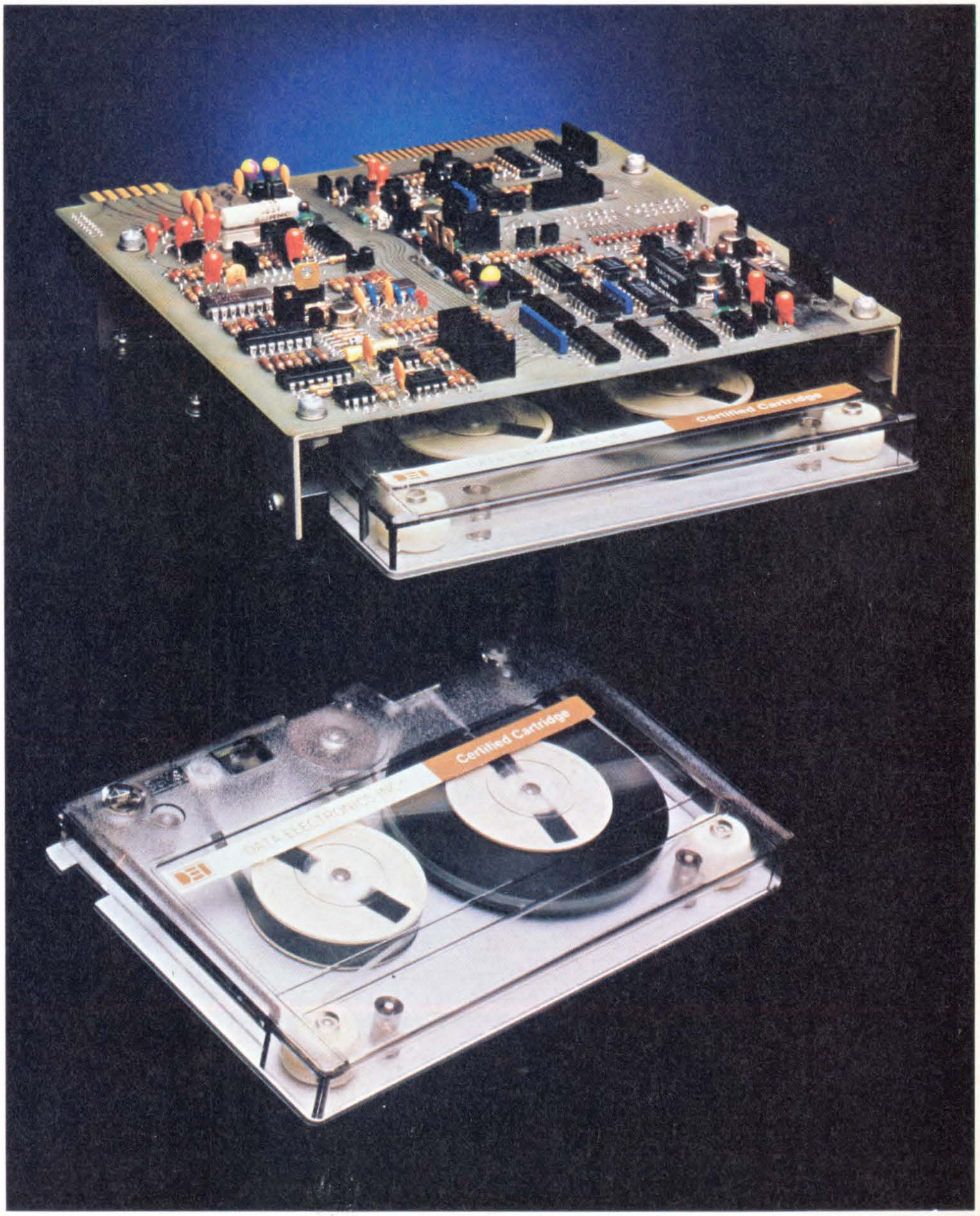
VOLUME 9, NO. 12

DECEMBER 1979

Digital Design

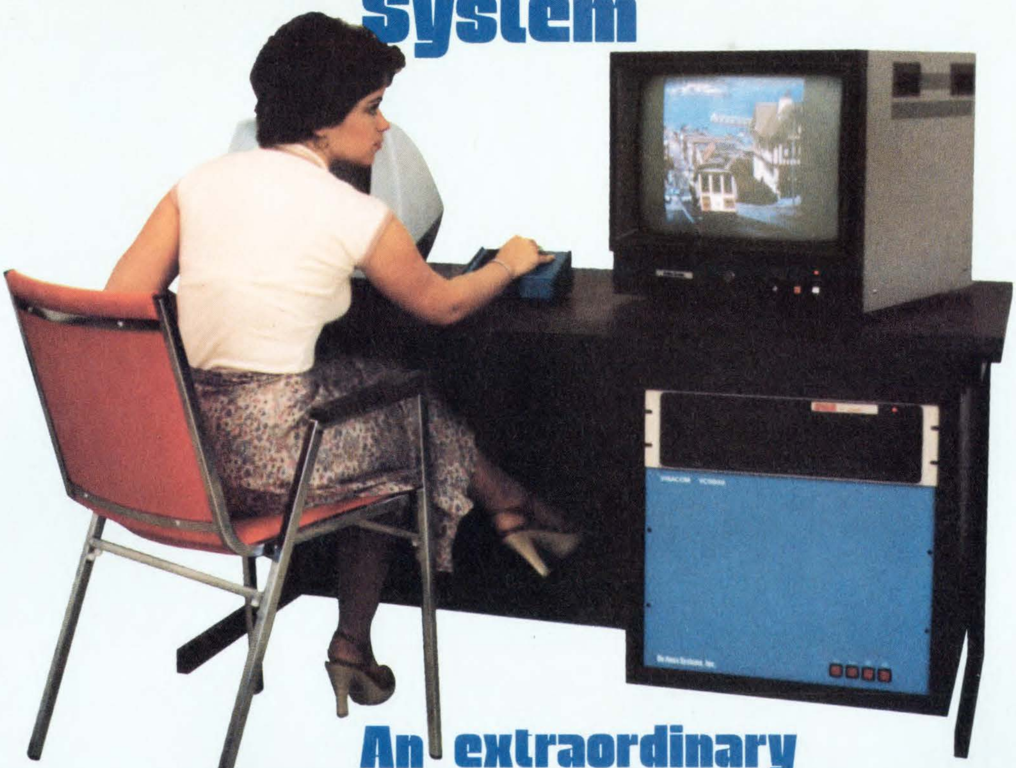
The Magazine of Systems Electronics

Alphanumeric CRTs
Color Graphic Terminals
Printers
Small System Printers
8-Inch Hard Disk Drives
Floppy Disk Drives
Plotters
Digitizers
Bubble Memories



1979 1980 REVIEW PREVIEW

μC Software
μP Development
Keyboards
Power Supplies
Reel-to-Reel Tape Drives
Streaming Tape Drives



WHEN IT COMES TO PUTTING IT ALL ON DISPLAY, THE ORION-60/S4 STANDS ALONE.

Magnavox combines the superior display and control features of the plasma-panel-based Orion-60 terminals with the powerful S4 Micro-Computer System.

The result is a stand alone graphics system that allows you the freedom to develop a wide variety of graphics application and development programs—while maintaining complete control over program storage, program-generated data, library routines and other facilities.

The Orion-60 display terminal offers full graphics with floppy-disc storage, as well as optional rear-projection functions. It lets you create your own displays and enter data by simply touching the screen with your finger. So you can program your own character sets and generate vectors of any length to absolute coordinates. And because the Orion-60 is plasma-based, you'll get bright, high-contrast images free of jitter or distortion.

The S4 Micro-Computer has system software with development capabilities that are as good or better than those found in many larger computer systems.

Features include CP/M* 8080 system utilities, Fortran with 32K RAM, and a full range of graphic utility routines including window, zoom, sub-image movement and rotation.

The Orion-60/S4.

For a demonstration, call or write Tyler Hunt at Magnavox Display Systems, 2131 South Coliseum Boulevard, Fort Wayne, Indiana 46803, (219) 482-4411.

Magnavox
DISPLAY SYSTEMS

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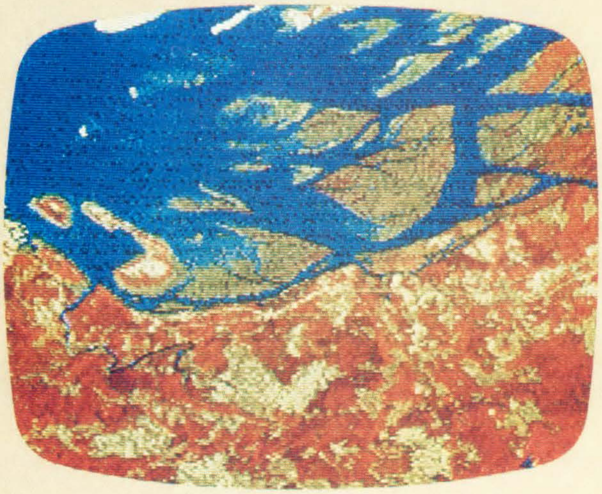
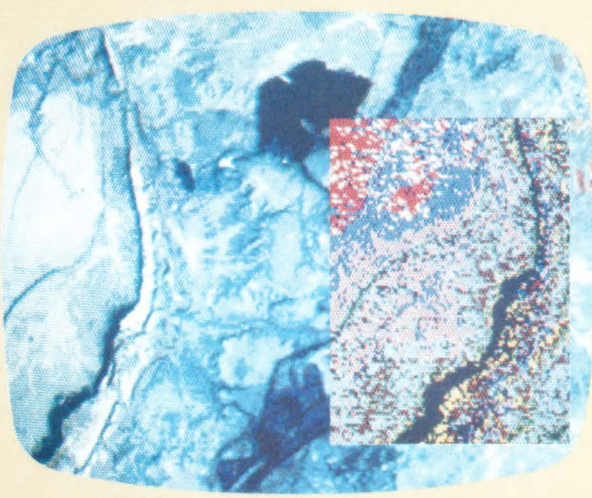
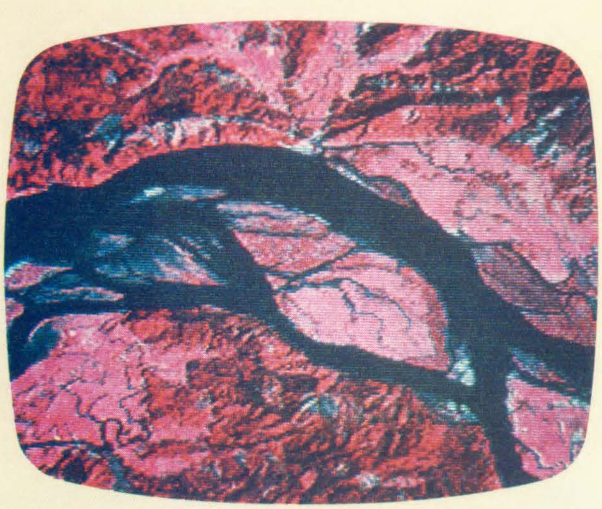
Circle 6 on Reader Inquiry Card







VOLUME 9, NO. 12 DECEMBER 1979

Digital Design
The Magazine of Systems Electronics

ON OUR COVER

With 8″ Winchester fixed disk drives demanding reliable backup, manufacturers are rushing to introduce streaming tape drives. For 8″ hard disk backup in the 10 to 100 Mbyte range, streaming tape drives provide unique advantages. (Photo courtesy of Data Electronics, Inc.)

Departments

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BPA CIRCULATION: 57,700 (NOVEMBER, 1979)

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Letters

Winds of Change

Dear Editor:

Congratulations on your hard-hitting Speakout ("The Winds of Change, Part 2" October 1979). IEEE's "head-in-the-sand" approach to problems of the working EE has made IEEE vulnerable to the inroads of another, responsive organization.

But will IEEE listen to its members' widespread dissatisfaction and demand for reform? If not, IEEE faces a worsening credibility gap and declining membership. Credibility must be restored to IEEE.

Your Speakout mentions members' dues that IEEE leadership has allocated for public relations. The amount is $216,000 for 1980, or about $1.13 per member; it is clearly designed to brainwash us into "loving IEEE". I am appalled at this shocking misuse of our dues and have filed suit in New York City's Small Claims Court alleging that this expenditure of members' dues for such public relations is not permitted under the terms of IEEE's incorporation.

What can you do? Please, if you are an IEEE member and care about this misuse of members' dues, I urge you to join with me in withholding $1.13 from our annual dues. Renewal time is near and this protest will be noticed by IEEE's hierarchy.

Irwin Feerst
Committee of Concerned EEs
Box 19, Massapequa Park, NY

TMS9900

Dear Editor:

I read the letter from Mr. Hines (Sept 1979, pg. 10) on Mr. Snigier's assessment of the TMS9900 with interest.

I disagree with Hines. As a consultant, I design with the TMS9900 and find it ideally suited for real-time processing, math calculations and data conversion. It has return opcodes (but no hardware stackpointer register). The CRU provides single or multi-bit I/O at reasonable cost. Most important are the multiply and divide instructions, which are great for fractional binary computations.

But there is one TMS9900 characteristic that T.I. doesn't describe clearly in their literature. the TMS-9900 s Borrow (Carry flag), for a subtract or decrement, is set to logic one prior to instruction execution. If a borrow occurs during the following ALU cycle, the Carry flag is cleared to logic zero. This is the reverse of 8080 and 6800 operation where setting of the Carry to 1 indicates that a borrow has occurred.

E. Von Essen, Jr.
Telos Computing, Inc.
Ventura, CA

Likes 8" Winchesters

Dear Editor:

The article, "Guide to 8-inch Hard Disks" by P. Snigier (August 1979), was an excellent survey of a very timely topic. Keep up the good work.

"Techniques for Designing Products" was a refreshing change from the usual "facts and figures" article. We need more technical design philosophy like this to produce better engineers.

John Zugel
Digital Software
San Jose, CA

High Level

Dear Editor:

I read your article, "Guide to 8″ Hard Disks Drives" (Snigier, August 1979), with a high level of interest.

Mathew E. Connolly
BASF Systems
Bedford, MA

Likes 8088/8" Winchesters

Dear Editor:

It was a beautiful way in your June Speakout of asking the readers to circle advertisement numbers. No catch? Yes, I did have a "catch."

A big catch of wonderful information on products. By doing this, I update myself and my company, and keep from being outdated.

Congratulations. You brought out the 8088 before other magazines. This was the chip we were looking for – well-worth waiting for. And you were first to realize the importance of 8″ Winchester drives and tape streaming.

