional preferential magnetic characteristics in order to establish the preferred axis of magnetization. Conductors for driving the individual binary storage members are provided in a flat planar pattern.

**3,723,983 High Density Thin Film Register** (Lienhard, Ampex Corp.) – Discloses a magnetic thin film geometry

**Table 8 Distribution of Domain Tip Propagation Memory Patents**



	By Patent Grant Date								Total 67-76E	By Patent Application Filing Date								Total 65-73	
	1967	68	69	70	71	72	73	74		1965	66	67	68	69	70	71	72	73	
Total Patents	3	2	1	1	1	5	1	1	15	2	2	2	4	3	13				
United States		2	1		4				9	1		2		3	1	7			
Total Foreign	3		1	1	1				6	1	2		1	2		6			
France	3		1	1	1				6	1	2		1	2		6			

wherein thin film strips have a preselected width to length ratio, film thickness, and value of coercive force. The geometry provides storage and transfer of stable magnetic domains with well defined boundaries and decreased interaction while allowing high packing densities.

#### domain tip propagation memories

Domain tip memories use the controlled motion of magnetic domains on a plane surface. Magnetic domains progress, stepwise, under the control of time varying magnetic fields in a medium of thin polycrystalline anisotropic layers in which a magnetic zone having low coercivity is surrounded by a basic layer having higher coercivity. The difference in coercivity restricts the formation and propagation of the domains to within a propagation channel. Binary information is represented by the presence or absence of a magnetic domain. Read out is accomplished by a number of methods generally including electromagnetic induction, Hall effect, direct optical sensing and magneto-resistance.

#### Recent Activity

Recent patent activity has generally focused on propagation techniques in the magnetic material. Emphasis has been placed on forming propagation channels suitable for stable movement of the magnetic domains. Patents issued since April 1972 include:

**3,889,246 – Propagation Register for Magnetic Domains** (Battarel, Techniques et Systemes Informatiques) – Discloses a new geometrical configuration of flat electrical conductors deposited on the same substrate as a polycrystalline layer. The electrodes are used for ensuring the propagation of magnetic domains, in a shift register operation, between an input division (write-in by nucleation) and an output division (reading).

**3,855,584 – Improved Register For Propagating Magnetic Domains** (Battarel et al, Techniques et Systemes Informatiques) – Discloses a shift register having a thin polycrystalline anisotropic magnetic film of low coercivity. The film has a ridge which is inclined 45° to the difficult axis of magnetization, has variations in slope between the two ends, and is formed by two separate zones of coercivity.

**3,846,770 – Serial Access Memory Using Magnetic Domains in Thin Film Strips** (Schwee et al, United States Navy) – Dis-

closes a polycrystalline thin film strip to store information in a serial manner in the form of reversal domains. The reversal domains are propagated along the thin film strip, which may be Permalloy, and then sensed to detect the stored digital information.

**3,806,900 – Multiplexing System for Thin Film Magnetic Propagation Channels** (Spain et al, Cambridge Memories, Inc.) – Discloses a magnetic device employing domain tip propagation in assemblies which include a number of shift registers within a single propagating drive coil. A high speed transfer in and out rate is achieved by employing multiplexing selector lines, one for each shift register within the coil, to select, within each period of drive propagation, each shift register channel in sequence for write in and read out.

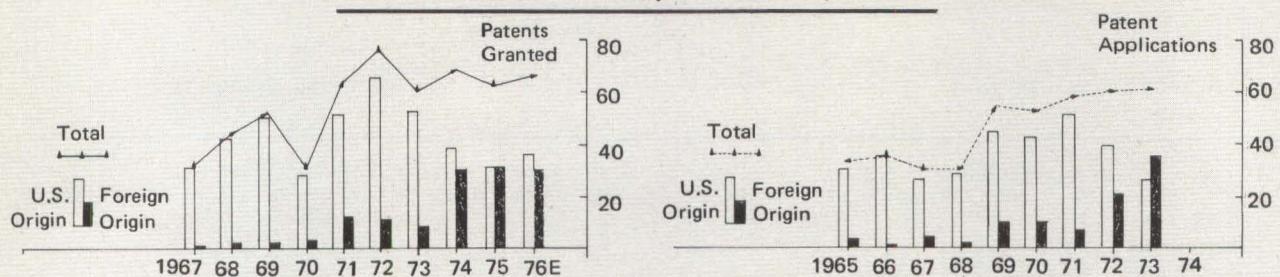
**3,786,449 – Magnetic Thin Film Shift Register Having Bidirectional Transmission Elements and Offset Block Sites** (Jauvtis, Cambridge Memories, Inc.) – Discloses a digital shift register propagating information as discrete regions of reverse magnetization. The shift register has a bidirectional transmission path and produces magnetic fields along the path. Domain-blocking fields are produced at sites along the path offset uniformly from the domain-holding locations by less than one-half the spacing between adjacent hold locations.

**3,739,358 – Shift Register Operating By Propagation of Domains in Thin Films of Magnetic Material** (Battarel, Techniques et Systemes Informatiques) – Discloses two zones of magnetic coercivity, the first zone extending along the axis of relatively difficult magnetization and being divided from the second zone on opposite sides by first and second boundaries in the form of regular saw teeth, with the second axis being displaced relative to the first by half the width of a saw tooth.

**3,656,126 – Bi-Directional Shift Register** – (Jauvtis, U.S. Air Force) – Discloses a magnetic domain punch-through diode shift register having a pair of vertical low coercive channels in a region of high coercivity. Dispersed in the channels are punch-through magnetic domain diodes which alternate with opposing polarities. A domain can be propagated in only one direction by applying a conducting pulse to a chosen diode at the same time as a drive pulse is applied.

# Patent Activity For CRT And Optical Memories

Table 9 Distribution of Optical Memory Patents



By Patent Grant Date

	1967	68	69	70	71	72	73	74	75	76E	Total
Total Patents	32	44	52	31	63	76	60	68	62	66	554
United Kingdom	31	42	50	28	51	65	51	38	31	36	424
Total Foreign	1	2	2	3	12	11	8	30	31	30	130
Japan	1	1	5	3	2	10	13	16			51
Germany	1	1	1	4	3	6	7	4			27
France			1	3	8	6	4				22
United Kingdom	1	2	3	1	3						10
Canada			1		1	2	2				6
Switzerland			1		1	2					2
Sweden				1	1	2					4
Netherlands						2					2
Italy						2					2

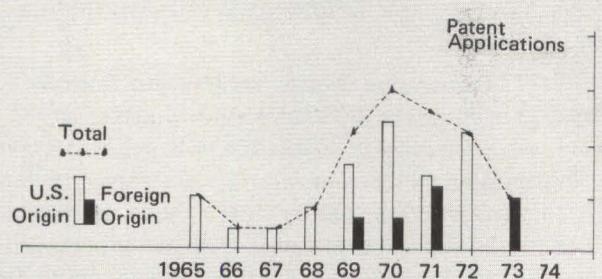
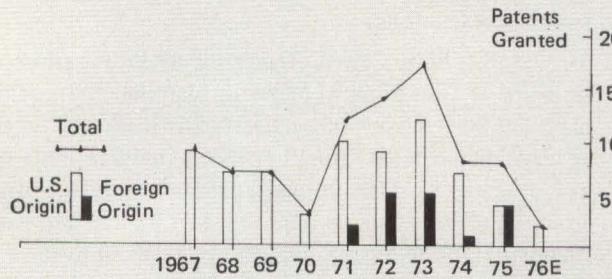
By Patent Application Filing Date

	1965	66	67	68	69	70	71	72	73	Total
Total	33	35	30	30	54	52	58	60	61	413
United Kingdom	30	34	26	28	44	42	51	39	26	320
Total Foreign	3	1	4	2	10	10	7	21	35	93
Japan	1	2	1	2	5	4	1	9	10	30
Germany	1	1	1	2	1	2	5	3	9	23
France			1	1	1	2		4	8	16
United Kingdom	2	1	2	2			2	1	10	
Canada	1						1	2	4	
Switzerland	1								1	2
Sweden									1	2
Netherlands									1	2
Italy									2	2

In the August 1977 issue of **Digital Design**, Benwill Technocast reported on charge coupled devices, core memory, semiconductor memory, cathode ray tube memory and optical memory. We inadvertently left these charts and tables out of that report. Table 9 details patent activity for optical memories. Optical memories include those memory systems in which laser beams are used to read or write information

from photosensitive films, semiconductors or ferroelectric materials. Table 10 details patent activity for cathode ray tube memories. CRT memories use photo-sensitive surfaces as a target upon which an electron beam reads and writes. For details of selected patents, see the August issue, available for \$3.00 (please send check) from Benwill Publishing, 167 Corey Road, Brookline, MA 02146. DD

Table 10 Distribution of CRT Memory Patents



By Patent Grant Date

	1967	68	69	70	71	72	73	74	75	76E	Total
Total Patents	9	7	7	3	12	14	17	8	8	2	87
United States	9	7	7	3	10	9	12	7	4	2	70
Total Foreign				2	5	5	1	4			17
Germany				3	3		1				7
France					1	3		4			4
Japan			1	1				2			2
Canada			1	1				2			2
Netherlands				1			1				1
United Kingdom				1			1				1

By Patent Application Filing Date

	1965	66	67	68	69	70	71	72	73	Total
Total	5	2	2	4	11	15	13	11	5	68
United States	5	2	2	4	8	12	7	11	5	51
Total Foreign				3	3	6			5	17
Germany				1	2	3			1	7
France							1		4	4
Japan				1	1				2	
Canada				1	1		1		1	
Netherlands					1				1	
United Kingdom				1			1		1	

# Using Microprocessor Development Systems

by Greg Miller

In the past few years, two powerful development tools for the digital designer have appeared. The first is the logic analyzer, covered in detail in this issue (see p. 55). The second tool, the microprocessor development system, has been introduced in response to the special development problems posed by microprocessor-based digital systems.

The logic analyzer, primarily a passive observational tool, does for digital domain information essentially what the oscilloscope has long done for time domain information. Using various display formats (timing diagram, state diagram, state map) the logic analyzer aids the designer in performing both logic state analysis and logic timing analysis. The former requires synchronous sampling of the digital information; the latter needs fast, asynchronous sampling. As opposed to microprocessor development systems, logic analyzers find application in all types of digital design, not just in the highly important area of microprocessor-based systems. It should be noted that logic analyzers can be sub-divided into two categories: general purpose types, which offer both state analysis and timing analysis, and those dedicated to microprocessor applications, usually offering state analysis only.