Microprocessors are like bricks; when we want a bungalow, we got bricks to build it. It's OK when we were kids first learning, but not now! We can't start everytime from the fundamentals like multiply, divide (etc) routines.

(Continued on next page)

(Continued from previous page)

The advertisers took utmost interest and care to send maximum information to us, and we expect to purchase in quantity.

Allen N. Leonard
Electric Control Equipment Co.
Madurai, S. India

Best Interests

Dear Editor:

You editorial staff deserves a cheer from the electronics industry, since the views aired in the speakout represent our best interests.

Walt Omdal
Era Transpac Corp.
Moonachie, NJ

DAC Licensing

Dear Editor:

The subject of this letter is an article in the September 1979 issue of *Digital Design* titled "Principles of Data Acquisition and Conversion – Part 3." The article includes a section on D/A conversion and describes several of the best circuit implementations for DACs. The author states "the most popular D/A converter design in use today is the weighted current source circuit illustrated in Fig 2." This and subsequent statements may leave the impression that this technique is in the public domain. I wish to correct that impression by stating that the principles illustrated in Fig 2 and 3 and described in the text are protected by U.S. Patents numbered 3,685,045; 3,747,088; and 3,803,590. These patents are issued to James Pastoriza and all rights are assigned to Analog Devices Inc. Specifically, the use of a reference transistor to stabilize the binary weighted currents and the division of a high resolution DAC into similar subsections joined by resistor networks are techniques protected by the above mentioned patents. Readers wishing to employ these principles in the building of converters should contact: Analog Devices, James Kunkemueller, Box 280, Rt 1 Industrial Park, Norwood, MA 02062, for licensing information.

A.P. Brokaw
Analog Devices Inc.
Wilmington, MA

Not a Member

Dear Editor:

I am not an IEEE member because they do not represent the working EE. I would be willing to join an organization that would represent me.

D.P. McNeely
Magnetic Peripheral Inc.
Rapid City, SD

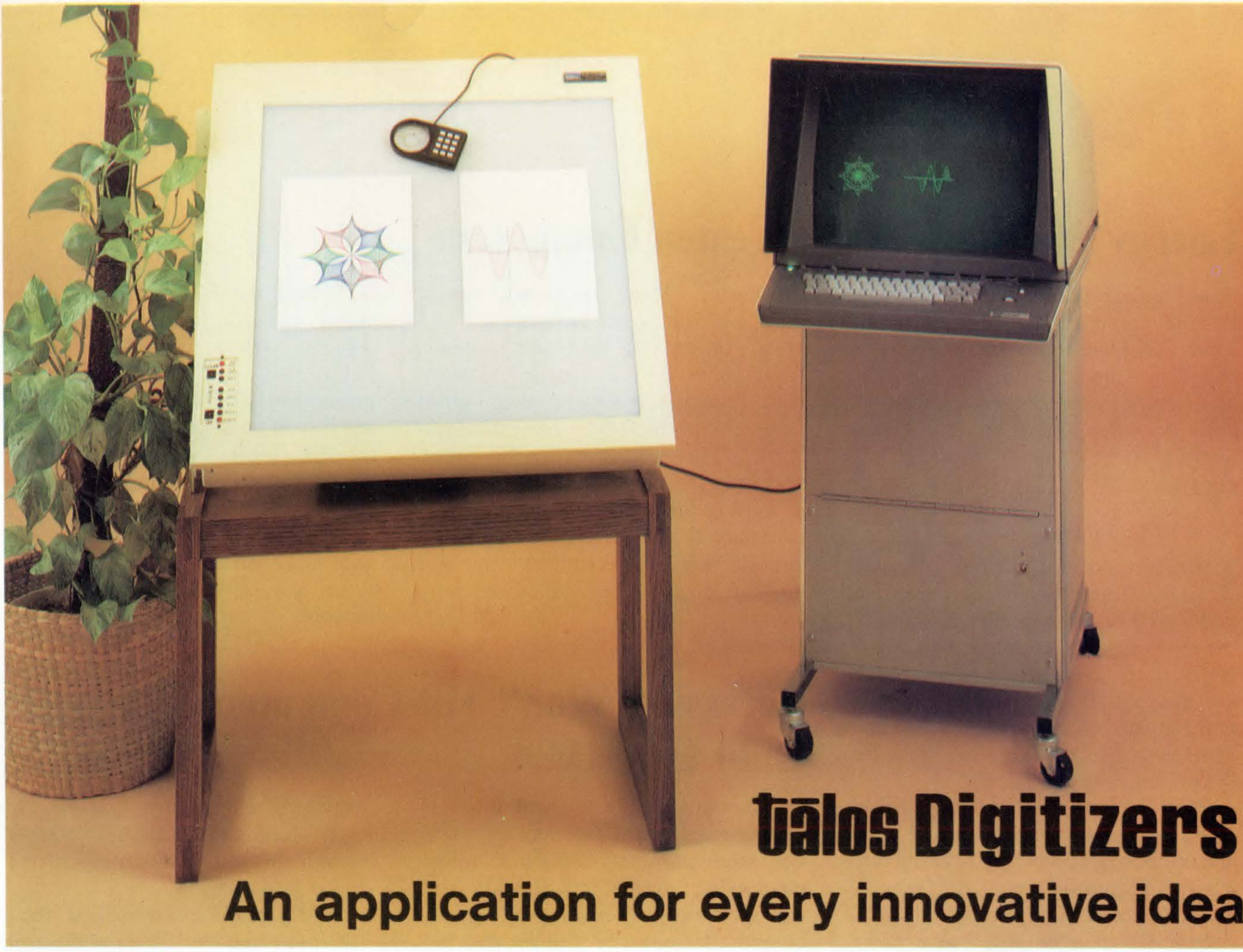
Additions

Dear Editor-

In your September editorial you mention my name, but you weren't talking about me. You wrote: "Although an IEEE Vice President for five years . . .". This is the *first* year I have been IEEE V.P. I was on the Board of Directors (as director of Division IV) for 4 years, 1971-74, when I often had to battle the Board to get professional activities started in IEEE. I set up one of the first PAC's (Professional Activities Committees) ten years ago, in 1969 (in the Microwave Theory & Techniques Society, when I was President), the first Division PAC in 1971, (when I was Division Director, with Bob Rivers as chairman), I served on the Constitution Committee that rewrote IEEE's constitution in 1972 to include professional activities, and became chairman of USAC (now USAB) in 1974. So what's this about "Leo Young's sudden change in views"?

I "retired" from the Board in 1975 to 1978, as all seemed to be going well, and devoted my energies to IEEE's very active Pension Committee as chairman for four years. We worked very hard and scored some notable successes. Yet, something else happened in 1975 you didn't mention: Schneider came on IEEE's Board of Directors and stayed for four years. You'd never guess it from your only comment "Candidate Burke Schneider, who is not on the IEEE Board of Directors . . .". True, but you're not telling the whole story. During those four years things gradually got worse; so I ran for Executive V.P in 1978, and am running for President in 1979. If I am elected President, I hope you'll help us get IEEE moving again on the professional path I helped map out in the early seventies. You are obviously interested, which is most welcome, as we'll need all the help and informed criticism we can get.

Leo Young
Executive V.P.
IEEE
New York, NY



What is a digitizer?

A digitizer is a graphic peripheral input device for transmitting points, lines and curves from the surface of a flat matrix tablet to a computer which accepts the data for immediate processing or future use and modification.

Who uses Talos digitizers?

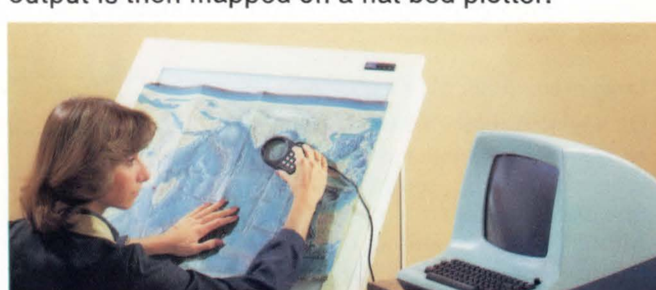
Since Talos designed its first digitizer in 1974 we have developed an extensive product line. We combine quality construction and dependable performance to give a range of applications that is limited only by the user's imagination.

Today Talos digitizers are found in use in virtually every major country in the world by such professionals as radiologists, medical researchers, geologists, geophysicists, engineers, environmental specialists and nuclear physicists.

How is it used?

Phoenix Baptist Hospital & Medical Center in Arizona uses a Talos digitizer to digitize PA and lateral X-rays for determination of Thoracic Gas Volume. This method has a .96 correlation with TGUs performed by body plethysmography.

Offshore Navigation in Louisiana uses our digitizer to establish water depths and to digitize sub surface formations on seismograph location maps. This output is then mapped on a flat bed plotter.



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Technology Trends

Energy Shortage Will Threaten Computers

Power shortages threaten the electronics and computer industry. With the spectre of a worsening energy situation haunting the electronics industry, many manufacturers are using the publicity to offer Uninterruptible Power Supplies (UPS) and electrical backup systems.

Need backup power?

If you're a systems integrator or user, should you purchase backup electrical systems? For most smaller computers, the answer is–probably not. When you consider the cost of a power generating backup plus air conditioning system, it can run between $50,000 and $110,000 – or probably too great for the risks involved.

Still not sure? To make a decision, consider. (1) the probability of a damaging power failure and (2) how serious the disruption would be. Obviously, if loss of data or computer time is critical (as in a hospital's emergency ward), the choice is clear. If data is lost, how serious is the disruption of information? With orderly shutdown, data is saved, with backup information in storage.

Then again, consider the types of failure that might hit. There is a big difference between poor quality power, brown-outs and rolling black-outs.

With brown-outs, 3% power reductions are common, but aren't likely to disrupt your computer operations. Start to worry when those cutbacks reach 7% or so. Rolling black-outs are a different matter, where regional areas are blacked out in an orderly and predictable manner. If this is a serious threat, consider the purchase of a power line to a second substation (about $250/month).

Lowers computer MTBFs

On a related topic, West Coast computer users who violated the 80°F minimum thermostat setting laws faced threats from utilities to cut off power. Although these shutdowns didn't materialize last summer, it does raise interesting energy-related questions for the future. Many computer makers warn that the higher temperatures will affect the MTBF of their systems. What about critical systems? Government bureaucrats asked that computer makers who feel their computer systems' MTBF is lowered by the higher operating temperatures should put this in writing for the bureaucrats. This is necessary for a waiver, they said. But you can bet not too many firms will do that; no computer maker wants the adverse publicity.

If peak demand periods in the northern and southern California areas coincide, (they usually don't), then California's five utilities' reserve power level could vanish, with resulting brown-outs and rolling black-outs by July 1980. Since so much of our nation's electronics/computer industry is centered here on the West Coast, nuclear power slowdowns could create a grim situation for computer manufacturers and users and threaten engineering jobs.

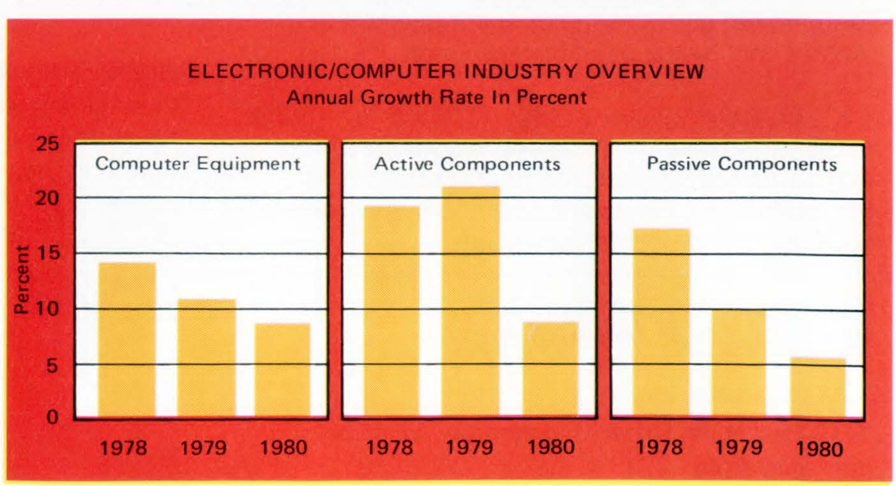
Recession Won't Hit Computers Until Late 1980

The computer industry will not feel the recession until later on in 1980. US production of computer equipment, which made a 14% gain last year, will grow only 8% next year because computers generally follow the fortunes of the capital investment sector.

This forecast comes from the just-issued third quarter edition of "Electronic Industry Econometric Forecast" (Gnostic Concepts, Menlo Park, CA), with its econometric models (including I/O techniques), that were used to forecast US electronics and computer hardware production.

Prospects for various major equipment markets are diverse. Consumer electronics will be extremely weak at 2%, and even communication equipment will expand by only 4%. However, business/retail and computer equipment will be relatively strong at about 12% each.

Active components bucked the deceleration trend in 1979; but electronic equipment growth will decelerate from about 14% during 1978 to about 10.5% in 1980. Active components will accelerate from 19% to almost 21%. The growth anomaly in active components is due to the rapid infusion of ICs into electronic equipment and inventory accumulation for major new computer product introductions. All three segments – equipment, active components, passive components – will be in harmony by 1981 as they all go through a growth acceleration.



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PLUG IT IN.

Simply plug your "inputs" and "outputs" into the Basic Controller™. Then add a video monitor and keyboard to form a complete control system.

START CONTROLLING. Enter instructions into the keyboard using simple English, like: "IF TIME = 053010 AND SENSE (18)=1 THEN TURNON RELAY 5," and immediately watch the results. You don't need programming or microcomputer experience to use this sophisticated electronic controller. Dynabyte has done it for you.