## Development Systems Are Not Logic Analyzers

Microprocessor development systems, while restricted in application to the design of microprocessor-based digital systems, do cover that area thoroughly. Unlike the logic analyzer, the development system plays an active, and in fact, interactive role in the design process. The flowchart in Fig 1 traces the parallel development of software and hardware for a microprocessor-based system and the all important step of integrating the two. The development system applies to all three parts of the design process.

On the software side, the designer enters source code programs into the development system via an input terminal. Fig 2 shows a block diagram of a universal microprocessor development system. After editing, the program is assembled into the object code of the new system's microprocessor. The program then runs under some form of debug control. Typically the user can step through the program one instruction at a time and print out the contents of registers internal to the microprocessor. Also, the user can change the contents of these registers.

Depending upon the development system employed, the

program run may use either a simulation or an emulation of the chosen microprocessor. Emulation (run on the actual microprocessor type) has an advantage over simulation (run on some other processor) in that it tests not only for pure software errors, but also for program-hardware interactions such as timing peculiarities of the specific microprocessor. Any detected program errors are corrected in source code; the program is then reassembled and rerun until no further errors are detected.

Some development systems include an in-prototype emulation capability. This entails a cable extending from the development system to the microprocessor socket of the hardware prototype. It allows the microprocessor and memory of the development system to emulate those of the hardware prototype. This in turn makes possible an orderly section-by-section check-out of the complete system when

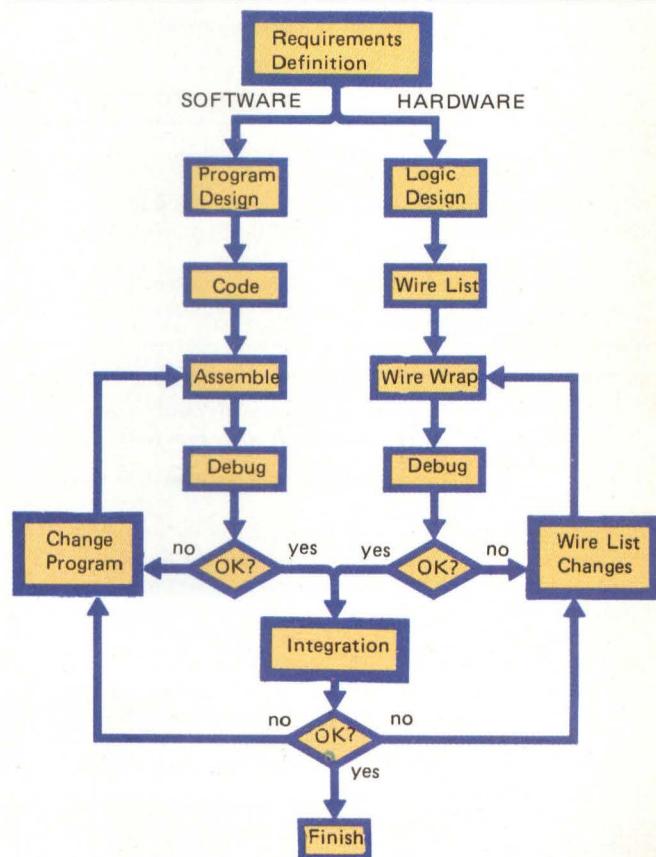


Fig 1 This flowchart shows the development of hardware and software in system design.

# digital design

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hardware and software are brought together. The in-prototype emulation cable also permits some basic testing of the hardware prototype even before software is completed. By writing some short routines, the designer can exercise the hardware to see if basic functions such as printer I/O are working at all.

### The Place of Microprocessor Development Systems and Logic Analyzers in the Design of Digital Systems

Micropocessor Development System Only	Joint Use	Logic Analyzer Only
Program entry and editing	Stimulus of prototype by development system and monitoring response of prototype with logic analyzer during hardware development phase.	Developing and checking out random logic (i.e., non-microprocessor-based) segments of prototype.
Program assembly	Debugging of program problems which result from hardware timing considerations.	Production or field testing of logic patterns against known good patterns.
Pure software debugging of program	Simultaneous monitoring of all microprocessor and all prototype I/O lines during checkout.	Logic timing analysis
Emulation of microprocessor and program memory		
PROM programming		

### Advances in Development Systems

Historically, microprocessor manufacturers have marketed development systems that support only one microprocessor type. Recently Tektronix brought out a universal development system, the 8002  $\mu$ P Lab; this system supports development when using one of several common microprocessor types.

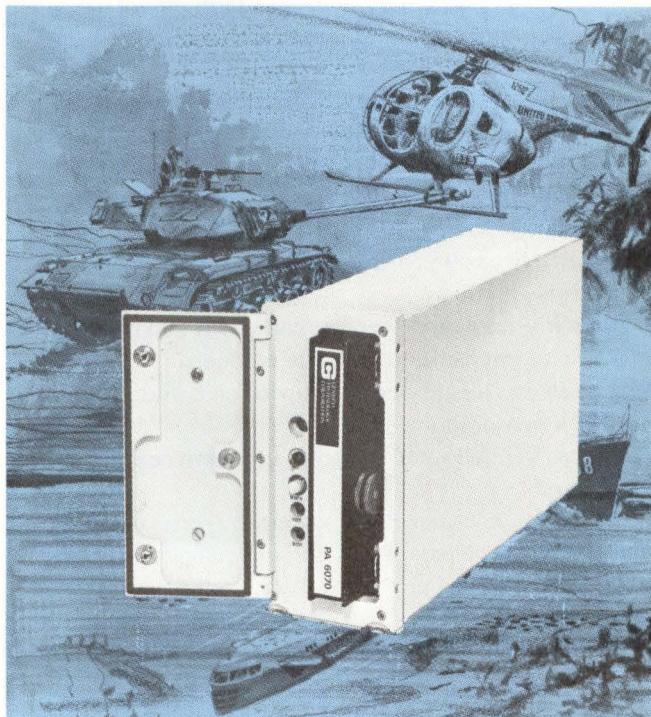
One significant advantage offered by this new development system is the addition of a feature termed "hardware trace." Software trace, the ability to single-step through programs looking at details such as internal register contents, was described earlier. While extremely useful, problems due to hardware phenomena may be overlooked when using software trace, since constant interrupts prevent the program from running in real time as it will in the final system. "Hardware trace" can be thought of as a partially dedicated logic state analyzer. The program runs in real time and 40 bits of information are recorded in a memory for each of the most current 128 sequential instructions. The 40 bit word includes 16 memory address lines and 16 data lines for the microprocessor plus 8 probes which the designer may use to look at whatever he chooses (I/O portion of his prototype, for example). The program runs in real time and interrupts only at established breakpoints representing an error or other condition of interest to the designer. Upon encountering a breakpoint, the program halts and memory contents are displayed on the development system's terminal. When a real time display is required, the breakpoint can trigger an oscilloscope.

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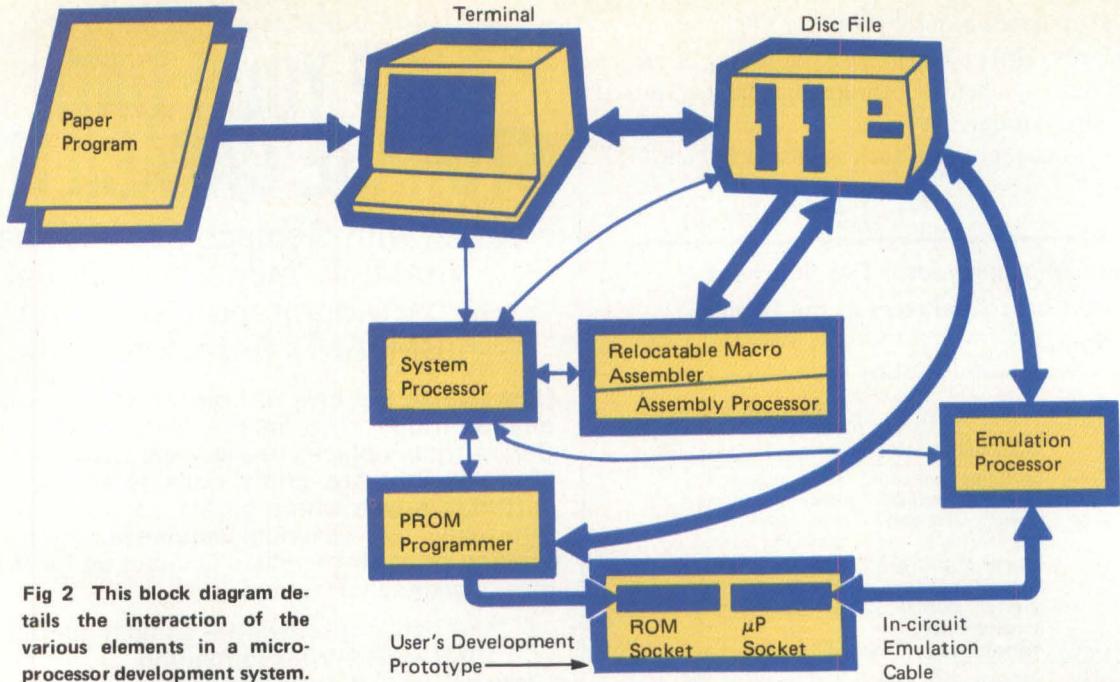
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**Fig 2** This block diagram details the interaction of the various elements in a microprocessor development system.

## Development Systems and Logic Analyzers Working Together

With attention to detail by the instrument manufacturer, microprocessor development systems and logic analyzers can work as a complementary pair to solve the problems posed by design of microprocessor based system. A microprocessor development system could include a complete

general purpose logic analyzer by expanding on the "hardware trace" concept. In general, however, it is probably advantageous to keep the two separate so that the designer can exercise the choice of when to use them on independent tasks. The table on p. 103 shows you when to use each instrument.