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Xylogics Technology Produces the Quality Family of Disk Controllers and Subsystems

When you choose any member of the Xylogics family, you get performance for your most demanding application and reliability that sets a new standard for the industry. In a word, you get *quality.*

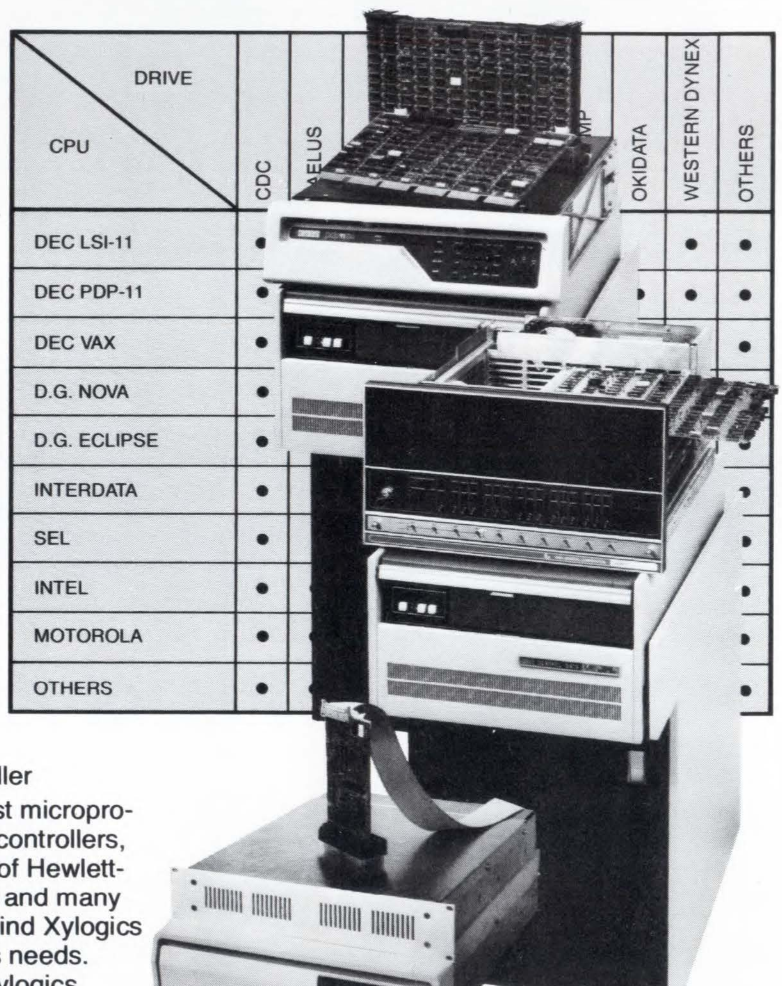
You also get *flexibility,* which has made Xylogics a leader in intelligent disk controllers. Xylogics broad range of disk controllers is continuously expanding to meet the growing list of popular mini and microcomputers being offered.

The Xylogics quality family includes:

- Model 410 SBC/Multibus Cartridge Disk Controller
- Model 510 DEC LSI-11® Cartridge Disk Controller
- Model 610 DEC PDP-11® Cartridge Disk Controller
- Model 810 Data General Nova/Eclipse Cartridge Disk Controller
- Model 211 DEC PDP-11 Storage Module Disk Controller
- Model 850 Data General Nova/Eclipse Storage Module Disk Controller

Systems designers know that the latest microprocessor technology goes into Xylogics controllers, insuring superior performance. Users of Hewlett-Packard, Varian, Interdata, Honeywell and many other mini/microprocessors may also find Xylogics technology applicable to their systems needs.

Regardless of your application, Xylogics technology delivers controllers and subsystems to match your exact specifications. For details, contact our Applications Department. Today.



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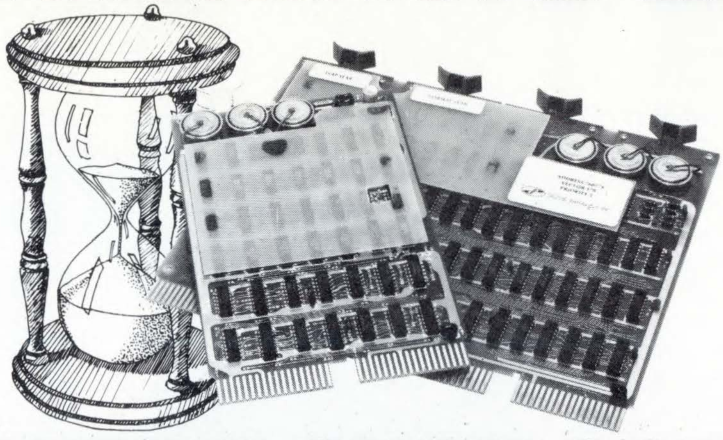
TIME after TIME



BATTERY SUPPORTED CALENDAR CLOCKS

PDP-11*

TCU-100 • $495

- Provides month, day, hour, minute and second.
- Can interrupt on date/time, or periodic intervals.

TCU-150 • $430

- Provides year, month, day, hour, minute and second.
- Automatic leap year.
- Patches for RSX-11M, RT-11 FB/SJ VO2, VO3 and UNIX.

LSI-11/2*

TCU-50D • $295

- Provides month, day, hour, minute and second.
- Dual size board.
- Patches for RT-11 SJ/FB VO2, VO3B.

Lockheed SUE

TCU-200 • $550

- Provides year, month, day, hour, minute, second and milli-second.
- Interval interrupts between 1/1024 seconds and 64 seconds.

Computer Automation (Naked Mini)***

TCU-310 • $385

- Provides year, month, day, hour, minute and second.

Multi-Bus**

TCU-410 • $325

- Provides year, month, day, hour, minute and second.
- SBC/BLC compatible.

HP 2100

TCU-2100 • $395

- Correct time restored after power failure.
- Compatible with the HP TBG card.

Serial Clock (RS 232 or 20 mA)

SLC-1 • $575

- Connects between any terminal and host computer.
- Provides date, time and more!

All Digital Pathways TCUs have on board NICAD batteries to maintain time and date during power down. Timing is provided by a crystal controlled oscillator. Prices are U.S. domestic single piece. Quantity discounts available.

For more information on these products, contact:
Digital Pathways Inc.
4151 Middlefield Road
Palo Alto, CA 94306
Phone: (415) 493-5544

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DIGITAL PATHWAYS

Circle 23 on Reader Inquiry Card

6504 Invades Tennis Courts

Microcomputers have entered athletics. One example, "The System" (a 115 lb. unit designed and manufactured by United States Machine Works, Inc.), uses a 6504 μP in the first true intelligent tennis machine that fires 1-99 balls – dropshots, lobs, drives and even service returns – one after another, in any sequence all over the court. It also fires smash serves from an overhead height and different types of ground strokes at different angles.

Flexible 6504-based control unit controls "cannon" (not shown).

"The System" – its hardware . . .

The control unit for The System ball machine consists of a 6504 MPU used in conjunction with three 6532 peripheral interface devices. These devices contain 128 bytes of RAM, no ROM, two 8-bit bi-directional data ports and a programmable interval counter with an interrupt capability.

The 6504, an on-chip-clock version of the 6514, uses a single +5V supply and has TTL-compatible signals, and differs from other 6500 family members in scope rather than function.

The 6532 Peripheral Interface Adapter (PIA) is a variant of the 6530, which MOS Technology designed as a multi-function support device and member of the 650X family to permit them to compete in low-end, high-volume markets. Addressing the 40-pin, +5V 6532 is a lot simpler than with the 6530, since it has no ROM and has separate Chip Select signals.

The non-volatile memory – four 2708 ROMs – are purchased pre-programmed and tested. These are available in a cost-effective plastic package.

The main logic is on a 11" x 8" PC card and is controlled via a front panel containing 81 pressure sensitive switches that are divided into two groups. The first group is made up of an 8 x 8 matrix configured "X-Y" which is the "Magic Court". The "Control" switches make up the second group and are connected with one side common to achieve a 1 of 17 configuration.

Four toggle switches are also located on the front panel and are used in conjunction with the pressure sensitive "Control" switches to modify the switch functions much the same as the shift key does on a TTY keyboard. The toggle switches are connected directly to the input port of a PIA device with no interface required.

The unit's fluorescent display mounts directly to the main PC board and is positioned to be visiable through the window on the front panel. It uses a fluorescent display to achieve a high degree of light intensity required when it is used outdoors or on a very well-lit tennis court. This display requires 42 Vcd for proper operation; therefore, level translators are a necessary evil. But the brightness of this display makes it a worthwhile expense.

The remaining logic on the main PC card consists of a decoder-driver and an 8-to-1 multiplexer to handle the "Court" switches, two address decoding devices for I/O and memory selection and a phased locked loop (PLL) and quad comparator for the tape and power-on reset functions.

A secondary PC card mounted in lower portion of the ball machine contains several solid state relays. These relays are used to activate several ac motors. SSRs' were selected to eliminate the noise produced by contact bounce, encountered when dry contact relays are used to switch moderate current.

The tape record routine generates the two frequencies needed by a PLL to recover the cassette data. These two frequencies are employed to generate a self-syncronizing bit cell when cassette data is read back into RAM. A check-sum is sent at the end of 99 bytes to assure a valid data transfer.

The interrupt timer feature of the PIA devices is used often during the program to allow the display to operate while a timer is counting.

All inputs from the pressure sensitive switches generate an interrupt which is interpreted by the software and acted upon accordingly. Switch bounce and/or noise is eliminated by software.

Want more details? Write. United States Machine Works, Inc., 21 Williams Pl., Lansdale, PA 19446.

THE INFLATION FIGHTER

You can't buy more capability for less . . . But you can buy less for more.

MPI presents the perfect answer to your inflation-riddled printer budget. THE MODEL 88T DOT MATRIX PRINTER. The first in a series of new full-capability low-cost printers designed specifically for the general use computer market. The Model 88T is a fully featured printer with a dual tractor/pressure-roll paper feed system and a serial or parallel interface. The tractor paper feed system provides the precision required to handle multi copy fanfold forms, ranging in width from 1 inch to 9.5 inches. For those applications where paper costs are important, the pressure-roll feed can be used with 8.5 inch roll paper. A long-life ribbon cartridge gives crisp, clean print without messv ribbon changing. The microprocessor controlled interface has 80, 96 or 132 column formating capability while printing upper and lower case characters bi-directionally at 100 characters per second.

With all of these features, **plus** quality construction, continuous duty print head and attractive styling, the Model 88T would easily sell at the competition's "under $1000" (999.99) tag. But we are offering it for only $749; this should make you happy and several hundred dollars richer.

Write for complete specifications and pricing information.

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Circle 24 on Reader Inquiry Card

Will 4-to-6-Inch Hard Disk Drives Hurt Floppies?

New storage technologies, such as 8″ mini-Winchesters ("microdisks") and low-cost floppy disks, will impact μC systems during the next five years.

Coming attractions. . .

During the next two years, new storage technologies to enter the microsystems memory market include: very low-cost consumer/commercial grade 5″ floppies, 8″ mini-Winchester hard disks, 4-6″ flying head micro-Winchesters, "back-end" processors combining disk controller and database management functions in specialized hardware, and on-line archive devices in both video-disk and automatic cartridge tape library configurations. These innovations, along with magnetic bubble memories, will pose a serious threat to the market for an expanded capacity, double-sided floppy disk. Long-delayed and trouble-plagued, double-sided floppy disk drives have stung system designers, and price increases may have hurt the future of floppy disks.

Low-cost mini-floppy drives, made in Japan on automated assembly lines currently used for cassette and 8″ tape decks, will appear on the market soon. Offered in both commercial and consumer grades, these very low-priced mini-floppies will be functionally equivalent to currently available mini-floppies, accounting for over 40% of total floppy production, but under 30% the price of conventional mini-floppy drives.

Over the next five years, 8″ hard disk prices will approach the current price of 1.2 Mbyte, double-sided floppy. The high-end unit capabilities will exceed 60 Mbytes with thin film heads and track following.

5″ Winchester drives?

Will mini-floppies also come under attack from flying-head disks? "Micro-Winchesters" could be introduced very shortly. These would be 1 Mbyte and up, 4-6″ disks (both hard and floppy), sometimes packaged with thin film heads in a removable module about the size of an eight-track tape cartridge. Pricing will eventually approximate the level of today's double-sided mini-floppies, with extra disk/head modules going at around $25 retail. The micro-Winchester's ten-times-access-speed advantage will be increasingly attractive as multi-tasking, virtual memory and database management software become more common on μPs, alleviating system bottlenecks created by the number of disk accesses.

Back-end processors will enter the marketplace in the early-to-mid 1980s. Specialized LSI systems which combine disk controller and database management functions, these back-end processors will use highly parallel architecture, content-addressed memory and magnetic bubble buffers, in conjunction with Winchester disks, to substantially improve file handling performance. Back-end processors will serve as a shared database resource which can support an office network of word processors, intelligent copiers, data entry terminals, personal computers and other workstations.

A related development will be on-line archives (OLA) at microsystem price points, i.e., a thousand or more Mbytes for an end-user price of a few thousand dollars. Major advantages of maintaining all data on-line include improved security, constant accessibility from remote locations and unattended operation of systems. Data is staged to disk before actual processing, making access speed relatively unimportant.

Leading OLA technologies are optical video disks and automatic cartridge tape libraries. Video disks offer fast access (under one second) and low costs reaped from utilizing consumer production scale economies. Automatic tape libraries could be an adaptation of video cassette recorders (particularly longitudinal format), 3M-tape cartridges or a new wide tape format.

Floppy capacity rises

In the future, expect the 8″ floppy to reach at least 5 Mbytes (but any payoff from going beyond that is in doubt). On-line storage applications are vulnerable to the ten-times and 100-times speed advantage of hard disks and magnetic bubbles. Off-line storage uses are susceptible to low-end floppies, 4-6″ micro-Winchesters, data communications, OLAs and high transfer rate sequential media more suitable for "save/restore" hard disk back-up.

These projections were taken from a new ($895) industry report, "Rotating Peripheral Memories I: Floppy Disks and Low-Cost Winchesters" from Creative Strategies International, 4340 Stevens Creek Blvd., Suite 275, San Jose, CA 95129.

Improved Self/Remote Diagnostics Coming?

Paul Snigier, *Editor*

Computer and peripheral makers and users are facing rapidly escalating maintenance and service costs. With more computer hardware located at remote locations, distributed processing systems and complex data networks, difficulties of maintaining and servicing take more time and expense.

Problems will worsen

Recent fuel price hikes and higher travel costs for field repair personnel are raising operating costs for suppliers' service organizations; recent price increases in supplies, which took a sudden upturn, didn't help. The spectre of predicted price and wage controls, sure to create artificial shortages of certain computer and peripheral parts, will worsen the severely-eroding profit margins in most supply categories.

As if this wasn't bad enough, the rapid growth in mixed-vendor systems and multi-vendor sites (partially due to increased competitive bidding) makes it difficult to determine causes for hardware failures—or even to determine which service organization to call! More management time is being drained to coordinate the growing

number of maintenance vendors.

The growing complexity of systems rapidly obsoletes trained service engineers and techs faster than the schools can re-tread or replace them. Even then, too many that enter the field, leave it. All this, coupled with the loss of the military as a source of trained field personnel, guarantees worsening shortages of qualified personnel.