DD

*Greg Miller is with Tektronix Corp., Beaverton, OR.*

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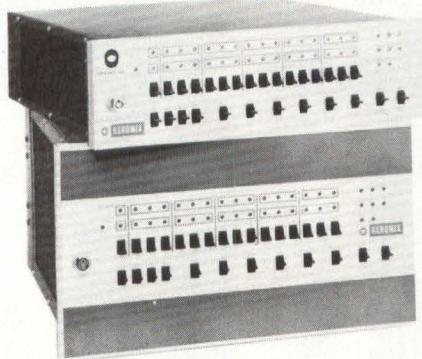
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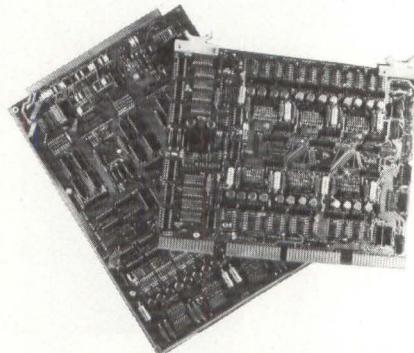


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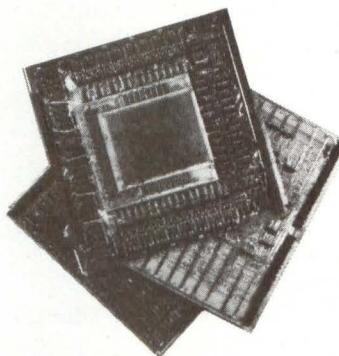
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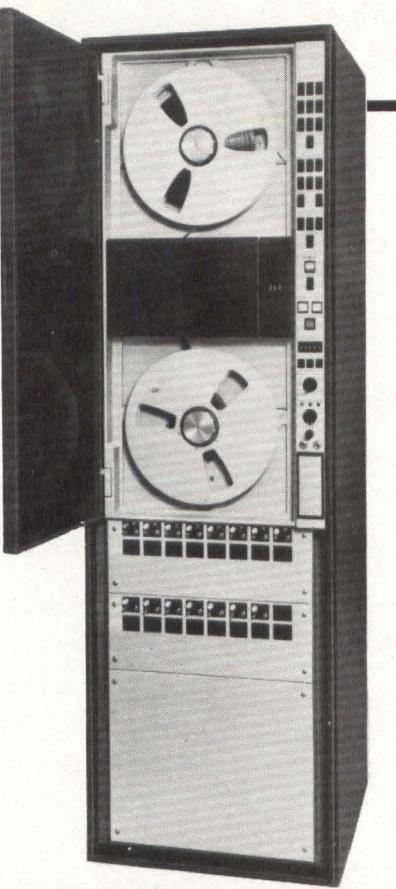
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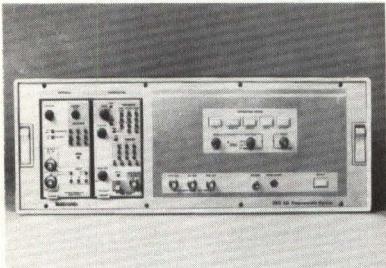
The Sabre X IRIG magnetic tape recorder/reproducer incorporates a programmable microprocessor, ten electrically selectable tape speeds and dual functioning channel electronics. The unit includes serial and/or parallel high density (HDR) electronics, tape lifting from the R/R heads during a slew mode, vacuum tape tensioning and modular design for immediate servicing access. The Sabre X operates at ten speeds from 240 thru 15/32 ips for record and reproduce. Each channel of electronics is dual functional for direct or FM process. Bandpass capabilities for each speed meet or exceed all IRIG requirements with bandpass capability extending to a 4 MHz at 240 ips for Wideband II. Sangamo Data Recorder Division, PO Box 3347, Springfield, IL 62714. (217) 544-6411.

Circle 157



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The TEKTRONIX 7912AD programmable waveform digitizer brings full programmability of operating parameters to what is said to be the world's fastest waveform digitizer. The 7912AD operates like an



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single-shot transients up to 500 MHz in its conventional operating mode and up to 1 GHz using direct access to the CRT deflection plates. Operation is fully programmable to 200 MHz. The digitizer uses scan conversion to capture single-shot transients. Equivalent writing rate of the instrument is 800 div/ $\mu$ s; acquired signals are digitized in 15 ms using a precise raster scanning approach. 512 points can be resolved on the horizontal axis within a time window as narrow as 5 ns; vertical resolution is also 512 points. Price is approximately \$22000 including programmable plugins. Tektronix Inc., P.O. Box 500, Beaverton, OR 97077. (503) 644-0161.

Circle 201

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A double-sided, single- or double-density "floppy" disk drive designed for the OEM market, the CDC 9406 flexible disk drive, provides unformatted storage capacity of 1.6 Mbytes of data using IBM compatible storage media. An enhanced version of the microprocessor-controlled

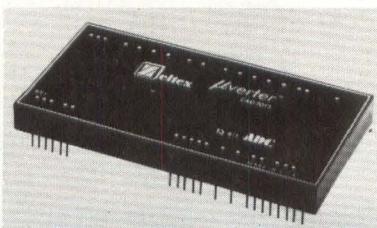
flexible disk subsystem, the CDC 9474, incorporates one or more of the double-sided drives, providing up to 6.4 Mbytes of unformatted data storage capacity in a four-drive configuration. Applications for the drive and subsystem include use with small business computer and intelligent terminal systems, dedicated minicomputer system installations, and in terminal, word processing and data entry subsystems.

The CDC 9406 double-sided drive operates with data formatting and timings resident in the host controller. A printed circuit board contains the drive electronics at the back of the drive chassis; the unit requires no electrical adjustment for either hard- or soft-sector operation. Access time is 6 ms track-to-track and recording density is 48 tpi and 3268/6536 bpi. The 9474 disk subsystem uses an Intel 8080 microprocessor to control the operations of up to four floppy drives. Single- and double-bit density, single- and double-sided units intermix on a subsystem to provide up to 6.4 Mbytes of data storage. The CDC 9474 quantity one price starts at \$2,600. Control Data Corp., Box O, Minneapolis, MN 55440. (612) 853-4656

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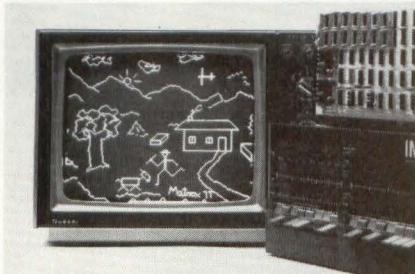
(+10V, +5V, 0 to 5V and 0 to 10V) and three output coding modes (unipolar binary, offset binary or 2's complement). Power required is less than 2.5 watts. Overall case dimensions are 2" x 4" x 0.4". Price: \$248.00 in 100 unit quantities. Zetex Inc., 940 Detroit Ave., Concord, CA 94518. (415) 686-6660.

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Circle 169

### GRAPHIC DISPLAY SYSTEM USES MODULAR DESIGN

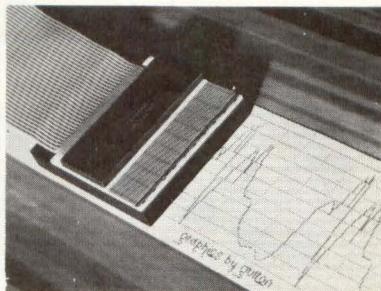
Using modular design so that special configuration requirements can be met, the GMR-26 graphic display system generates displays in a dot-matrix grid consisting of up to 512 horizontal television raster lines, with as many as 512 pixels along each line. Display entities may be positioned at any pixel location on this grid, and each pixel may be individually addressed and altered. Refresh memory channels store all alphanumeric, graphic and image data; these channels are periodically scanned to provide standard video output signals. Only 1.5  $\mu$ s are required to access any point on the display; 256x256 resolution 8-bit images can be written into refresh memory in less than 1/10 sec. Prices start at \$5450. Grinnell Systems, 2986 Scott Blvd., Santa Clara, CA 95050. (408) 988-2100. Circle 203

### DIGITAL PRESSURE TRANSDUCER SIMPLIFIES CONNECTIONS

The 8 bit output from this pressure transducer connects to the 8255 or the 6820 interfaces for 8080 or 6800 systems. Transducer outputs are unclocked and available for sampling at any rate defined by main program control. Power input is +5Vdc or 110Vac with pressures up to 30,000 psi available. Siltran Digital, PO Box 437, Silverado, CA 92676. (714) 649-2704. Circle 162

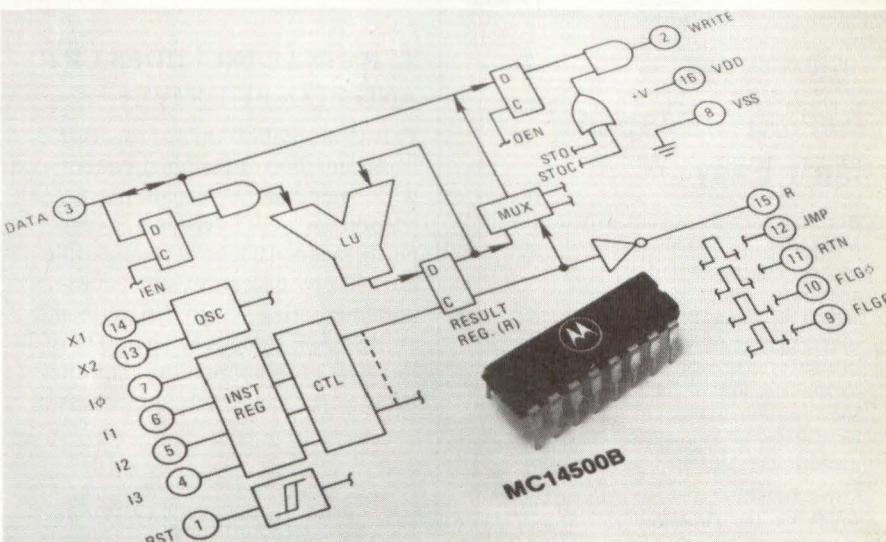
### PRINthead MIXES DATA FORMATS

The DM1099 and DM10101 thick film dot matrix thermal printheads permit simultaneous printing of analog, graphic and alphanumeric data. Each printhead contains a single continuous row of printing elements on a pitch of 50 points per inch.



Each dot is composed of two halves printing in parallel. The printing elements are organized into decades for multiplexed operation. Complete diode isolation of each element is provided on the printhead. The DM10101 has 101 dot elements where the 101st dot is for applications requiring both a zero and 100th data point. The DM1099 contains 99 dot elements to be used with the DM10101 for data expansion. Price: \$121.20 each, \$75.75 100-499 quantities. Gulton Industries Inc., 212 Durham Ave., Metuchen, NJ 08840. (201) 548-2800 X201.

Circle 148



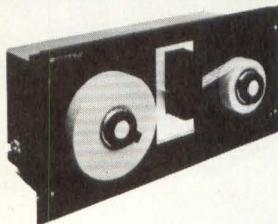
### DIGITAL PROCESSING: ONE BIT AT A TIME

A one-bit static CMOS processor, the MC14500B Industrial Control Unit (ICU), performs logical operations on data occurring on a one-bit bidirectional bus and on data in a one-bit accumulating result register within the ICU. The MC14500B operates with a 16-instruction set. ICU applications include traffic controllers, copier controllers, microprogram-control sequencers,

serial bit-stream communications and telephone dialing systems. The ICU incorporates an oscillator circuit on the chip, executes one instruction per clock cycle, operating from DC to 1.0 MHz. The four instruction inputs are TTL-compatible; the outputs can drive one Schottky load or two TTL loads. The circuit is offered in a 16 pin DIP. The 100-999 price is \$7.58. Motorola I.C. Division, 3501 Ed Bluestein Blvd., Austin, TX 78721. (512) 928-2600.

Circle 145

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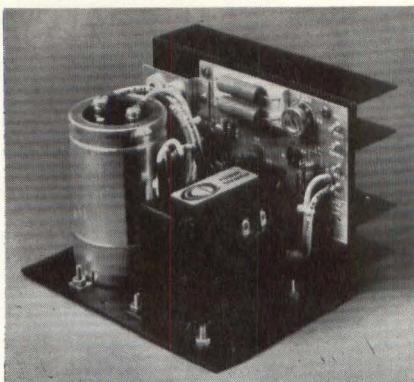
Electronics Marketing Services

CIRCLE 68

## PRODUCTS

### ARRAY PROCESSOR FITS LARGE COMPUTERS

The model AP-190L Array Processor interfaces to major mainframes such as IBM 370, UNIVAC 1100, CDC Cyber Series, and the PDP-10. A typical AP-190L increases the throughput of major mainframe systems by factors up to 20 times, yet sells for less than \$97k, including an extensive software development package and library of more than 150 routines. The AP-190L consists of fast registers, program source memory, data memory, floating-point adder and floating-point multiplier—all interconnected by seven parallel synchronous data buses. A fast (167 ns) instruction cycle and large (up to 1 million 38-bit words) floating-point data memory provides high throughput; thus increasing speed and the ability to conveniently handle batches of data. Floating Point Systems, P.O. Box 23489, Portland, OR 97223. (503) 641-3151. **Circle 204**

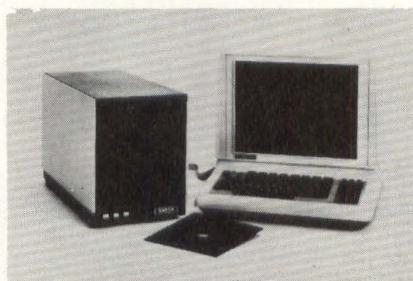


### POWER SUPPLY HAS FEWER COMPONENTS

The LN series 60 watt open frame power supply, designed for the OEM market, includes complete short circuit protection by automatic fold-back limitation, integrated circuit regulation, high MTBF, fewer components, all American made parts and the availability of a five year limited warranty. Price: \$61.00 each. Control and Computing Devices, 3130 Benton, Garland, TX 75042. (214) 272-6435. **Circle 177**

### TERMINAL INCLUDES CRT AND FLOPPY DRIVE

This Omron 8080 microprocessor-based, intelligent terminal system with "stand-alone" capability incorporates a CRT terminal, a high performance IBM 3740-compatible dual floppy disk subsystem, complete operating system software and an RS-232C interface. The 8035 offers user programmability; all functions of the system are under soft-



ware control. Dual-drive floppy disk subsystem for auxiliary data storage and generation of a program library provide up to 4 Mbytes of memory. In communication applications, the 8035 system operates up to 9600 baud. Price: \$7,200.00. B.J. Johnson & Associates, 2503 Eastbluff Dr., Suite 203, Newport Beach, CA 92660. (714) 644-6037. **Circle 166**

### $\mu$ P TO SCIENTIFIC CALCULATOR INTERFACE IN KIT

This interface board utilizes hardware for mathematical calculations, employing a scientific calculator circuit for use by 8080, Z-80, 6800 and other microprocessor systems. The interface, to a powerful scientific calculator chip, the 7529-103, makes basic and complex math functions possible with simple software. 1K of memory suffices for interpreter or compiler calculations usually requiring 8K to 16K. The board avails the user of the functions of a 40-key scientific calculator including trig functions, inverse trig, logarithms, anti-logarithms, exponentiation and factorials. Two versions of the board are available: the RM Series matches the Motorola Exerciser bus and adapts to an Intel SBC 80/10 system, another version has an S-100 standard bus. The power requirements using CMOS and 74LS IC's:  $\frac{1}{2}$ A at +5V and 30 MILS at +12V. Available in kit form at \$99.95. Mini Micro Mart, 1618 James St., Syracuse, NY 13204. (315) 422-4467. **Circle 146**

## ADD-IN MEMORY FITS LSI-11

The LS-IN-11, a semiconductor add-in memory for the DEC LSI-11 and PDP 11/03 microcomputers provides 8, 16, 24, or 32K of memory on a card, using 8K or 16K dynamic MOS N-channel chips. The LS-IN-11 uses a 2-wide connector which plugs into a single chassis slot position. Card size is 8.5" H x 5.187" W x .375" T. Memory segments are switch-selectable from 0-32K in 4K increments. Fabri-Tek Inc., 5901 South Country Rd. 18, Minneapolis, MN 55436. (612) 935-8811.

Circle 155

## CONTROL METERS HANDLE TO 4½ DIGITS

4100 Series process control meters are available in 3½, 3-3/4 and 4½ digit models, with analog input accommodating standard and special current or voltage loops. Differ-



ential input is standard with parallel, latched BCD output optional. The meters come in standard NEMA-sized cases and use either .6" LEDs or Beckman displays. Electro Numerics Inc., 1811 Reynolds St., Irvine, CA 92714. (714) 549-8821.

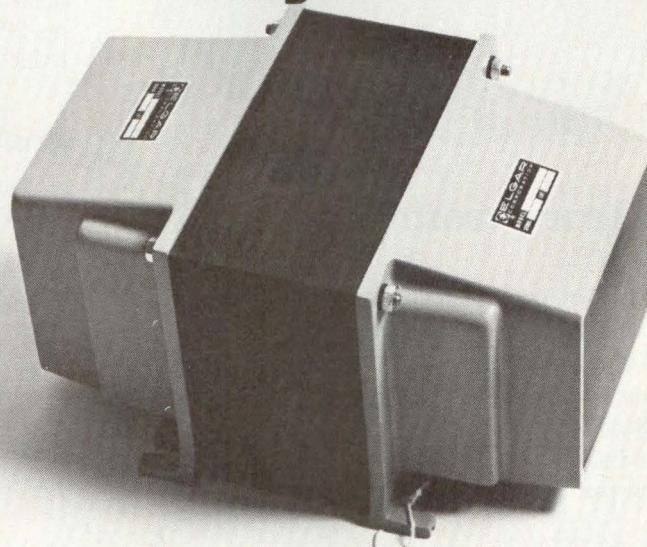
Circle 158

## RS-232C INTERFACE FOR SMS ROM SIMULATORS

RS-232C interface plugs into SMS ROM Simulator mainframe allowing direct connection to host computer. Reflected data is provided to users for software verification of transmitted data at user's option. Use of the same data/control format as paper tape reader allows existing software to be utilized with only modification of the output driver. Price: \$970. Analytx Electronic Systems Inc., 106 Daniel Webster Highway South, Nashua, NH 03060.

Circle 167

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# MODEL 612



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CIRCLE 70

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## PRODUCTS

### BINARY COUNTERS OPERATE FROM DC TO 600 MHZ

The SP8735B and SP8736B high speed counters with  $\frac{1}{8}$  circuits and binary outputs, operate from dc to 600 Mhz, respectively. Both devices accept input from 400 to 800 mV, gate to their maximum operating frequencies and dissipate 450 mW. Price: \$22.50 for the SP8735B, \$16.00 for the SP8736B. Plessey Semiconductors, 1641 Kaiser Ave., Irvine, CA 92714. (714) 540-9979.

Circle 150

### MODEM USERS CAN PURCHASE DAA'S

Modem users can now purchase Data Access Arrangements (DAA's) instead of renting them from the telephone company. The DAA's have been designed to meet or exceed the direct connect registration requirements of FCC Rule 68. Connecting to either the Bell type 97A Universal Data Jack (RJ41S) or the type 97B programmable data jack (RJ45S), the DAA includes a transmit level control circuit that continuously monitors the modem's output level. All circuitry mounts on a 6-3/8" x 13" p.c. board and the front end card-edge connector plugs into the chassis motherboard. The rear end of the PCB provides a hardwired connector cable, a plug-in connector and the line output indicator for each DAA channel. The hardwired connector provides the 8-pin data jack interface and the plug-in connector accepts the 9-pin modem interface cable. Price: VA851 single channel \$135, VA852 dual channel \$215. Vadic, 505 Middlefield Rd., Mountain View, CA 94043. (415) 965-1620.

Circle 147

### 16K ROM WITH PROGRAMMER FITS PDP-11

The RMP-116 combines an EPROM programming facility with a read-only memory on one PDP-11 small peripheral board. The system based upon Intel 2716 UV erasable PROM or its masked equivalent (2316) ROM, accommodates 16,384 16-bit words on each board. The system may be expanded to include a "solid-state software" library or data. 16 EPROMs load onto the board and program while in place: two independent addressing modes, direct and indirect, read from memory. RMP-116 costs \$895. Digital Pathways Inc., 4151 Middlefield Rd., Palo Alto, CA 94306. (415) 493-5544.

Circle 168

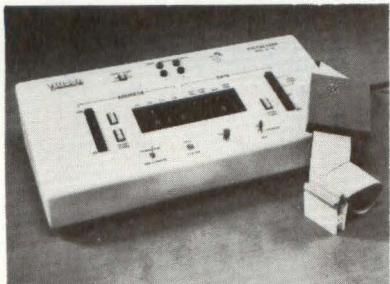
### BOOTSTRAP FOR DEC DISKETTE SYSTEM

A hardware bootstrap for the DSD 210 DEC compatible floppy disk system allows PDP-11 or LSI-11 users to load RT-11 from the diskette unit with a single command. The bootstrap instruction sequence is contained on a PROM, part of the DSD 210 interface. This saves the cost and backplane slot of the REV-11 board for LSI-11 users and it can reduce start-up time on the PDP-11. The controller, power supplies, and up to three diskette drives come packaged as a complete unit which can be used with LSI-11, PDP-11 or PDP-8 minicomputers simply by changing interfaces. DSD 210 price is \$1000. Data Systems Design Inc., 3130 Coronado Dr., Santa Clara, CA 95051. (408) 249-9353

Circle 172

## REALTIME MPU LOGIC ANALYZER

Yuccalyzer Model YA-20, a real time, non-interfering analyzer, comes equipped with probe and data display, using 8-bit data bus structured 6800 and 8080 type uP's. Up to 128 30-bit data words can be trapped and stored at any address, data or user input in the program.