Suggested solutions

Attacking service/maintenance troubles should begin with the designer. You must design in diagnostics *from the start* – not as an afterthought – and concentrate major design effort on increasing the reliability of most frequent trouble makers: tape and disk drives, keyboards, printers, solenoid-containing units and the like. Ideally, your system and terminals should contain self-diagnostics and be designed so users can do more servicing themselves.

Consider remote diagnostic centers and build self-diagnostic intelligence into your boards, peripherals and systems. Let sophisticated support processors diagnose hardware troubles, with continuous and automatic errors logged, thus helping to diagnose systems programming and hardware problems. This cuts on-site calls by software and hardware support engineers. For example, some remote (and self-diagnostics) detect unusual line transients that occur at time of fault or error. Others analyze troubles and provide a code, which enables service engineers to bring the proper spare parts—thus saving wasted plant visits.

Keep track of faults and errors by computer, so trends can be followed. Although this may be of immediate interest to administrative personnel, feedback can be useful to you in altering next-generation designs.

Other solutions outside the realm of the designer do exist, such as creating subdivisions between service personnel; for example, with board-swapping techs (re-trained TV/radio servicemen?) who do not analyze system-type problems versus systems-level techs diagnosing complex problems, along with sub-specialties. Some firms are offering various-priced levels of maintenance; for example, next-day repair or traditional maintenance or a fixed number of calls. Not all users or operating conditions are alike.

Still other solutions exist, but they also fall outside the realm of most system designers. It would help to increase third-party maintenance and repair service firms that handle government (and commercial multi-vendor) sites or systems in a local area. Today, it's too common for one firm to handle all units used in a specific data network, even if dispersed throughout the country—even if this degrades service by increasing travel costs, spreading technical expertise too thin and increasing down times. Third-party firms already are finding their niche in servicing small users or systems that equipment vendors can't service (or lease systems from third parties).

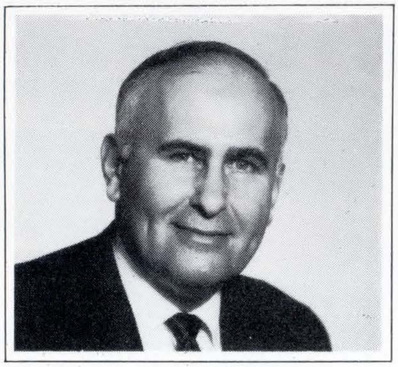
Throwaway computers?

With the maintenance/repair costs rising, soon it will be more cost effective to toss out a bad CPU than repair it. This concept of the "throwaway" or "disposable computer", which Computer Automation is already experimenting with, promises to become commonplace. In any event, the soaring repair/maintenance costs will force system designers to rapidly improve system diagnostics and reliability.

Introduction

George King, *Editorial Director*

The Picture For The 1980s



This issue contains articles on various aspects of digital system technology. Each article, authored by a member of a leading company marketing products related to the segment of technology under discussion, describes changes that have taken place and could occur in 1980 and beyond. Part 2 of this Technology Review/Preview is continued in January.

Why did we decide to devote almost all of the editorial space in this issue to a technology update and forecast? Obviously and importantly, we did it for you, our readers. We hope that these separate articles will form the basis of a picture that clearly indicates where our industry stands technologically and where it might be heading. This picture should help you design and implement new products with more confidence, because it displays the current state-of-the-art and provides a perspective of the near future.

Nearly all of the articles emphasize that in 1979 programmable chips have finally succeeded in fulfilling the promise of being able to provide intelligence and flexibility to host products to become ubiquitous. We now routinely expect nearly all products intended for most types of digital – and even non-digital – systems to contain at least one programmable chip and to require some form of software. The need for programming hangs heavier than ever, even as programmable device capabilities and power improve with the changing word size from 4 to 8 to 16 bits and higher.

Without being told, nearly all of us know of the trend toward higher and higher level languages and as well as the development of new languages. In 1978, PASCAL made its first appearance in a microcomputer. According to author Leventhal, PASCAL will become the all-purpose language for microcomputer-based systems.

All of the other industry segments experienced a number of changes, some more important and greater than others. Floppy disks, in particular, went through some painful periods while manufacturers learned how to improve their two-sided drives to eliminate media wear and other problems. Such new products as one-megabyte bubble memories, 8″ Winchester drives and data streaming backups suddenly appeared and cast an alluring spell over designers to use in their latest systems.

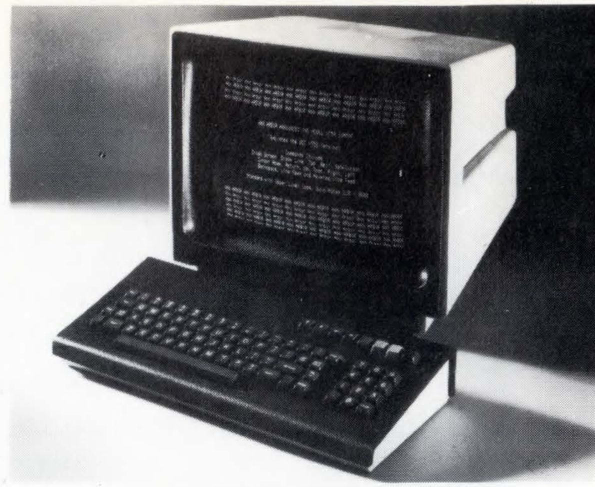
What about the future? Surprising though it may seem, all the authors seem to feel that the future will be bright with specific changes that will provide better, lower-priced, more sophisticated products. Even the more mature segments – for example reel-to-reel tape drives – will continue to evolve into better products that designers will continue to use in their systems.

As you read the articles, we hope that each one appears to you to contribute its share to the picture of now and the 1980s.

George King

1979
1980
REVIEW
PREVIEW

Alphanumeric CRT Terminals



CRT Terminals in 1980

Engineering Staff Report
TEC, Inc., Tucson, AZ

Last year, 1979, saw a pivotal point occur in the CRT display market. Growth continued, and will continue through 1980 and probably well into the mid-1980s before levelling off.

Since IBM and Teletype Corp. have the largest share (thus dictating "rules"), the "smart " terminals – non-intelligent, but yet intelligent) is where most manufacturers are settling. With distributed Data Processing (is it real or fiction?) leading the way, the sales of "smart" terminals should surpass those of the "dumb" and/or the intelligent variety of CRT's. The low cost of micros has fueled this growth along with the new lines of protocols over the past years such as SDLC.

A settling-in of functions and features took place; few, if any, manufacturers can cite their product as uniquely advantageous over its competitors. No longer does one CRT manufacturer have control over this segment of the business.

How long can a company grow at a profit making and selling inteligent CRT's. Today's cost of sales are soaring while the customers dictates are for a low price terminal. The move toward "system manufacturing" and "system selling" is gaining tremendous support among many of the historical OEM manufacturing operations. Today, in most OEM manufacturer's long-range planning meetings, where for their company's history, one product, whether it be a CRT, printer or disk, prevailed and accounted for all of their sales – this one product theory is being replaced by a "one system" plan.

Will 1980 see lower prices?

Although the numbers of qualified and large users will rise a little, competition will force prices lower, making it imperative for manufacturers to have a solid sales plan for capturing their part of the marketplace.

The year 1980 will differ from previous years. Main frame companies are realizing that by building their own CRT, they are losing money and they (CDC, Univacs, Honeywells, and possibly IBM) will reopen the doors to OEM manufacturers that want to bid on CRT quotations.

As for new entries into the CRT manufacturers, it will be less – perhaps five % of what today. Existing manufacturers will decline. Any recessionary trends in the economy won't be reflected in the CRT terminal industry to any great significance in 1980, although by late 1980 this effect could become more pronounced, although probably not dominant enough to override other trends.

Here is a technology forecast for 1980 and beyond: (1) it will be the same as today from a marketplace standpoint (that is, the numbers of qualified and large users have remained the same), (2) the competition in industry will force prices lower (thus making it imperative for manufacturers' solid sales plans for capturing their share of the market), (3) the dramatic difference from previous years will continue due to main-frame companies realizing that by building their own CRT, they are losing money; and they (CDC, Univacs, Honeywells and possibly IBM) will reopen doors to OEM manufacturers that want to bid on CRT quotations.

No, the answers aren't direct. The number of new entries into CRT manufacturing will be less; the existing members will decrease (10-15%). The reasons? The end-user market must deal with service and financing.

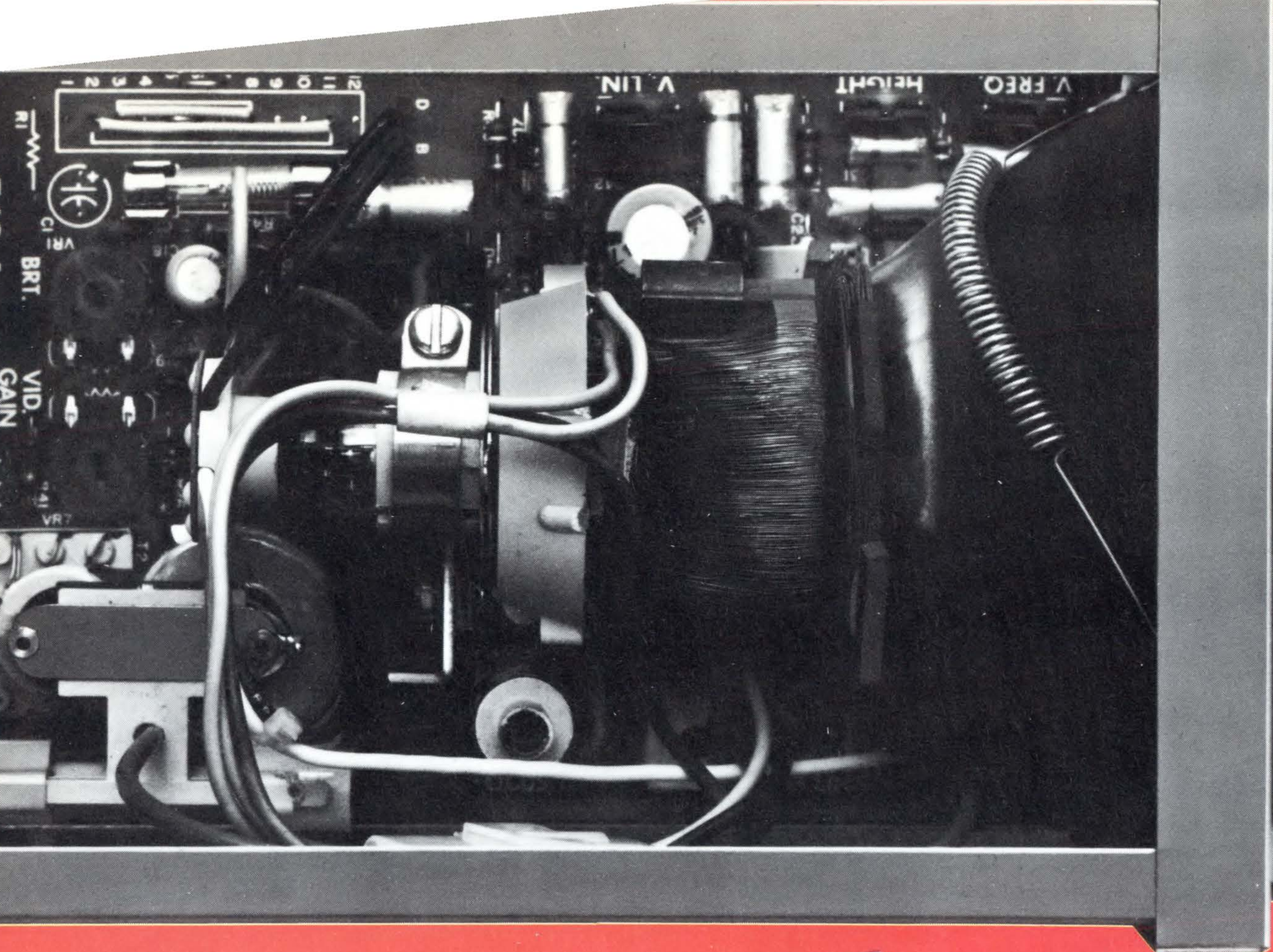
Financing the company, the oncoming danger for OEM suppliers is that more Fortune 1000 companies are looking at building their own small systems and terminals. Thus they will become OEM prospects and customers in their own right! They won't give up the perogative of leasing their equipment – a danger for poorly-financed companies or companies which never lease their goods.

What alternatives to entering the market is there? Simply this: don't. Will potential orders tempt firms? Yes. The result: perhaps the only way to stay in the OEM business is to sell to the traditional end-user. How? Be financially prepared.

In addition to leasing, another portent emerges: the ability of OEMs to service end-users well. The cost of this to the OEM must be apportioned to the growth in sales (not easy).

This new service area is a disaster area for companies failing to evaluate and plan for its growth within profitable guidelines.

As to the OEM arena in which CRT and small system competitors will wage wars in the future, price will yield



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This popular Audiotronics data display is one of our 48 standard models. We have sold thousands of them to giants in the industry. Maybe it's perfec for your requirements. If not, talk to us about your specifications. We're dedicated to innovative product design, quality production standards and complete customer satisfaction. Whatever you need, we have the experience and talent to design it, or improve it. Contact us today.

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to corporate image and plans to support customers.

Although the OEM market will never die, will it fade away? Will it be replaced by a new image which emphasizes customer support in a much more acute manner than just words? No and yes, respectively.

Trouble ahead?

The Fortune 1000 Corporations (end-users) are swinging back to dp centralization. Cost of low-cost terminals/systems is now costing as much money as the CPU which they replace! Users wanting low-cost terminals to replace low-end main-frame systems won't get exactly what they want, at least not after further developments take place. In either case, 1980 promises to be a good year for CRT terminals. Innovative technology – magnetic bubble memories, VLSI, new lower-cost OEM keyboards, etc. – won't begin to impact CRT terminals until past 1980.

CRT Terminals Beyond 1980

Engineering Staff Report
Perkin-Elmer Corp.

Will 1980 see a continuation of the demise of dumb terminals? Are the days of the "dumb tube" numbered? Perhaps. With new technologies and number of CRT manufacturers at the low end, will the market soon become saturated (and less attractive), unlike the market for "smart" CRTs and intelligent terminals? In the past few years, many CRT manufacturers optimized their product designs at the high performance end of the spectrum, applying appropriate enhancements or improvements to their low-end CRTs only when required. But too frequently, "new", low-cost CRTs are less-capable versions of high-performance terminals – but offering fewer options! This will change.