YA-20's selective trapping permits "write only" selection and VMA selection for 6800  $\mu$ P's - DBI for 8080's. Instructions can be read a data word at a time (32 words back - 96 words ahead) on hexadecimal LED displays. Trigger can be generated by an address on the bus, by a selected data word, by any combination of address, data or external inputs, or by an external trigger. A clip-on probe for either 6800 or 8080  $\mu$ P's has a 10 megohm impedance. Yuccalyzer YA-20 cabinet measures 18" x 9" x 4", and runs on 115Vac. Price with probe is \$875. Yucca International Inc., 14415 North Scottsdale Rd., Scottsdale, AZ 85260. (602) 991-1491.

Circle 154

## SOLID-STATE MEMORY FITS PDP-8

The VM816 semiconductor memory system plugs directly into the DEC PDP-8 Omnibus chassis and packs up to 16K of memory per slot. The memory system is software compatible with all standard PDP-8 operating systems and comes in four models: 4K x 12, 8K x 12, 12K x 12, and 16K x 12. The 4096 x 1 NMOS STATIC RAM design uses 3.1A @ +5Vdc per 16K of memory. A field select DIP switch allows memory field assignment for each 4K increment. Computer Extension Systems Inc., 17311 El Camino Real, #176, Houston, TX 77058. (713) 488-8830.

Circle 165

## The Perfect Cover-Up!!!

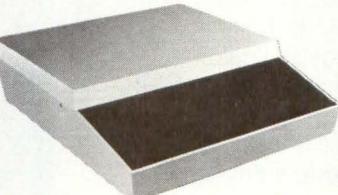
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CIRCLE 72

## PRODUCTS

### LED INDICATORS MOUNT ON PC BOARDS

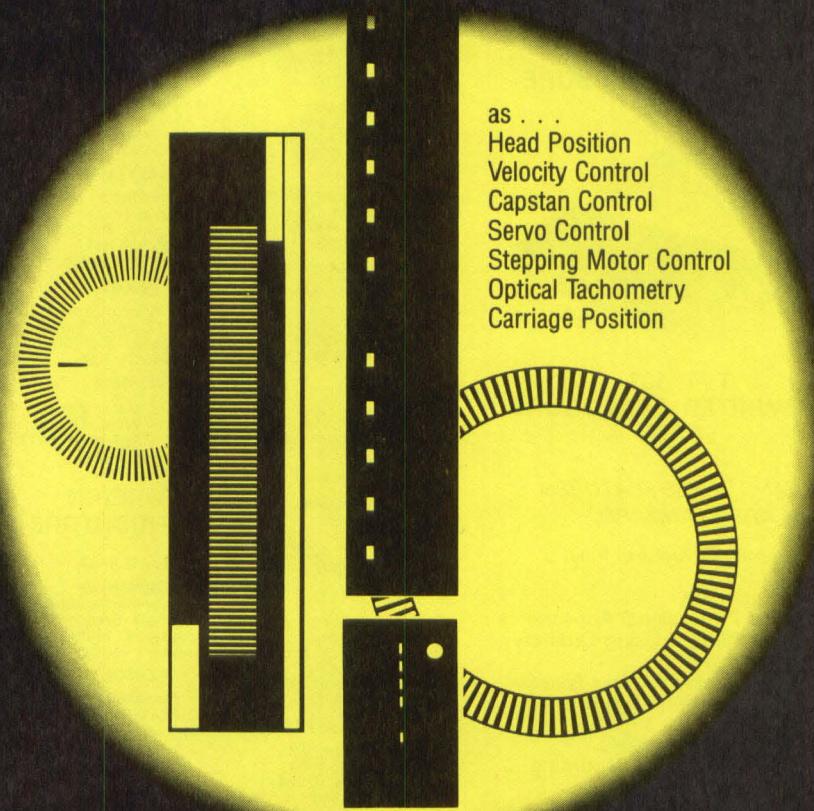
These light emitting diodes for logic state and fault indication in black plastic packages mount on printed circuit boards. The 547 and 555 Series indicators can be driven directly from TTL and DTL logic circuits. Standard ratings range from 3 to 20mA and 3.6 to 14Vdc. Less than

0.1" W x 0.3" H, these units mount as closely as ten per inch for logic state and fault indication, binary data display and similar applications. The 550 Series for PC or panel mounting come in a package configuration nominally 0.25 x 0.25 x 0.36 in., with or without an integral resistor. Prices start at \$0.39. Dialight, 203 Harrison Pl., Brooklyn, NY 11237.

Circle 156

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The 263A Wire Line Modem transmits and receives digital data over a non-loaded metallic loop at rates of 2.4, 4.8, 9.6 or 56 Kbps. It operates in a full-duplex or half-duplex



mode with 4-wire loops and in a simplex mode with 2-wire loops. 2.4, 4.8, and 9.6 Kbps arrangements conform to EIA interface specifications RS-232-C and RS-334. For the 56 Kbps unit, clock and data signals meet CCITT Recommendation V.35, with control signals conforming to RS-232-C. The unit's internal clock provides transmitter signal element timing. A buffer allows received data to be clocked out into synchronous networks for data multiplex applications. The wire line modem is equipped with automatic line build-out facilities with an equalization range of 0 to -34 dB. Extensive built-in test functions include remote loopback, digital loopback and analog loopback. GTE Lenkurt Inc., 1105 County Rd., San Carlos, CA 94070. (415) 591-8461.

Circle 174

### THREE MICROCOMPUTER BOARDS EXPAND CAPABILITIES

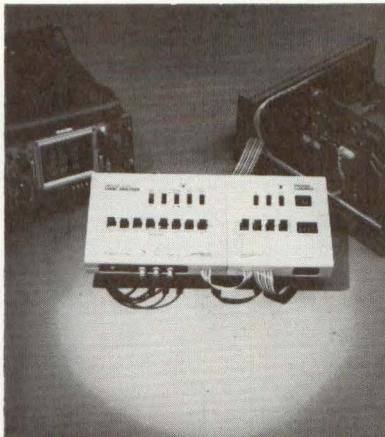
The Z80-VDB video display board, with 256 bytes of dynamic RAM for line buffering to the MCB, interfaces the Z80-MCB directly to TTL horizontal, vertical and video drives of a standard TV monitor. Providing programmable control of up to 64 I/O lines, the Z80-IOB includes four Z80-PIO parallel interface controllers. The Z80-SIB Serial I/O board with two onboard Z80-CRT programmable timers provides eight serial (four full duplex) channels, each capable of synchronous or asynchronous data transmission including Bi-Sync protocol. Prices: Z80-VCB \$475, Z80-IOB \$350, Z80-SIB \$375. Zilog, 10460 Bubb Rd., Cupertino, CA 95014. (408) 446-4666.

Circle 160

## CHARACTER GENERATOR DRAWS SPACE SHIPS

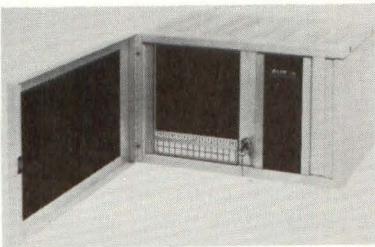
This programmable character generator for S-100 bus computers adds the ability to dynamically create the characters generated by a video display device. For those who require special mathematical or scientific symbols such as APL characters, sub- and superscripts, high density bar graphs, Greek letters or game characters such as space ships, the device creates and stores new characters while the original character set remains intact and available for use. Keyboard interface and dual joystick interfaces are provided on the board. Objective Design Inc., P.O. Box 20325, Tallahassee, FL 32304.

**Circle 170**



## RATECHANGER CONNECTS DDS TO ANALOG CIRCUITS

The 50/56 Kbit Ratechanger permits tandem interconnection of DDS circuits operating at 56K bits per second and analog wideband circuits operating at 50K bits per second with Bell 303 modems or equiv-



alent. The same hardware used in the Ratechanger permits rate changing between any two of the commonly used wideband data transmission speeds (i.e. 40.8, 48, 50, 56 Kbps). Price: in pairs, \$2040 per end. Micom Systems Inc., 9551 Irondale Ave., Chatsworth, CA 91311. (213) 882-6890.

**Circle 152**

## EXPANDER CREATES 16 BIT ANALYZER PACKAGE

The Model 10 Trigger Expander mates with the 8-bit Paratronics Model 100A to form an integrated 24 bit logic analyzer package for microprocessor troubleshooting training and system development applications, or functions stand-alone as a 16-bit "word recognizer," providing a programmable sync pulse for

scope triggering at (or delayed from) the occurrence of a particular machine state. Besides expanding the triggering capability of the Model 100A from 8 bits to 24 bits, the Model 10 utilizes a multiplexing scheme which permits an 8-bit x 16-word deep truth table display of the microprocessor's data byte. Paratronics Inc., 800 Charcot Ave., San Jose, CA 95131. (408) 263-2252.

**Circle 138**

## INEXPENSIVE PANEL METERS RUNS DC OR AC

The Series B500 contains one IC, 7 passive components and the display. The bipolar differential unit is auto-zeroing and accepts 200mV to 1000V input; it operates from either 5Vdc or 115/230Vac, 47-400Hz, and consumes 200 to 800 mW. The display is .5" high L.E.D. red. Price: \$59 each; \$39 in 100 quantities. International Microtronics Corp., 4016 E. Tennessee St., Tucson, AZ 85714. (602) 748-7900.

**Circle 159**

## 8-CHANNEL MULTIPLEXER INTERFACES DG MINIS

A multiport communications interface for Data General and Data General emulating minicomputers is available in either a four or eight channel configuration. Each board has all necessary control logic on a single 15" by 15" printed circuit board that inserts into the minicomputer. Data format and baud rate are jumper selectable on an individual channel basis. Prices start at \$1250. Custom Systems Inc., 2415 Annapolis La., Minneapolis, MN 55441. (612) 553-1112.

**Circle 133**

# RK-II/RK-05 MEDIA CARTRIDGE fully DEC compatible

The AED 2200 hard disk subsystem offers complete compatibility with all RK-11/RK-05, and associated DEC software. Plugging directly onto the PDP-11 Unibus®, the 2200 Controller can handle up to 4 drives, providing 4,915,200 16-bit words of economical storage. The AED 2200 subsystem is supplied with Diablo Series 30 or similar type disk drives, and is available immediately on a 30-60 day delivery basis. Check our competitive prices below.



### Compare these features

- Direct substitute for RK-11/RK-05 System
- Complete DEC media/software compatibility
- A 2-drive power supply is included with controller
- Complete with Unibus® and controller-to-drive cables

® Reg. Trademark of Digital Equipment Corp.

### Compare these prices

- Quantity 11 with 1 drive (2.5 Mbytes): \$7,255  
Quantity 11 with 1 drive (5.0 Mbytes): \$8,110  
Quantity 11 with 2 drives (10 Mbytes): \$13,060  
Quantity 11 with 4 drives (20 Mbytes): \$22,960

### Advanced Electronics Design

P.O. Box 61779, Sunnyvale, California 94088  
Telex: 357 498 Cable: Disksystem

call  
**Disk City**  
PHONE 408-733-3555

## PRODUCTS

### DRIVERS WORK WITH CORE, BUBBLE MEMORIES

Two quadruple memory driver ICs have TTL compatible logic inputs and are designed for use with core and bubble memories. The SN75328 and SN75330 each contain four 600mA memory drivers and operate from two power supplies — one of 5V, the other from 4.75 to 24 V.

The SN75328 driver comes in 16-pin, dual-in-line plastic or ceramic packages; the SN75330 driver comes in 20-pin, dual-in-line plastic package. Prices in quantities of 100: SN75328, \$2.47 plastic; \$3.20 ceramic; SN75330, \$3.20 plastic. Texas Instruments, P.O. Box 5012, Dallas, TX 75222. (214) 238-2481.

Circle 130

# RESPONSYN® fine angle stepping motors

- Excellent Position Control
- High Transient Performance
- Low System Cost

**Fine Step Angle** — RESPONSYN motors are fine-angle, high-resolution stepping motors. They offer step angles from 0.75° to 0.18° and resolution from 480 to 2000 steps per revolution.

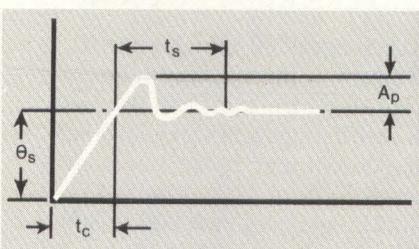
**High Accuracy** — RESPONSYN design ensures accurate stepping via a positive spline coupling between stator and rotor. For example, the HDM 155 motor's maximum one-step error is ±4 arc minutes, non-accumulative.

**Low Overshoot** — The RESPONSYN motor has a single-step crossover time on the order of one millisecond and an overshoot of approximately 40% of one step. Consequently, the RESPONSYN motor rapidly positions a load in a corridor only a few arc minutes wide.

**Excellent Settling Time** — The short settling time of RESPONSYN motors, as little as three or four milliseconds, makes them well suited to critical applications. Fast settling as well as low overshoot are accomplished without elaborate and expensive electronic drives.

**High Start/Stop Rate** — RESPONSYN motors handle load inertia at high start/stop rates.

**Low System Cost** — RESPONSYN performance and efficient design result in lower total system costs. RESPONSYN motors eliminate the added expense of sophisticated electronic drives, gearing, and damping devices.



#### Transient Characteristics

Typical values for the HDM-155-800-4 RESPONSYN® motor are:

Crossover Time (tc)	—	1.2 milliseconds
Settling Time (ts)	—	6.3 milliseconds
Overshoot (Ap)	—	40 percent
Step Angle (θs)	—	.45 degree



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### Harmonic Drive Division

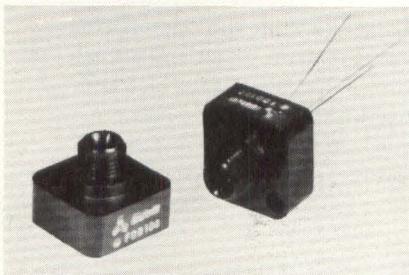
51 Armory Street, Wakefield, Massachusetts 01880  
Tel: (617) 245-7802 TWX 710-348-0586 Telex 94-9442

### USM Corporation

CIRCLE 75

### RECEIVER USES FIBER OPTICS TECHNOLOGY

Designed for optical communications and data transmission, light collection efficiency is optimized with maximum operating bandwidth with the FOD-100 fiber optics receiver. It has a fiber interface, a receiver area of 5.1 mm<sup>2</sup>, a responsivity greater than 0.65 amperes/watt at 904 nanometers, a spectral range of 350-1100 nm and a rise time (10-



90%) of less than 1 ns. EG&G Inc., 35 Congress St., Salem, MA 01970. (617) 745-3200.

Circle 137

### D/A CONVERTER COMES PACKAGED IN DIP

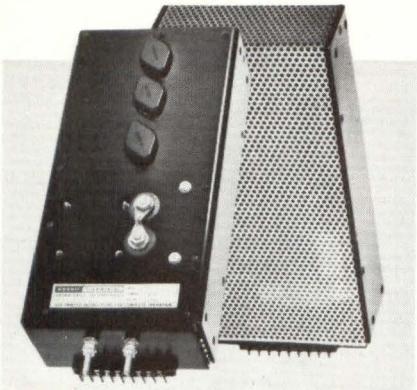
The MN3310 16 Bit Digital to Analog Converter has guaranteed monotonicity better than 14 bits over 0 to +70°C operating temperature range. The MN3310 consumes 420 mW of power, has a 35 μSec setting time and is packaged in a hermetic, 24 pin, dual-in-line package. Typical applications for these converters include precision servo and control systems, high accuracy instrumentation, non-linear function generation and microprocessor system applications. Micro Networks, 324 Clark St., Worcester, MA 01606. (617) 852-5400.

Circle 131

### CASSETTE STORES DATA USING AUDIO RECORDERS

The LT-4800 tape cassette, specifically made for digital data storage with audio recorders, contains 150 ft. of tape in a digital-quality cassette enclosure, but has the linear response and high output of top-grade audio tape. Price: \$3.00 each in quantities of 100-up. Digital Laboratories, 600 Pleasant St., Watertown, MA 02172. (617) 924-1680.

Circle 136



### POWER MODULE RUNS AT 80% EFFICIENCY

The DC100 series of high efficiency switching regulated power modules designed specifically for computer and computer peripheral applications in the telecommunications and interconnect industries, run on 41 to 52Vdc. Three units are available with outputs of 5Vdc, ± 12Vdc and ± 15Vdc with total power of 100 watts. Line and load regulation is less than 0.5% and peak-to-peak ripple less than 100mV. The power modules include overvoltage protection, short circuit protection, over-temperature shut-down and remote error sensing. Measured efficiency is as high as 80%, and they come packaged in a case 5.5" x 10.5" x 2.5". Price: \$325 each. Abbott Transistor Laboratories Inc., 5200 W. Jefferson Blvd., Los Angeles, CA 90016. (213) 936-8185. **Circle 175**

### TERMINAL CONTROLLER PLUGS INTO PDP-11

A plug-in controller that enables the PDP-11 to serve as the intelligence for up to 32 remote CRT stations includes two-monitor capability and a video/data multiplexer allowing keyboard, printer and TV monitor to share a single coax wire. Applications are seen in areas such as banking, text editing and data entry. The CVD-11 consists of a controller card that plugs into a hex slot and two small remote interfaces. The controller card contains all the electronics to support two remote CRT stations, including independent display memories, character generators, TV sync generator, and Uniibus® interface. The CRT display is 1920 characters in an 80x24 format. The printer interface is capable of

driving commonly available serial-input character printers at 30 characters per second. Echolab Inc., 213 Middlesex Tpke., Burlington, MA 01803. (617) 273-1512. **Circle 132**

### COMMUNICATIONS INTERFACE SERVES μP BASED EQUIPMENT

Designed for 8-bit microprocessor serial communications, the 2651 PCI MOS/LSI circuit combines the functions of a Universal Synchronous/Asynchronous Receiver/Transmitter (USART) with those of a baud rate generator in a single 28-pin, dual-in-line package. Capabilities of the 2651 include modem control, support of IBM's BISYNC protocol, asynchronous echo mode and local and remote self-testing. Independent double-buffered transmitter and receiver sections permit either half or full-duplex operation. The internal baud rate generator provides 16 different program-selectable baud rates, ranging from 50 to 19.2 Kbits per second, for the transmit and receive clocks. Price is \$13.70 in 100 quantities. Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086. (408) 739-7700. **Circle 135**

### CRT TERMINAL INCLUDES MK 3870 MICROCOMPUTER

A CRT terminal built around the MK 3870 single-chip microcomputer, the video adaptor board (VAB-2) forms a complete video terminal when connected to an ASCII keyboard and video monitor. The board offers a screen format of 16 lines of 64 characters (5 x 8 dot matrix), and a ROM character generator for 96 alpha numerics and symbols including lower case letters. Output is EIA composite video; data rates of both 110 and 300 baud are supported with either 20mA current loop or RS-232 interface compatibility. The board fits standard ASCII keyboards (14" x 5") and operates from 5.0Vdc on board power supply. The complete board is priced at \$195. Mostek, 1215 W. Crosby Rd., Carrollton, TX 75006. (214) 242-0444. **Circle 129**

# 8-BIG DISK, 4-CPU μCONTROLLER for DEC/DGC software

The new AED 8000 mass storage system with micro-programmable controller can be completely integrated into your DEC or Data General system. You can now enjoy patch-free use of any OS changes generated by the mainframe manufacturer, because AED's emulation capability ensures continuous compatibility to standard software. Add to this AED 8000's unique ability to serve up to 4 CPUs per controller at the same time, its built-in Error Correction System, and a multiple-register scroll that displays mainframe register information plus valuable diagnostic data, and you'll see why the AED 8000 is way ahead of the competition. AED's field-proven reliability and fast 45-60 day delivery make the AED 8000 mass storage system a serious contender for your disk dollars.