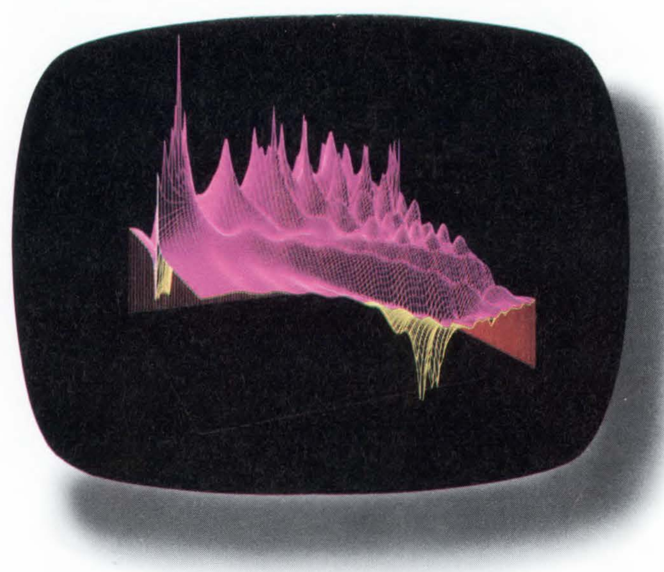
There remains a real market for compact, inexpensive, highly functional CRTs with the features for an office environment.

Looking back...

In the first generation of low-cost CRT terminals (pre-1974), both character decoding logic and CRT control were built from state-of-the-art TTL. This was an advance, and resulted in a total system IC count of 150. Every function (generation of horiz. and vert. synch timing) was performed in discrete logic. Execution of line feed increments, char.-line address counting, or carriage returns required numerous gates. Decoding input characters to cause normal displayable data to get written into memory needed decisions affecting numerous counters in the circuitry. Designing them, or retrofitting such 1st-generation CRTs, was no fun. Everything was hard-wired. Since options or changes were difficult, labor was the major portion of terminal cost. A first-generation CRT terminal was about $1600-$2000.

In the second generation, LSI entered. Some containing microprocessors and sold at $1000. Microprocessors permitted simplification of the character decoding and an increase of function. IC count was about 100.

Adding the micro gave more function, not simply to emulate TTL logic. Other requirements of ROM, RAM and clock circuitry came along. With the micro, editing functions could be added. Adding extra memory and logic let



the screen memory be interrogated, and a full editing CRT could be built with an IC count of 125.

By using micro technology, much TTL was eliminated. It could easily add many more standard features and options – at a reduced cost.

Previously optional functions, such as cursor addressing, ability to set tab stops at every position, tab and backtab keys, automatic repeat keys, separate print keys, full upper and lower case characters, transparent mode for simplified debugging, or fully buffered print port, could be offered as standard features in second generation CRTs because the additional labor charges occurred only once – in programming the micro. More important were other promises for future enhancements – such as ease with which options (like a line drawing character set or function keys) might be provided. Inexpensive, "dumb" second-generation CRTs sold for $970-$1600 two years ago.

Big changes continue

With the third generation, the market trend continued toward smarter terminals. The next major change came with the introduction of LSI controller chips.

In these CRTs, the CRT control logic is replaced by an LSI circuit (retaining the micro for character decoding function). A third generation CRT system took about 60 ICs. Did adding the CRT controller give terminal manufacturers some flexibility in the sytem? Yes, they could now generate a number of different screen formats by reprogramming the controller. The CRT controller interrogates memory and generates and displays whatever is in memory.

Eliminating logic by using the LSI controller is overkill. It's not cheap.

In the fourth-generation, character decoding logic and CRT control logic are combined in one, custom LSI chip. Design is such that it can be used to implement a cost-effective CRT with expansion capability for use with a micro in an editing CRT. The fourth generation allows a low-cost CRT terminal to be built with 19 ICs. Some maker's decision against using third-generation CRT controller came from a feeling that this would produce an interim CRT, at least in the low price market. The entire CRT circuitry was re-examined with an eye to redesigning it. There were areas where significant cost reduction and performance improvements could be made: (1) since the character decode function requires so little of a microprocessor's capability, this was an area for potential optimization, (2) with the available general purpose LSI controller chips, the additional features which are unnecessary for low-cost CRTs only add to manufacturing costs, (3) since with its own LSI design facility, it is not cost-prohibitive to incorporate specific characteristics needed into a single, custom-designed chip.

One of the advantages of the second generation – reduced energy requirements due to the LSI components – allowed manufacturers to eliminate cooling fans from CRT terminals. With the fourth generation custom-controller chip, power use is cut by half.

The winners?

If CRT makers use in-house LSI design capability, they realize cost savings, and assure multiple manufacturing sources. By manufacturing even the major components such as the CRT monitor and keyboard and using custom LSI, they achieve total vertical integration.

A Beautiful Way To Interface

IQ 140

SOROC's first and foremost concern, to design outstanding remote video displays, has resulted in the development of the IQ 140. This unit reflects exquisite appearance and performance capabilities unequaled by others on the market.

With the IQ 140, the operator is given full command over data being processed by means of a wide variety of edit, video, and mode control keys, etc.

The detachable keyboard, with its complement of 117 keys, is logically arranged into 6 sections plus main keyboard to aid in the overall convenience of operation. For example, a group of 8 keys for cursor control / 14 keys accommodate numeric entry / 16 special function keys allow access to 32 pre-programmed commands / 8 keys make up the extensive edit and clear section / 8 keys for video set up and mode control / and 8 keys control message and print.

Two Polling options available: 1) Polling compatible with Lear Siegler's ADM-2. 2) Polling discipline compatible with Burroughs.

IQ 120

The SOROC IQ 120 is the result of an industry-wide demand for a capable remote video display terminal which provides a multiple of features at a low affordable price. The IQ 120 terminal is a simple self-contained, operator / computer unit.

The IQ 120 offers such features as: 1920 character screen memory, lower case, RS232C extension, switch selectable transmission rates from 75 to 19,200 bps, cursor control, addressable cursor, erase functions and protect mode. Expansion options presently available are: block mode and hard copy capability with printer interface. The IQ 120 terminal incorporates a 12-inch, CRT formatted to display 24 lines with 80 characters per line.

SOROC TECHNOLOGY, INC.

165 FREEDOM AVE., ANAHEIM, CALIF. 92801
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The industry is changing rapidly; unless manufacturers have in-house LSI design facilities they cannot afford the time and cost required to get a chip designed. By the time the LSI specs are written (considering the tight controls required at every step), it could take a couple years to get the actual part in hand! Having the chip designed outside might cost $200 K. Semi manufacturers have two functions: run-of-the-mill ROM, RAM, and micros and custom work. CRT companies on the leading edge of that trend – those with their own LSI design facilities – will be ahead of the pack in the 1980s.

Continued Trend to Intelligence

How does a systems integrator measure data entry peripheral, intelligent video display terminal intelligence?

Given the similarity of basic components in most systems, you could be tempted to use purchase or lease price as a first measure of terminal intelligence. Unfortunately, such an approach only provides a rough measure of how much of the distributed intelligence of the system lies within the controller, and this is not a very reliable guide to the absolute intelligence of your particular configuration. You also must consider that software support and maintenance requirements often determine the level of your system's working intelligence and contribute a large proportion of the on-site system costs. Things won't change in 1980.
Several performance characteristics exist as indicators of terminal intelligence. But manufacturers place differing values on these particular characteristics. As a general rule, increased intelligence has been a function of the evolution from hardwired logic to interchangeable PROM to dynamic, stored μP or μC program operation; as a result, a correlation exists between intelligence and features that make the terminal less subject to obsolescence in 1980 and beyond.

Among the features used to measure intelligence are protected fields that provide you with a fill-in-the-blanks capability. Formerly accomplished by off-line user programming, this feature is now included in the software package provided by most of the manufacturers. Similar features, also provided by software, are validity checking for alpha characters in user-defined numeric fields and range checking to signal values which exceed established limits. The ability of the host computer to read the address of the cursor, rather than simply monitor cursor movement, constitutes another measure of intelligence.

Editing capabilities of the terminals are also used extensively as measure of intelligence. Buffered CRT terminals feature selective movement of the cursor in the up, down, left and right directions as well as a quick return to a predefined or home position. Additional intelligence comes from user-defined special function keys, often combined with separate numeric key groups to provide speed advantages in both data entry and editing. The addition of more intelligence to a CRT terminal, or specifically, additional memory and logic, allows features like the insertion or deletion of lines and individual characters to occur in the terminal, rearrangement, insertion of fixed text, and more advanced features now in use and to come in 1980.

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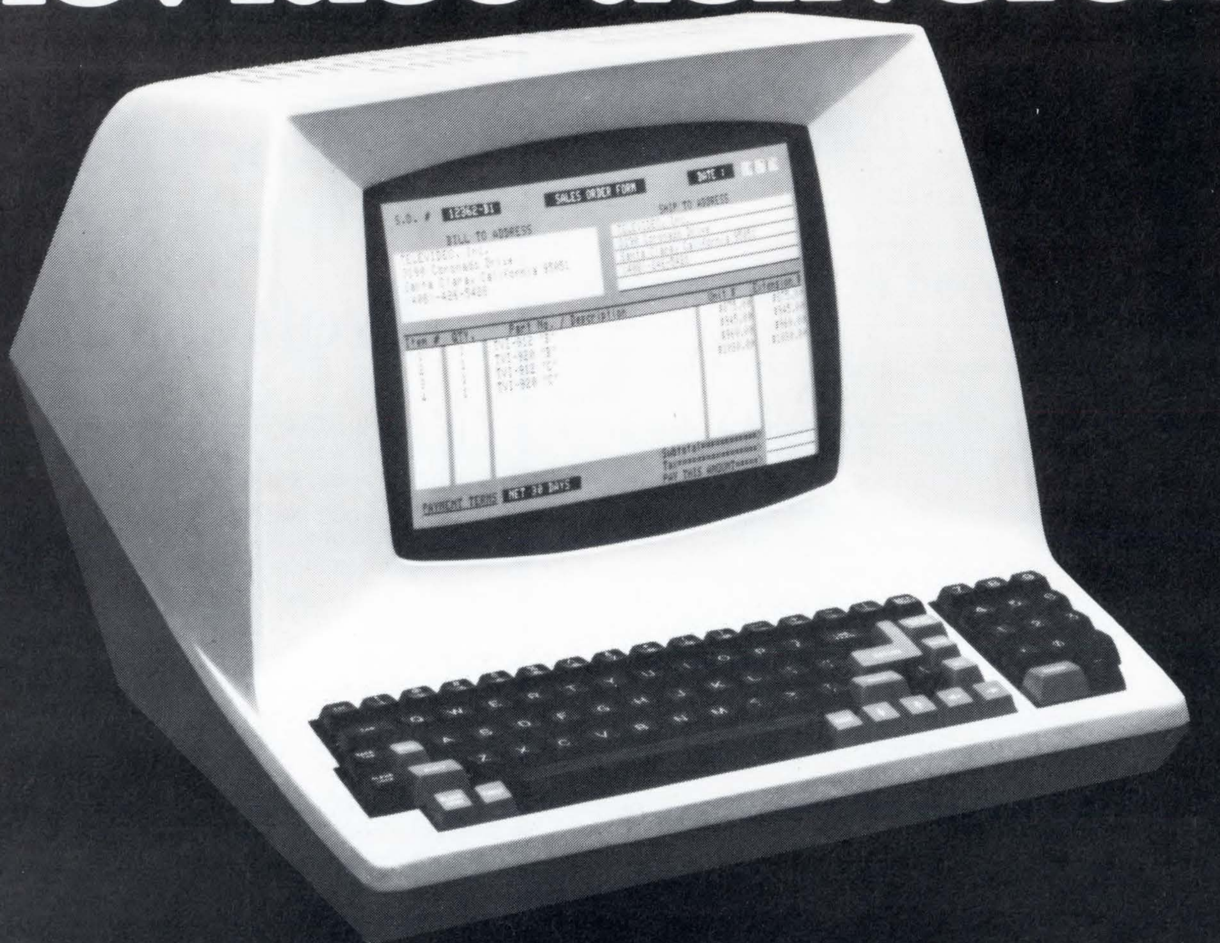
TeleVideo delivers...



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The TVI-912 and TVI-920 are the results of one and a half years of development by TeleVideo, Inc., a four year old company whose main business has been the production of CRT video displays. The SMARTS, RELIABILITY, and FLEXIBILITY offered in both our products are available only on terminals costing hundreds of dollars more.

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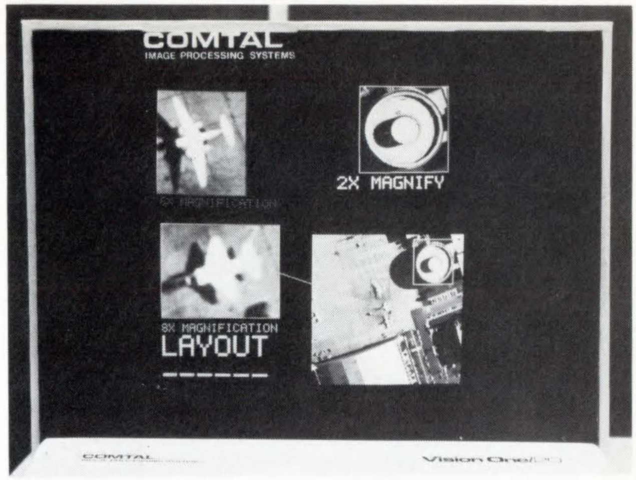
1979
1980
REVIEW
PREVIEW

Color Graphic Terminals



Harry Shershow, *Associate Editor*

"Over The Rainbow" with dazzling color graphics systems

The post-impressionist artists of the Fauvism school – the restless painters of the early 1900's – were inspired by Van Gogh and Gauguin. They were aptly called the "wild beasts of the palette" because they created works with dynamic, vibrant colors using savage brush strokes drawn from many globs of intense pigments. Their painting tablets usually contained as many as 100 different hues at the same time. Canvases created by Matisse, Roualt and others in their group are today ranked among the great masterpieces in the art world. How these creative giants would have glorified in the current digital society! They could have had a colossal palette of colors such as one currently being displayed on the Comtal graphics screen. Where the Fauvists compounded a mere 100 vivid color combinations, Comtal would now offer them 16,000,000! One can only wonder at the creative works that might have emerged from Van Gogh's brush if he had been able to sit in front of a Comtal display and stare into the fantasy world of digital color.

Comtal Corporation of Pasadena, CA. is currently on a work project with CSP of Burlington, Mass. They are trying to blend Comtal's world of color graphics into CSP's sophisticated array processor.