### Compare these features

	AED 8000	DEC DGC
Megabytes per drive	67.4→250	40 92
No. of drives per controller	1→8	8 4
Megabytes per controller	540→2,000	320 368
No. of CPU's per controller	4	1 2
16-bit transfer rate	1.6 μs	8.4 μs 2.5 μs
16-bit buffer	256	6 8
Error Correction Code	by controller	none
Bootstrap	IPL in controller	CPU ROM
Micro-processor	40 ns. 24 bits	none
• Emulates DEC/DGC controller	yes	—
• Macro Instruction Code	yes	none
• Data Scanning & Management	in controller	in CPU
• Variable Sector Length	yes	none
• CPU to CPU transfers	bypass the disk	none via disk

Price: Quantity 1 \$20,250 incl. 67.4 Mbyte drive

 Advanced Electronics Design  
P.O. Box 61779, Sunnyvale, California 94088  
Telex: 357 498 Cable: Disksystem

call  
**Disk City**  
PHONE 408/733-3555

## PRODUCTS

### SPROM INCLUDES POWER-SWITCH CIRCUITRY

The SPROM, a bipolar PROM with built-in power-switch circuitry, fits directly into existing designs without wiring changes and programs with conventional equipment and an adaptor card. Both 256 x 4 and 512 x 4 SPROM's come in either open-collector or tri-state configura-

tions using standard industry pin-outs. Prom power switching allows memory banks not in use to be switched off, for energy savings of up to 90% in open-collector versions and 75% in tri-state versions. A commercial version accesses in 70 ns max. 100-up quantity prices start at \$4.25. Raytheon Semiconductor, 350 Ellis St., Mountain View, CA 94040. (415) 968-9211. Circle 171

## Put A Fixed-Head Disc Where Your RK05 Is...

**Now there's an economical alternative for PDP-11 users who feel restricted by RK05, RF11 or RC11 data storage. With our DC-111 Controller you can reduce access time, while getting fixed-head performance and reliability—all for less than \$8,000.**

Installation of the DC-111 Controller is simple. Packaged on three DEC-type "quad" boards, it can be installed as a sub-chassis in the CPU—or be ordered with its own separate chassis.

The DC-111 is transparent to RSX-11 or DOS software, and is unibus-compatible. When used as an RK05 system, it's the only controller available that makes the fixed-head disc "look" like the RK11/RK05 disc system to the CPU. This means you can bootstrap directly from our Model 980 fixed-head disc, just as with an RK05. Similarly, when replacing RF11 or RC11 systems, the DC-111 fixed-head disc system is fully transparent to the DEC fixed-head software.

With an 8.5-ms average access time at transfer rates up to 8.4 Mbits/sec, the fast Model 980 system features our interchangeable Disc Cell™—a unique fixed-

head disc cartridge containing spindle, Winchester-type media, and read/write head assemblies. The Model 980 provides storage from 0.5 to 4.0 Mbytes, (larger capacities by daisy chaining).

We make a fixed-head disc controller for Data General users, too. Transparent to RDOS software, our DC-100 Controller slides into a circuit board slot in the CPU for quick and easy installation.

Seismic, Process Control, POS, Data Processing—whatever application you have in mind, you can count on us for fixed-head storage systems that are priced commercially, but built to meet military environmental specifications. For prices and technical details on any of our products, circle the R.S. number or call us at (408) 732-7070 in the West, (516) 487-2232 in the East.

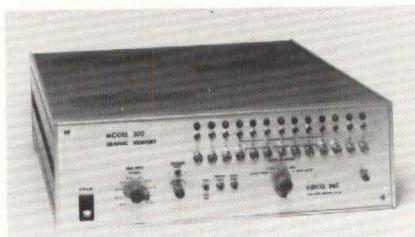


**DATAFLUX**  
1050 Stewart Dr., Sunnyvale, CA 94086

CIRCLE 77

### DIGITAL SCAN CONVERTER INCORPORATES MOS MEMORY

A solid state graphic memory providing digital storage and multi-channel display capability, the Model 300 YT Graphic Memory accepts analog signals, converts them to digital form and stores them in MOS memory for continuous television display or video recording. This model accepts up to thirteen inputs simultaneously, plots signals against an internal time base and permits selection of one or any combination of

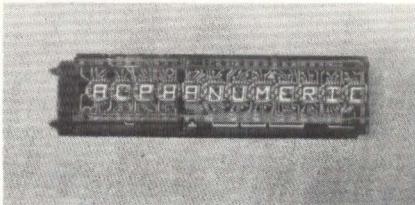


the thirteen inputs for immediate display via front panel switches. The Model 300 YT Graphic Memory is expected to have broad use in the medical, research and scientific fields. Video Inc., P.O. Box 25452, Portland, OR 97225. (503) 292-4104.

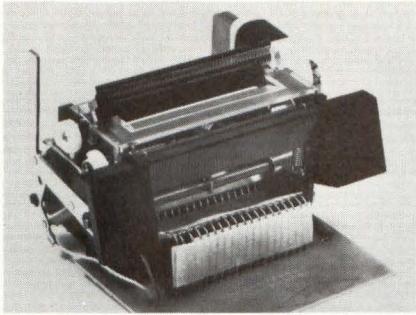
Circle 140

### FIRST 16-SEGMENT DISPLAYS OFFERED BY HEWLETT-PACKARD

HDSP-6504 and HDSP-6508 four-and eight-character light-emitting-diode (LED) alphanumeric displays have a 16-segment font plus centered decimal point and colon and offer complete 64 character ASCII set capability. The red LEDs are magnified by an internal lens that enhances character intensity while



keeping power use at a minimum. Price: \$19.00 each for HDSP-6504 and \$38.00 each for HDSP-6508 in 100 quantities. Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. Circle 139



### THERMAL PRINthead HAS 14 COLUMN CAPACITY

A 14 column 5 x 7 matrix alphanumeric thermo printhead, the Facit 4506 can be readily incorporated into calculators, cash registers, measuring or data logging systems. The 4506 has a 14 column capacity, character spacing of 3.1 mm, line spacing of 4.5 mm and a printing speed of 2 lines per second. The unit uses the thermal principle for printing on temperature sensitive paper. The only moving part is the line-feed solenoid. Facit-Addo Inc., 66 Field Point Rd., Greenwich, CT 06830. (203) 622-9150.

Circle 141

### 16K STATIC RAM BOARD AVAILABLE IN KIT

The MB-7 16K static RAM board allows for system expansion beyond 64K, operates on low power and is fully-buffered. Automatic memory unprotect and protect features allow users to protect memory in 4K block segments with automatic unprotect at power-on. Price is \$525.00 in kit form and \$625.00 fully-assembled and tested. Solid State Music, 2102A Walsh Ave., Santa Clara, CA 95050. (408) 246-2707.

Circle 126

### INTERFACE HAS SELECTABLE BAUD RATE

The 2031 Series asynchronous line interfaces interface a CRT or Teletype® at any baud rate using a single interface card. Baud rates, address selection and operating mode are all DIP switch selectable. EIA Voltage level or current loop are selectable with a cable connector. The

Model 2031-01 replaces DECTM Models DL11-A and C 20 mA current loop operation only. Baud rates vary from 75 to 9600. Price: Model 2031-01 is \$525, Model 2031-02 is \$575. Gen/Comp Inc., 6 Algonquin Rd., Canton, MA 02021. (617) 828-2008. Circle 163

### MONOCHIP DESIGN KIT

This IC design kit, the MO-K, contains the information necessary to design linear or digital custom circuits. The kit contains a 212-page handbook with sections on component parameters, computer analysis, pre-designed functional blocks, IC layout and chip selection. As an introduction, the kit contains an audio cassette with a 30-minute overview of IC design. The kit also contains 20 dual-in-line kit parts for breadboarding and several design tools. Price: \$59. Interdesign Inc., 1255 Reamwood Ave., Sunnyvale, CA 94086. (408) 734-8666.

Circle 173

# IRIS

The foremost business operating system for NOVA\* type minicomputers

*New Features: BUFFER POOLING  
PARTITIONING*



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1682 Langley Ave. • Irvine, California 92714 • (714) 556-4242

## PRODUCTS

### PROGRAMMABLE SONIC DIGITIZER PERFORMS MATH FUNCTIONS

The Model NT-503 programmable sonic digitizer performs mathematical functions which previously required hand calculation or external data processing equipment. The unit incorporates a GP-3 bus allowing any Graf/Pen™ GP-3 interface to

be used with it. Model NT-503 requires two point sensors above the work area, allowing interaction with a variety of inputs, such as CRT or plasma displays, projected images and maps or drawings on drafting tables. Price: \$5,500. Science Accessories Corp., 970 Kings Highway West, Southport, CT 06490. (203) 225-1526.

Circle 127

### MODEL 1900 LSI-11 TO UNIBUS TRANSLATOR

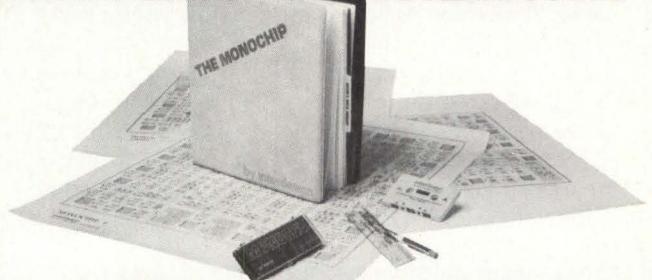
The Model 1900 bus translator allows LSI-11 peripherals to operate with a Unibus CPU (any of the PDP-11 series). The Model 1900 inserts directly into the Unibus; it consists of a quad size board (8½" x 10") that plugs into the C-D-E-F positions of any of the four slots of a DEC DD11A system unit. Adac Corp., 15 Cummings Park, Woburn, MA 01801. (617) 935-6668. Circle 144

### SWITCHING SUPPLIES SERVE COMMUNICATION APPLICATIONS

Designed specifically for computer and computer peripheral applications in the telecommunications and interconnect industries, the DC50 series of switching regulated power supplies are available with outputs of 5Vdc, ±12Vdc and ±15Vdc with total power of 50 watts. Line and load regulation is less than 5% and peak-to-peak ripple is less than 100mV. Other devices in this line include 100 and 150 watt units. Package size is 5.5" x 9.4" x 2.0". Price: \$310. Abbott Transistor Laboratories, 5200 W. Jackson Blvd., Los Angeles, CA 90016. (213) 936-8185.

Circle 142

### WHAT COSTS \$59 AND MAKES YOU A COLLEAGUE OF THE FINEST I.C. DESIGNERS IN AMERICA?



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The Monochip Design Kit has become a vital tool for progressive electronic engineers. It teaches you fast and easy ways to convert discrete digital or linear circuits to economical, high reliability IC's.

For \$59, you receive an easy to follow design text, more than 100 predesigned circuits, a set of breadboard parts, and a variety of handy design tools. It's everything you need to design your own sophisticated IC.