The big number-crunching systems (array processors) which are becoming increasingly popular in computer technology are typified by the CSP's MAP (Macro Array Processor). This 64-bit device swallows hugh chunks of arithmetic, processes them through proper formulization, then transmits the results to its own display, or as suggested in Comtal's on-site demonstration, to the image processing system. Comtal then uses the filtered mathematical input to perform its own high speed task. Comtal had come to the CSP company to discuss a pending linking of the two systems for a customer that had a particular problem to be solved. Such procedures are becoming commonplace now. The various image processor companies talk to the many array processors and develop joint systems for specialized applications. It is a marriage of two technologies that is sure to lead to further sophistication of both systems. A typical arrangement of such systems can be seen from CSP's operating cycle where output, instead of going to a console or to bulk memory becomes the input for an image processor, such as Comtal or Genisco, or DeAnza or Corvus or some of the other leading names in this growing, fascinating branch of computer applications.

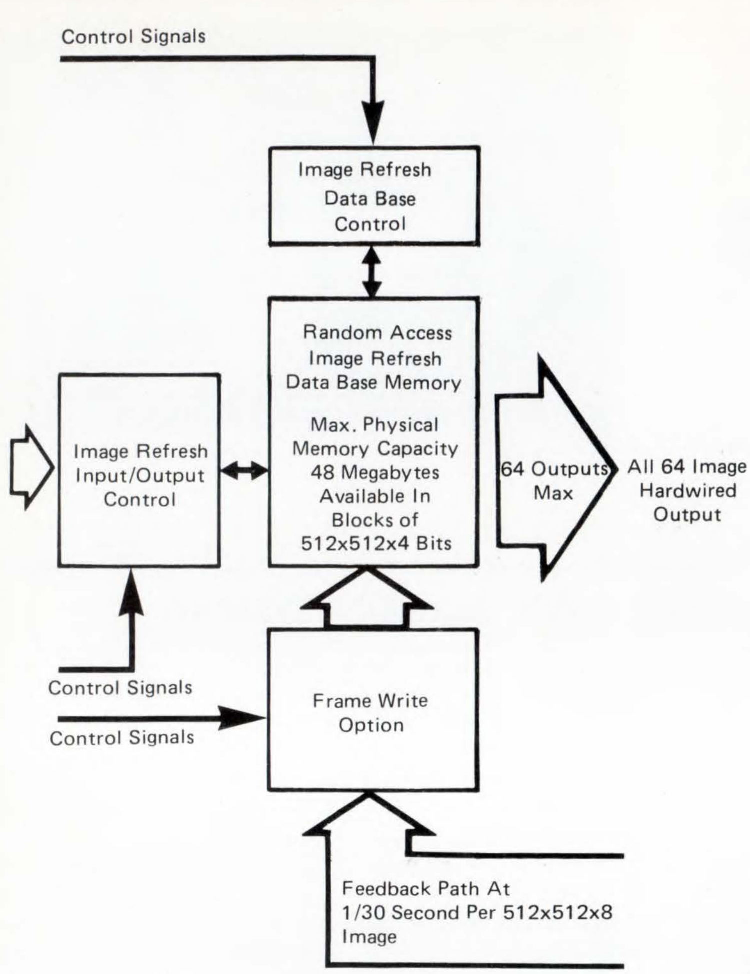
While on site at Burlington, the Comtal people conducted a four-session demonstration for anyone interested in this specialized branch of digital technology.

Some of the astonishing antics Comtal executed at the demonstration (any of which would have caused Henry Matisse to drop his sable brush for the light pen) included: split-screen bands of rainbows rolling across the screen in opposite directions at varying speeds and in changing hues; colors of San Francisco Bay being altered to suit the whim of the keyboard operator; a black and white photograph slowly blending into a multi-colored display; and a bouquet of roses in which a single rose was sent through the various levels of the entire spectrum while the colors of the rest of the bouquet remained static. To show off its further versatility, Comtal also displayed black and white panels (some were high-altitude aerial photographs) which were then enlarged and examined in detail. Shadows, appearing as black or gray patches on the original photograph, were stripped away in successive layers to discover if anything lurked in the dark areas. In a final explosion of digital color, the Comtal unit created a vivid, rapidly changing disco-abstraction which changed from a gental Rembrandt shading into a sunburst illumination and whose color combinations ranged far beyond all the spectrums in the world.

What lies in the future development of graphics display and what is image processing itself? These questions were answered, in part, by Harry C. Andrews, Vice-President of Comtal writing in the April 1979 issue of SPECTRUM.

"Image understanding," wrote Dr. Andrews, "is still in its infancy. The task of understanding images is a monumental one when trying to define 'understanding'. Pattern recognition, as well as artificial-intelligence techniques, are used, in addition to traditional signal processing. Scene analysis procedures using edge and texture segmentation, as well as object recognition, can be considered the current early stages of the image understanding technology. On the other hand, symbolic representation, relationship grammas, and syntactic manipulation are expected to play major roles in future stages.

"Cultural experiences are built into the task of recogniz-



Main Control

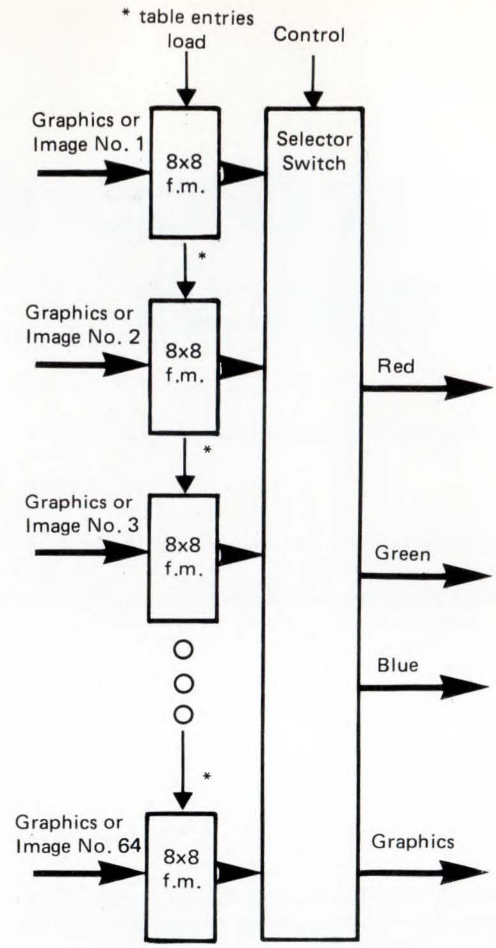
Controls the Dual Ported RAM Refresh Memory

The refresh memory is at the heart of Comtal's image processing system. Colors to be displayed are produced by "stacking" image planes in proper combination. Primary control of these image planes is handled by three separate I/O card types as suggested in "main control diagram."

The Image Refresh Data Base Control Card produces roaming or zoom magnification (2x or 4x).

The second card (Random Access Image Refresh Data Base Memory) generates simulated "movies" in 2-second, 8-second or 32-second sequences of non-repeated imagery at 30 frames per second (TV display rate.)

The third card allows full-frame array processing of individual video frames.



- 64 Image input ports
- 3 Image & 1 graphics output port per user station
- Image port is 8 bits deep => 256 brightness shades
- Graphics port is 4 bits deep => 16 graphics colors

Image Control

Multi-image Pipeline Processors

The "Image Control" diagram suggests how Multi-image Pipeline Processors produce color implementation and variations in display. This control can cause local brightness variations in the displayed image with accuracies down to a single pixel level. (This allows **small area** correction without modifying surrounding display data.) The pipeline processor also produces desired colors in the display by selecting combinations of red, green or blue channels.

ing an image. For example, understanding an airport in a reconnaissance image is extremely difficult for anyone who has not flown at high altitudes or observed aerial photography.

"Simple segmentation of an image into its homogenous parts, a task performed consistently by humans, is still extremely difficult for a machine. The acquired experiences of professional viewers (photo interpreter, criminologist, radiologist, cytogeneticist or materials inspector) are probably not possible to duplicate in machines of the near future. But research is sure to provide insights to this task. Payoffs and rewards will be great once success is achieved.

"As an illustration of the difficulty of automating even the simplest task, consider the problem of edge detection. Humans constantly encounter edges in their viewing experiences, but how does one define an edge? If it is a difference in shades of gray; how different? If it is a difference in texture, how does one define texture? Once an edge operator is developed and an image is processed by that operation, the machine acquires an array of pixels whose amplitudes represent 'degree of edgeness'. Simple thresholding of such edge magnitudes results in a pattern of binary pixels. Humans readily 'connect the dots' of the pattern to define the edge, but machines are still unable to make such con-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nections. Progress is painfully slow in the simplest essentials of image understanding; but rather than poor research, the fault lies with grandiose objectives."

This consideration of differences in viewing images is remindful of English philosopher Richard Bentley's description of this phenomenon. "Consider how we all differently look at objects," he wrote, 300 years ago. "And consider, also, how different animals see the same image in different ways. What you see depends on who you are. A dog for instance, watching a human walking away from him, decides, logically, that when a man walks away, he shrinks in size." And Bentley could have added that a human never views an animal bone with the same passion as does a dog.

The CSP company, where Comtal's special demonstration was being held, currently operates from its new plant in Burlington, Mass. This particular area of Massachusetts, lying about 15 miles to the north of Boston and forming part of the "computer belt" which begins at the edge of Rhode Island and runs all the way to the New Hampshire border, is currently being described as the computer center of the world. More than 1,000 computer companies, turning out everything from complete systems to silicone slices, are operating from this area. Most of them are in new buildings, none more than 10 years old. Emphasizing this claim of world leadership is the help-wanted section of the Boston Sunday Globe. Usually, more than 50 pages of classifieds appear in that paper and most of the ads are seeking computer people in a wide range of titles from keypunch operators to systems designers.

Both Comtal and CSP are representative examples of the increasing family of such sophisticated computer systems that are beginning to spring up in the industry. It is significant that one of the recent Nobel prizes was awarded to two scientists because of their work on a CAT-scanner, a device closely related to the image processor. The CAT scanner displays on a CRT, a slice of tissue of the human body and subjects it to digital analysis. The CAT (Computerized Axial Tomography) was first developed in Great Britain and was introduced in the United States in 1973. Growth of its use has been extensive since then with more than 1300 such scanners in use in the States today.

In general the function of both graphics display and array processors are closely related. They analyze a CRT display in full color or in black and white. The type of analysis performed is dependent on its highly sophisticated ROM content and its newly designed architecture.

The advanced sophistication of an array processor like CSP's was shown in a ping-pong-ball demonstration. Six balls were blown about on an illuminated panel by a fan. A camera, trained on the swirling balls, located the ever-changing center of gravity of these moving balls by pipeline calculation and "fixed" this center as the intersection of the X and Y coordinates. As the balls swirled about, the coordinate-focus followed the moving center of gravity, precisely locked on the imaginary target.

The specifications for a typical image processing system, like Comtal's include:

More than 400 million bits of refresh data for image processing. This "refresh" characteristic of the system permits display of an image, storing it in memory, adjusting it by operator commands, displaying the new image, recalling it, further adjustment, further display, and high-speed iterations in this manner until an objective is reached. Any of the images, including the original, can be recalled at any time and reworked to a different pattern, zoomed, rolled, paged, dissected, etc. The complete list of specifications that defines the average image processor can be seen from the accompanying table of Comtal's technical specifications.

The RAM Refresh Memory of an image processor is usually a 512x512x1 bit plane cycling at 10 megapixel/sec (10 million picture elements per second.) Four such planes stacked together provide 1 million bits of 16K RAM or one-half an image plane. The full image as used by Comtal requires an eight-plane array. These image-refresh data boards permit the user to roam the data through a 512x512 monitor window or through one that is 1024x1024. The data can be displayed in monochrome (eight bits deep) or color (24 bits deep) at the TV rate of 30 image frames per second.

The control of Comtal's refresh memory is handled by three separate I/0 card types. Most active of these three cards is the "image refresh data base control card (REFC)." The REFC card defines offset values for each memory card to permit free-roaming. It is a raster addressing circuit board that extracts the starting pixel (upper left hand corner) of each image plane at that roam location. Because this address can change as rapidly as 30 times a second (TV frame time) one can roam quickly with respect to viewer response. The REFC card also provides zooming for both 2x and 4x magnifications at any location in the memory. Because roam addressing can be changed as often as 30 times per second, loop movies are possible. And by introducing a slower-sequencing control, slow-motion movies can be obtained.

Other capabilities possible with this system include left-right, right-left, up-down or down-up scrolling; freeze framing; annotating; labeling; outlining; and color correction of arbitrarily shaped multiple small areas.

Probably the most significant characteristics of current image processors is the newly-designed architecture with its multiplexing of data channels; pipelining of processors; use of high speed refresh memory chips and the perfection of very high resolution color shadow masks and monochrome monitors.

The pipeline processor, which forms the essential part of the significant architectural skeleton of the system, consists of functions contained in hard wired tables. These tables are connected to each possible image and graphics plane in the refresh memory. (See system block diagram.) A 64-image system (4096x4096 pixels) contains 64 tables (each, 8 bits x 8 bits). By wiring a single image plane to two different function memories and loading them differently, one can achieve local brightness variations in the displayed area with accuracies down to a single pixel level. This feature is known as arbitrarily shaped small area correction and allows the user the ability to enhance local structure in an image without modifying the surrounding data. This capability was dramatically shown at the Comtal demonstration by displaying the previously mentioned bouquet of roses in a changing palette of full color, and then coloring an arbitrarily selected single rose in the bouquet in a progression of changing colors.

Contemplating the perpetual commotion of the universe, one can surmise that if the human mind could stand still for awhile in this world of constant motion, then one might deduce where we came from and where we're going. Lacking that possibility, one can only look at these pending marriages between array processors and image analyzers for a possible clue to such elusive answers.