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**interdesign**

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### MICROCOMPUTER BASED VIDEO TERMINAL BOARD FITS S-100

A video terminal board, designed around the Mostek 3870 microcomputer, fits S-100 systems, but also stands alone. The SCT-100 includes both ASCII and BAUDOT serial interfaces, full X-Y cursor control (both absolute and relative), screen clear, clear to end of line, page mode and autoscroll, 96 displayable characters, 16 line by 64 character display and multiple baud rates up to 300 baud ASCII. In S-100 systems the SCT-100 may be powered from the unregulated +7 Vdc bus. Stand-alone, the board runs directly from an external 6.3Vac, 1.0A transformer. The board is available as a kit or fully assembled. Vectron, P.O. Box #20887, Dallas, TX 75220. (214) 350-5291. Circle 151

## CONVERTERS HAVE 8 BIT RESOLUTION

The ADC541 Series analog-to-digital converters include 8 bit resolution with 10  $\mu$ s conversion time using 700 mW from standard  $\pm 15V$  and +5Vdc power supplies. All models come sealed in a 24-pin DIP package with a thin-film DAC, clock, comparator, reference and register. All models pin-connect externally for 3 unipolar and 3 bipolar input ranges. Output coding in the bipolar mode is user selectable as either offset binary or 2's complement codes. Applications include data transmission, transducer digitizing and infinite sample and holds. Price each: ADC541-8 \$107.00; ADC541C-8 \$114.00; ADC541B-8 \$124.00. Hybrid Systems Corp., Crosby Dr., Bedford, MA 01730. (617) 275-1570.

Circle 149

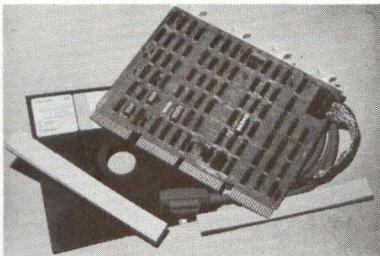
## SINGLE BOARD HOLDS DIGITAL AND ANALOG COMPONENTS

Incorporating four independent power planes, each one bussed to all 264 pad positions, the UMB universal printed board allows both analog and digital components to be used. The grid of 792 holes available for components is aligned on .100 inch centers in both X and Y axes, and none of the component pads are tied to any of the power planes; power planes are bussed beside every pad position and require only short jumper wires to make a connection. Dual-inline packages as large as 66 pins may be accommodated. Size: 4.5" W x 4.0" L. Board substrate is .062" G10-FRY glass-epoxy, with 2 oz. of copper plating below .001" solder plate. Hole diameters are .043" and plated-through. Cost: \$13.25 (100 quantity). Midgard Electronics, 26 Walnut St., Watertown, MA 02172. (617) 924-9053.

Circle 134

## PDP-11 INTERFACE SERVES IEEE BUS

This PDP-11 compatible interface allows any PDP-11 series computer to be a talker, listener or a controller on the IEEE Std 488-1975 Gen-

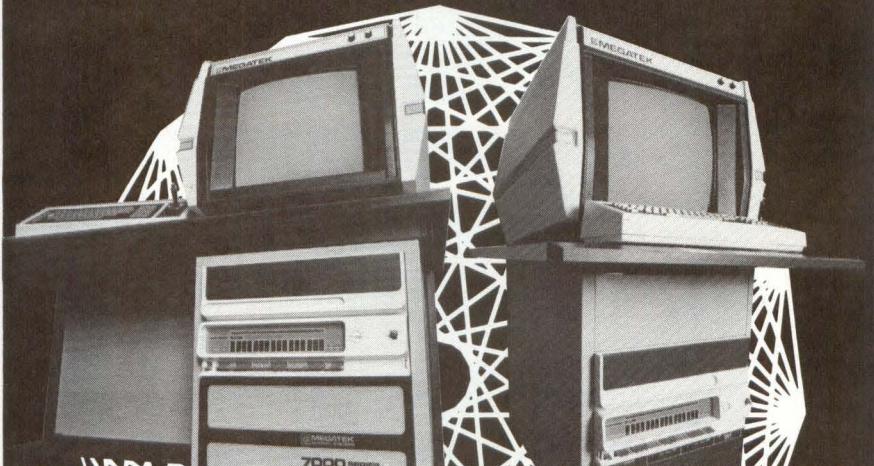


General Purpose Interface Bus. Packaged as a single quad-height card,

the GPIB11-1 provides hardware decoding of bus messages. A two meter cable comes with a standard GPIB connector on one end. The software package provides for transmission and reception of ASCII or free formatted data. Price, \$1,495, including cable and software. National Instruments, 8330 Burnet Road, Austin, TX 78758. (512) 453-3475.

Circle 143

## Two New Refreshing Alternatives MEGRAPHIC 5000 & 7000 SERIES



## Dollar For Dollar, The Best Performing, Most Powerful, Intelligent Graphics Systems

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CORPORATION

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CIRCLE 80

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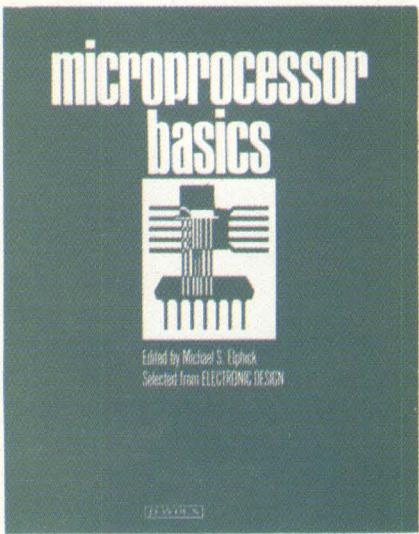
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## 8080 Programming

**Practical Microcomputer Programming** — The Intel 8080 promises software relief for 8080 users. Authors W.J.

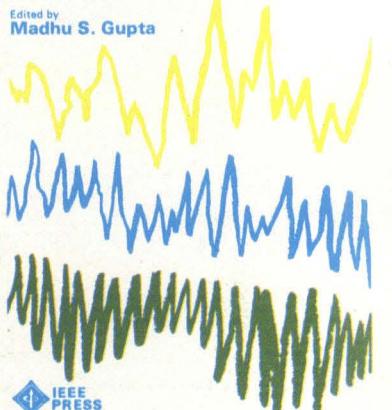
Weller, A.V. Shatzel and H.Y. Nice address the book to the programmer and cover the use of 8080 instructions to accomplish binary arithmetic including multiple precision, software multiplication and division, stack-pointer use and management, handling of arrays and tables and software conversions between binary and other number bases. Example programs illustrate the process in 8080 assembly language. Northern Technology Books is accepting prepaid orders at \$21.95 a copy at P.O. Box 62, Evanston, IL 60204. The 18-chapter book will be available in a few weeks.

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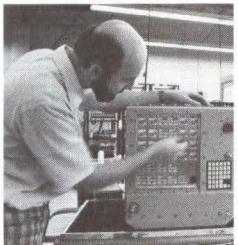
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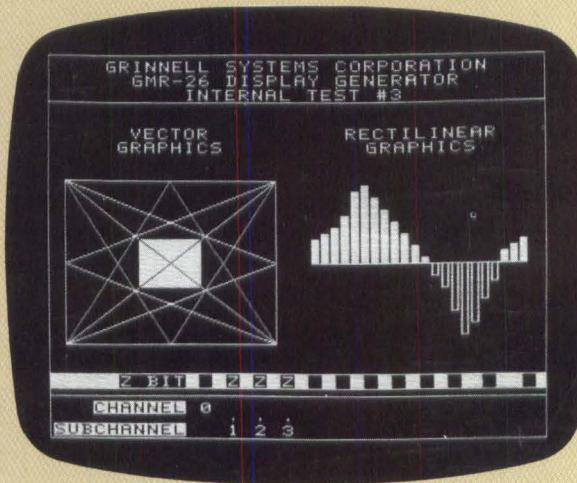
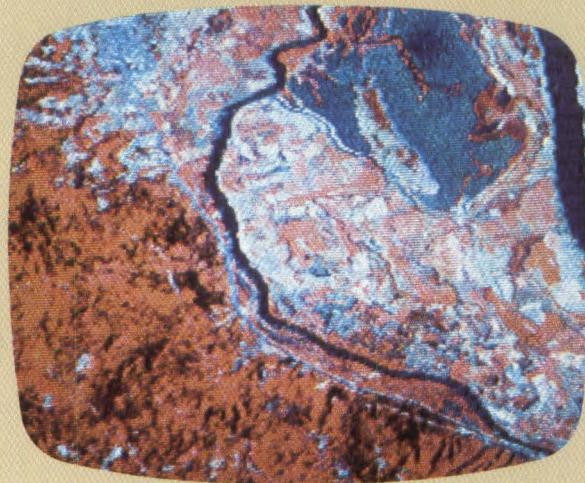
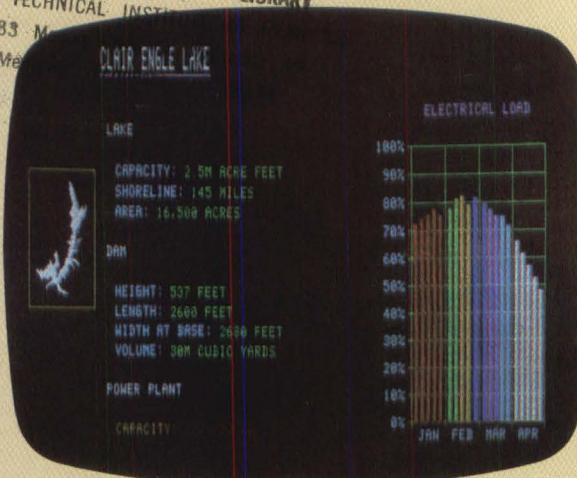
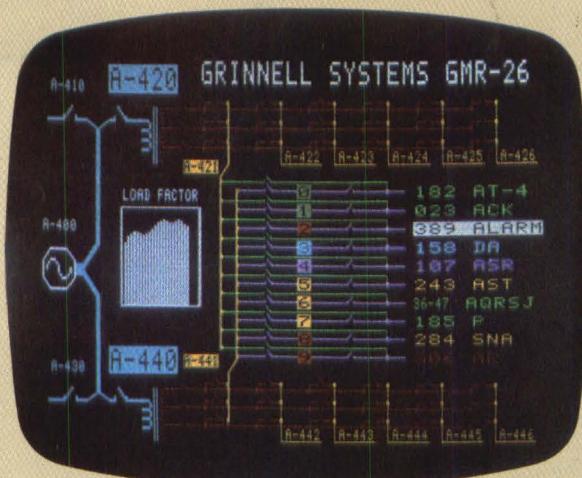
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