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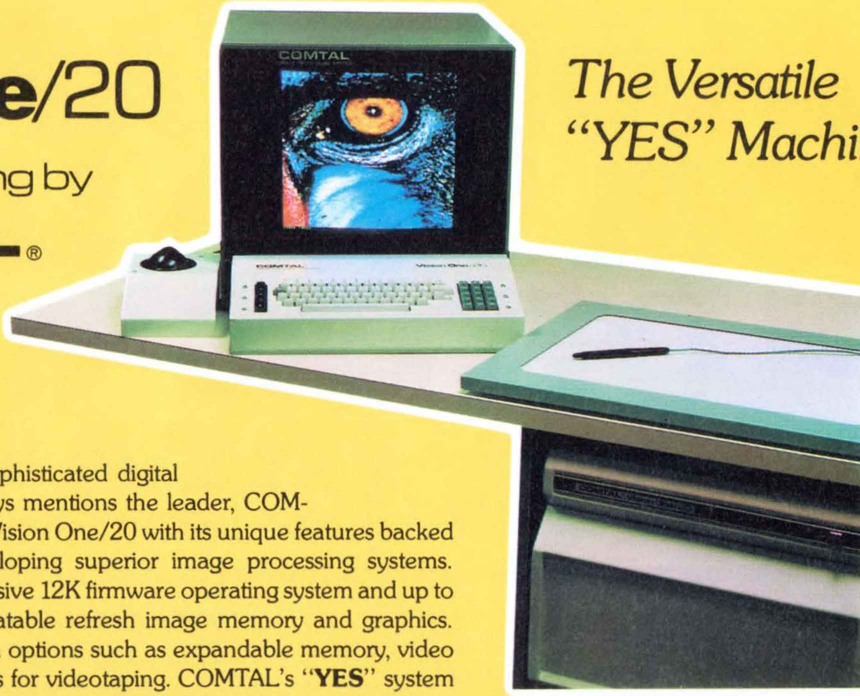

Professional talk about the most sophisticated digital image exploitation equipment always mentions the leader, COMTAL. ☐ **YES**, and that includes the Vision One/20 with its unique features backed by the experience gained in developing superior image processing systems. ☐ **YES**, Vision One/20 has an exclusive 12K firmware operating system and up to 48 megabytes of dynamically allocatable refresh image memory and graphics. ☐ **YES**, field upgradeability through options such as expandable memory, video input and output, as well as TV rates for videotaping. COMTAL's "**YES**" system requires a minimum of training for effective utilization. Other options such as magnetic tape and disc storage are available. Specialized image processing hardware is available for image arithmetic combination, convolution, Landsat classification, plus small area color correction, and all function in real-time, in 1/30 second. ☐ **YES**, all this—in a system that can accommodate future growth as application requirements expand. Multiple user capability, up to 4 work stations, offers resource sharing. ☐ **YES**, with COMTAL's leadership pacing the state-of-the-art, it adds up to flexibility now—and flexibility later. ☐ **YES**, Vision One/20 image processing systems have dual-ported random access memories starting at 512x512 pixels at multiples of 4 bits of brightness depth, with growth up to 4096x4096-24 bit pixels. ☐ **YES**, random access refresh memories are constantly growing in size and shrinking in cost. Digital image rotation is a reality now. ☐ **YES**, a 24 bit x 24 bit color computer is available for image composition, as is independent arbitrarily shaped small area processing capability in monochrome and color. There's high resolution digital stereo and instantaneous—1/30th second—convolution for filtering. Or, bigger filters exist by recursively iterating and updating kernels 30 times/sec. ☐ **YES**, Vision One/20 provides stand-alone full feature image processing as well as the ability to interface to numerous host computers. ☐ **YES**, dynamic refresh memory partitioning allows for different applications. ☐ **YES**, real-time roaming, with window sizes 512x512 pixels or larger, through the data base, as well as 2X and 4X zooming and 3x3 convolution at 70 MIPS—all implementable in real-time. Ask about the future of image processing from the company with renowned research experts, hardware experts, firmware experts and software experts. COMTAL's field service offices on the East and West coasts are there to help users. ☐ **YES**, successful sales representation worldwide as COMTAL triples its present production capacity in new facilities.

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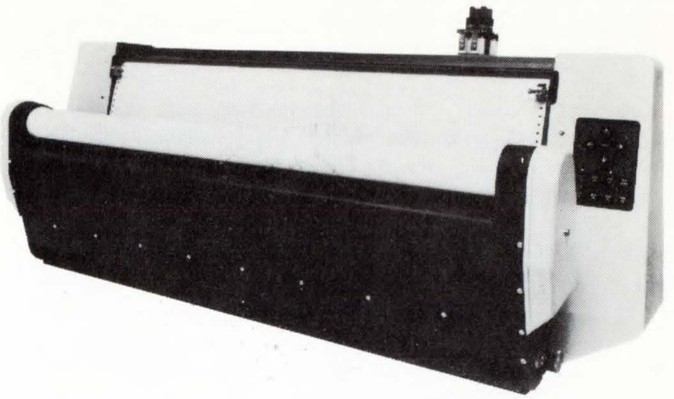

Morris Samit

Lower costs and increased variety to come

1979 was a year of marketing and positioning movements. While product enhancements and improvements certainly occurred, there were no unique developments. Since changes were due to marketing and financial activities, the hectic activity in the plotter industry resulted in plotter companies now able to offer almost a full line of plotter devices.

While both electrostatic and pen plotter usage is growing, independently, there are now three companies (Houston Instruments, Calcomp and Benson-Varian) able to offer both types of plotters. A number of pen plotter manufacturers were active. Versatec still was the leader in electrostatic plotters. Benson-Varian evolved from the acquisition of the Varian electrostatic plotter line from Varian by Benson, S.A. of France. Benson has long been a leading plotter manufacturer in Europe and used this opportunity to introduce its line of quality plotters to the U.S. The new Varian-Benson organization now can supply both kinds of plotters to all its users. The new input of Benson financing to this organization has spurred marketing activity and should make this company a strong force in the plotter industry in the U.S.

Much attention during the past year has been focused on developments at Calcomp. While Calcomp divested itself of a number of its operations, clearly of interest to the graphics industry has been the proposed but much delayed acquisition of Calcomp's graphics activities (Sanders owns 35% of Calcomp). This transaction creates a powerful entity in the graphics industry in as much as Sanders is already an established manufacturer of graphics displays. Calcomp, in addition to its well known reputation as a manufacturer of plotters has, for the past year, been selling a complete computer graphics system. Concurrent with these activities, Calcomp has embarked on some other roads to strengthen its position as a graphics marketing company. With a loan from Sanders, Calcomp purchased Gould's electrostatic plotter division, thus affording Calcomp the ability to provide both electrostatic and pen plotters. In another move, Calcomp, which initially sold plotters using manufacturers' representatives, and switched to its own direct sales force as the company grew, has now with one of its product offerings, the 1012 plotter, gone back to selling, using reps. This move should create greater sales activity for this low cost plotter, with the more expensive plotters still to be sold by the Calcomp direct sales force. Obviously, there are many questions in the minds of users, reps and competitors.

New plotter companies attracting attention during the past year are Logic Systems and Soltec. Logic Systems, though not a new company, has reintroduced its improved line of desk-top self-contained drum plotters which feature a programmable graphics processor. The unique feature which Logic Systems is touting, is its singular ability to draw true curved lines in one continuous motion rather than as a succession of short incremental vectors. The Soltec plotter is a small, low cost, flatbed with many features including three pens of different colors and widths. Other new plotters have been introduced by Tektronix which has actively been marketing a multiple-pen flatbed that can produce C-size drawings, and Hewlett-Packard has added to its 9872 model the ability to handle roll-feed paper which is automatically cut to size, either 8 1/2" x 11" or 11" x 17". This multiple-pen plotter stores the pens, accessing each as needed. The Tektronix and Hewlett-Packard plotters are primarily intended for the use with the manufacturers' own equipment in small low cost systems and represent further enhancement of the position of each as a computer graphics system supplier.

Special attention must be given to the development of systems by both plotter manufacturers and manufacturers of other graphics products. It appears that both small and moderately sized peripherals manufacturers as well as large multiproduct-line companies such as Tektronix and Hewlett-Packard see the future of computer graphics in being able to offer low cost graphics processing systems rather than mere peripherals. Therefore, we have seen many such companies by acquisition, licensing, or in-house manufacture produce hardware and software combined into complete systems. The most prominent have been the systems offered by Tektronix and Hewlett-Packard. Calcomp has very actively marketed its IGS interactive graphics system.

Graphics systems normally consist of, besides software, a digitizer, a graphics display, a processing unit, and, of course, a plotter. As other graphics peripheral manufacturers, such as those manufacturing digitizers and graphics displays, have added hardware and software to produce a complete system, so have plotter manufacturers.

Calcomp, as mentioned previously, has been the first with its emphasis on its graphics system. Capitalizing on its well established representation as the leading plotter manufacturer, Calcomp should find a willing purchasing customer base.

Zeta has recently entered the systems field via its acquisition of I Corporation which produces software for printed circuit board layout. The system utilizes Tektronix hardware. The software and hardware combined with the Zeta plotter will now permit Zeta to offer a CAD system. Not only will the forthcoming year see increased emphasis on their systems by Calcomp and Zeta, but systems activity should be of great benefit to the user who, rather than having to configure his own system by purchasing a number of peripherals, will be able to get support from a single source. Systems houses will enter the graphics market by assembling systems for special disciplines. Of course, the independent plotter manufacturers will also benefit by attracting new system houses, users, and OEMs.

Though the major application use of plotters is in general graphics, CAD, cartography and research, there will be more plotters used for business graphics purposes producing bar charts, pie charts, histograms, wave forms, etc. Business graphics is particularly suited to major corporations and financial institutions to replace long tabular reports with easily read and understood graphic representations. Much of this activity is being spearheaded by increased media interest and advertising of Hewlett-Packard and Tektronix. Most of their developmental efforts and advertising are specifically slanted to the business graphics market. With this greater awakening of user interest in business graphics there will be increased potential for both electrostatic and pen plotter usage.

Greater emphasis has been placed on color among plotter manufacturers and users in keeping with the emphasis required by the industry for color visualization be it on graphic displays or on hard copy. Most plotter manufacturers now produce plotters of small and large size that can produce multicolor output. There has been an increase in plotters sold with multiple pens. This capability has so far been limited to pen plotters and not electrostatic plotters.

One development that has caused much interest has been the color output plotter from Trilog. This device produces color plots by using a dot printer with a multi-color ribbon.

The μP was incorporated into system controllers with programability to allow user utilization of existing software. Software development will increase to make the plotter independent of the software. Heretofore, each plotter had its own software package, usually designed for IBM 360/370 computers.

Where 1979 was a year of marketing movements and business growth planning activity for plotter manufacturers, spurred by the increased recognition of computer graphics, 1980 should yield emphasis on product improvements, more user support, greater programmability, lower prices, more systems and increased competition — all benefiting current and future users.

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Small System Printers

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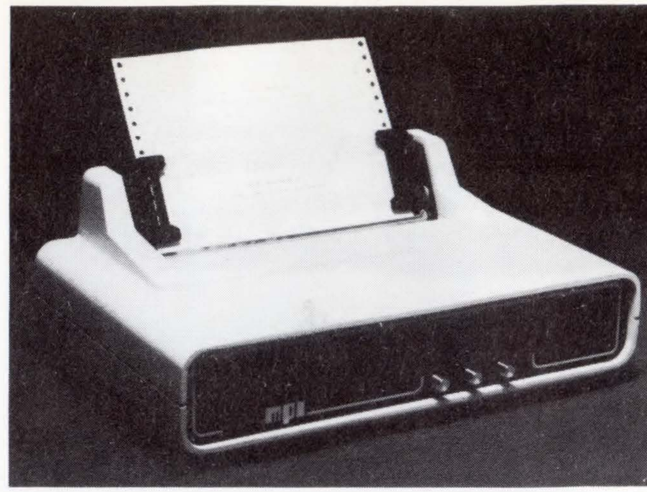


Explosive market in small system printers ignores old rules

The year 1979 has witnessed the near explosive development of a totally new market for the printer industry: the small system printer. This market development has been a source of joy, despair, concern, indifference and even contempt for the marketing manager of practically every major printer manufacturer. It has enticed new entries to the hardcopy world while driving some contenders out. It has defied analysis by some of the most competent marketing organizations in the printer business which have been unable to make it conform to the rigid rules and standards they have developed from years of experience. All of these symptoms are the result of the creation of a new market rather than an extension of an old market. Businessmen and professionals from a broad spectrum of disciplines have been attracted to the magic of the computer. Individuals who have never been directly involved in the computer industry do not conform to the traditional "computer user" mold. Having heard the powers of the mysterious computer being universally praised, they have decided that it too can be the answer to their problem. The success of the TRS-80s, Apples, Pets, etc. in educating them to the availability of an "affordable" computer system to solve their problems has fueled the sales of small systems to undreamed of heights. It has also led to the realization that the usefulness of a system is directly proportional to what you get out of it, and a printed copy is the most direct means of getting it out. Estimates of the add-on-sales for printers as a percent of the original system sales is as high as 71%. A projected small system market value of $2.4 billion by 1982 then translates into the emergence of an enormous market for a low cost printer that can meet the qualifications.

MANUFACTURER	MODEL	TYPE OF MECHANISM
Anadex	DP-8000	Impact Wire
Compuprint	912	Electrostatic
Centronics	730	Impact Wire
Data Royal	IP-5000	Impact Wire
Epson	TX-80	Impact Wire
Heath	WH-14	Impact Wire
Intergal Data Systems	440	Impact Wire
MPI	88T	Impact Wire
Okidata	Microline 80	Impact Wire

Manufacturers of under $1,000 small system printers.

At the beginning of 1979, the number of printers fitting the small system requirements were easily counted on one hand with a few fingers left as spares. None of these manufacturers have moved down from the general computer printer markets. They were relatively small companies who had recognized the potential and were able to react faster than their larger cousins. The NCC show in June signaled the true beginning of the race. No less than five under $1,000 printers were introduced either at the show or shortly before. The list of entries has now grown to at least nine companies and includes such industry notables as Centrionics, Data Royal and Okidata. The number of entries that have moved *up* into the small system printer market still outnumber the printer industry stalwarts with the latest tally being six new entries into the field and three veteran computer printer manufacturers.

The hardcopy requirements of a small system cover a broad range of usage that must be met by a single printer. The small system cannot afford specialization in its peripherals if the system itself must perform a range of applications. The fully formed character printers are ideal for letter-quality printouts, but the initial cost and size preclude them from all uses except those requiring the printout quality. Other types of printing techniques such as ink-jet, chain, zerographic, drum and laser can only find use in systems requiring higher speeds that can justify the increased costs of the mechanism. The low cost criteria has resulted in the emergence of three basic types of mechanisms, all using matrix printing techniques in which a print head is driven serially across the page forming a dot matrix character in either single or multiple passes. They are the ther-

mal, electrostatic and impact-wire matrix printers. Each has its own advantages and disadvantages. The thermal and electrostatic units can use lightweight print heads which can be zipped back and forth easily at high speeds for fast thruput and are virtually silent. The thermal unit can use coated paper to give several choices of colors and with copy almost indistinguishable from impact printers. The electrostatic units print excellent copy at very fast rates, but are saddled with aluminized paper. Both can be used for many small system applications but share the same serious drawback. They are non-impact and cannot make multiple copies. The serial impact-wire matrix mechanism is slower and generates more noise, but it can handle a variety of forms while making copies.

Analyzing the different functions required of the ideal small system printer, the following basic requirements are evident: 1) It must print a minimum of 80 columns on 8-1/2" paper 2) It must be capable of printing on a variety of forms, such as checks, invoices, etc. 3) It must be capable of making a minimum of one original and two copies 4) It must have paper handling for using preprinted forms 5) It must be reasonably reliable, and 6) It must represent a small percentage of the overall system cost. This leaves the serial impact-wire matrix printer as the prime contender for filling the hardcopy needs of the small system. All but one of the major entries in the small systems printer market utilize an impact-wire matrix printer.

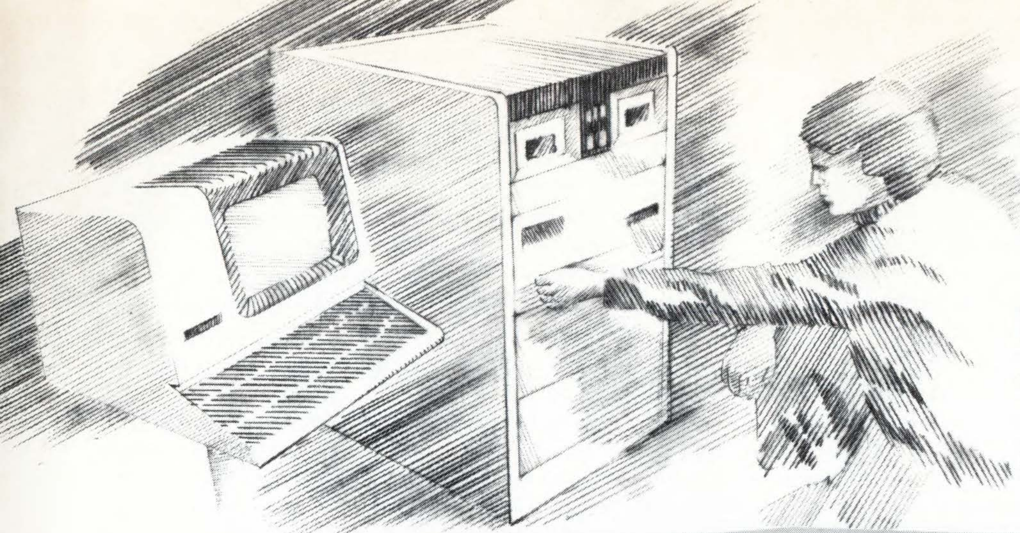
The low cost restriction places a severe restraint on the design of a printer. Cutting build cost does not necessarily imply a low-cost unit if it results in more service and maintenance. Reliable operation is a must for the system using one printer to cover many functions. True low cost is achieved only through a sophisticated marriage of mechanical and electrical components. Careful design can reduce the number of components required to accomplish the job and enhance the reliability of the unit. The emergence of the microprocessor has given the printer manufacturers a powerful tool to accomplish in the electronics what was previously only practical to do by mechanical means; bidirectional printing that doubles the thruput with no increase in mechanical complexity, stepper motors giving precision control of head drive and paper handling, character sets and densities that can be changed instantly and many more innovations limited only by the imagination of the software engineer.

Development of the low cost printer during the past year has seen the extensive use of available technology to reduce the cost of previously expensive components. Each mechanical component has been analyzed and optimized for the specific needs it must fill. Print heads that were designed for calculator-type machines were found lacking in performance and reliability; ones designed for higher speed computer printers are not cost effective for the application. Print heads are designed to be mass-produced for the new breed of printer. Head drive systems have a minimum of moving components and frames use precision stampings rather than costly castings. Paper drive components are made to assume the double duty of friction and pin-feed applications. All of this implies the development of completely new components specialized for the particular application. Seldom can existing components used in older printer designs be made to fit into the strict constraints of the price/performance ratio of the small system printer.

A review of the prime contenders for the market gives a quick insight into the advances and technology being used to custom fit the serial impact-wire matrix printer to the small system applications. The clapper print wire drive has emerged as the predominant technique. Careful selection of materials along with precision injection moldings has producted heads with lifetimes exceeding 100 million characters and quantity one replacement costs under $40. Seven wire heads predominate even though they cannot give the print quality of nine wire versions. They involve 22% fewer coils, print wires and driver circuits giving lower cost and increased reliability. The fewer number of components also results in a decreased mass, producing less strain on the head drive parts. The head drives are designed for constant linear velocities using AC synchronous, servo controlled DC, or pulse driven stepper motors. The new low cost stepper motors used in conjunction with the microprocessor offer a prime example of the use of microprocessor technology to enhance the capabilities of mechanical components. Requiring only one-half of an eight bit output port to control the stepper motor, the head velocity can be placed under software control to give an almost infinite number of character densities. It can be wave-stepped, half-stepped and even reversed to give absolute control of the head position without any increase in component cost. Character thruputs range from 50 to 150 characters per second using the microprocessor to control the stepper while formatting the data for bidirectional printing. The paper handling techniques also offer the opportunity for improvement in the cost/performance ratio. The simplest method used is to advance paper synchronously as a by-product of head motion, however this places a severe restraint on the system thruput as the head must complete one print cycle to advance paper one line, resulting in an unacceptable paper slew rate. Independent paper control overcomes this objection but at the cost of additional components. The two common types of paper drive techniques used are the solenoid driven ratchet and the stepper motor designs. The solenoid ratchet is simple and effective, but is limited to the number of lines per inch as dictated by the number of detent positions in the ratchet designs. It also involves the jerky motion caused by the pulsing of the solenoid, resulting in pressure contact points and high paper acceleration. Again, the low cost microprocessor controlled stepper motor offers many advantages and unique possibilities. Using the remaining four bits of the output port left over from the head drive stepper motor control, the paper drive stepper motor allows precise control of the paper movement, allowing any number of lines/inch desired at resolutions of a fraction of a dot position. True graphics may be performed since the positioning can accurately cover any vertical dot position on the paper. The vertical paper movement can be done at fast rates for quick paper movement such as forms ejection or at slow rates for properly positioning forms in the printer.

Three different philosophies are represented in the paper drive mechanism. A friction feed using a pressure roller is used for roll paper or cut sheets. Sprocket hole paper is driven accurately by adjustable tractor devices or pins placed at the ends of a typewriter-type round platen. The tractor drives pull the paper past the print head and can be adjusted to accomodate any paper width. The pin-platen drives offer almost immediate access to the last printed form, but are limited to a fixed sprocket-to-sprocket width, limiting the usable form size that can be accomodated. Several of the new printer offerings incorporated both a friction and sprocket feed system, allowing the user to select the type of paper used.

The magic word for any interface design is compatibility. The general computer industry can thank IBM for providing



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The Raycorder Cassette Terminal Model 6801

The Model 6801 Raycorder Cassette Terminal is a dual-cassette operating system capable of reading, writing, and copying data at switch selectable rates from 110 to 9,600 baud through a full duplex, asynchronous RS232C interface.

Operating under the control of a microprocessor with up to 4K of firmware, the Model 6801 has designed-in versatility never before available in a system of this type.

Connected to a serial port of a DEC PDP8 or PDP11 and given the proper address, it will emulate the typical paper tape reader/punch and perform the functions of program load, data logging, assembly, edit or duplication. Select one of two Texas Instruments Silent 700® modes, and tapes can be written, read, or copied that are completely compatible with the 733ASR but at much higher data rates.

With its extension connector, the Model 6801 can be connected to any RS232C port without disturbing the device formerly connected there. With this feature, for example, tape storage can be added where only hard copy print out or CRT display had previously existed.

Utilizing two of Raymond's time-proven 6406 Raycorder cassette drives, the Model 6801 provides the ultimate in a reliable, flexible data storage and handling device for a multitude of applications. Detailed specifications will be provided on request.

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Raymond's small tape drives, long the standard of the industry, are now available with all new electronics that make interfacing a cinch.

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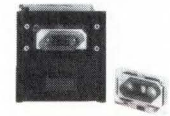

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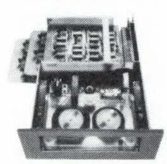

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(or forcing) worldwide computer I/O standards. However, the lack of an overwhelmingly predominant personality in the small systems industry to enforce such a standard leaves the door open for experimentation. Fortunately, most of the system manufacturers have recognized the importance of insuring an adequate supply of peripherals for their systems. The easiest and least expensive method of meeting this goal is to use common interfaces supported by many peripheral manufacturers. For a printer, this turns out to be the async serial interface or the 8-bit Strobe/Acknowledge parallel port made popular by Centronics. The few computer manufacturers who could not resist the temptation to be different have generally ended up having to develop their own printers or paying a premium to have standard interfaces adapted to meet their special requirements. The ideal situation for the lowest cost interface design is to have only one interface version for all applications. This is not practical for the small systems market since two different interfaces are commonly used. Another solution being provided by some manufacturers is the inclusion of both the serial and the parallel interface in one design. The dual interface approach takes on added significance with the increased role of the distributor in small system sales. Instead of stocking two different models of the same printer, one dual interface version is stocked. The distributor's inventory costs, configuration problems and spare parts stock have been minimized while the printer manufacturer has lowered the build cost. Profitability has been increased at both ends of the distribution network.

An expensive printer attached to a large system can justify scheduled customer service visits for periodic maintenance. It does not, however, take many of these visits to equal the original cost of the new small sytems printer. A different concept must be developed for handling service requirements. The new printers have established several trends in the area of maintenance and repair. All have intelligence provided by a microprocessor controller, allowing them to provide self test features in addition to the normal controller activities. The self test capability coupled with the increased use of operator replacable components and a reference to a trouble shooting chart allows the operator to quickly repair a malfunctioning printer. The more obstinate cases can be taken care of by a short trip to the local distributor repair facility, which is less of a problem with a 15 pound printer as opposed to the 50 pound plus weight of the older printer series. The reduced complexity of the interface circuitry made possible by the microprocessor allows all of the electronics to be consolidated on single printed circuit board assemblies with a resulting reduction in the interconnecting cables and associated problems. The simpler designs with fewer components result in increased reliability and lower repair costs.

Looking ahead to the coming year, many of the trends established during 1979 by the small system printer manufacturers will continue to evolve. The availability of faster and more powerful single chip microprocessors will result in the incorporation of more capability and features in the basic units. Complete forms handling will be offered, reflecting the demands of the small business user. Multiple character densities and fonts controllable via host command will be available in the new offerings. Stepper motor usage will increase and drive the cost of the motors even lower, making them irresistable for new designs. The small business system and the small word processors will slowly merge into a single system since most users have requirements for both types of systems. This will increase the demand for letter quality printers which can serve both functions.

The mechanism usage will continue to be dominated by the serial impact-wire matrix unit. It will be refined to allow multiple pass printing techniques to enhance the letter quality and open up the vast word processing field. The latter part of the year will see the emergence of low-cost full-width 132 column printers using the same cost reduction techniques developed by the 80 column mechanisms.

One of the most important continuing trends will be the increased usage of the regional stocking distributor as a vehicle for meeting the needs of the new market. Small systems are used primarily by small users that can be more economically serviced by a local distributor. It is not practical to use the same techniques to service his needs as is used for the large OEM accounts. Instead, the printer manufacturers will increase their dependence on their distributor network to provide a damping effect on their production schedules and provide increased level of service and sales support. In return, larger distributor margins will be allowed, reflecting the increased importance of distributors in their marketing philosophy.

We will see the emergence of four manufacturers during 1980 that will dominate the small system printer market. They will establish their market share on performance, cost, and quality. Other manufacturers will comfortably exist only because of the inability of the leaders to provide enough printers to satisfy the explosive growth of the market.

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Printers

Peter M. Craig
Printronix, Inc.

Printers to exhibit greater flexibility and intelligence

Adaptability of printers to meet application needs of 1970 resembled Henry Ford's selection of paint for the Model T. Except for the pioneers in pen plotters, the application was either printed in 10 pitch, 6 lpi or it probably wasn't printed at all. Printer flexibility and system engineers' alternatives were nil. The microprocessor and LSI changed that.

Flexibility grows

LSI and μPs offer system engineers a vast array of printer alternatives. The application of technology will serve to enhance the flexibility of printers, to enable economic use of new imaging techniques for hard copy creation and reduce expenses presently associated with "non-standard" output. No longer will systems engineers be chained to 10-pitch, 64-character alphanumberic output; instead systems engineers will generate output symbols of a size and style suitable to the user of the output.

This flexibility emanates from basic changes to each principal subsystem within the printer – image generation, control electronics and interface electronics. **Image generation** in this context refers to the technology of the basic mechanism: impact solid font, impact matrix, non-impact thermal, et cetera. **Control electronics** technology refers to those electronics which pertain to character/symbol/image selection and which cause the image generation mechanism to select a specific symbol. **Interface electronics** technology refers to how the printer communicates to the outside world, what information is received, how it is to be formatted, and what support is required by host systems to generate useful images. Each of these areas will see major evolutions from that with which we are presently familiar.

Evolution of image generation

The image generation subsystem is the most visible (no pun intended) of the three subsystems. Indeed, when we think of printers, we almost reflexively classify them by their image generation technique. Most commonly, we divide printers into *impact and non-impact* technologies, with non-impact printers dominating both low-cost/low-performance applications. The vast majority of mid-range applications are the domain of solid font and matrix impact printers.

While this application division is expected to remain, boundaries defining where impact versus non impact dominate will migrate; and within the impact application domain, a significant shift to matrix should occur.

Solid font impact printers – currently epitomized by band printers and daisy wheel printers for line and serial descendants of long-term printer technology. In some cases, they are charac- nology. In some cases, they are characterized as late generation mechanized Gutenberg presses since they physically move a font past paper and electronically select the character to be struck as it comes to the appropriate position. While the band and daisy wheel implementations enjoy both price and performance benefits over their solid font predecessors, many experts feel they are the last generation of solid font printer products. Why? For a number of reasons. First, they are *mechanically more complex than matrix technology*. In some cases, the additional complexity increases moving parts by 50% and carries an associated reliability and maintenance burden. Worse, they can't adapt (inflexible) to emerging output requirements. The solid font printer's symbol repertoire is limited to what's embossed on the wheel (or band); and although these are more easily changed on daisy wheel and band printers than drum printers or teletypes, they still require physical operator (mechanical) intervention to do so.

This restriction is a burden to users, systems engineers and vendors. By the mid-point of the decade, users will shift the workhorse role from mid-range-speed applications to matrix line printers supplied by Printronix, Tally and others. These units today are characterized by simplicity, durability and flexibility to construct symbols and images due to virtually unlimited dot placement. They are a dramatic improvement over early-1970 vintage matrix printers.

Poor print quality was associated with matrix. Today, matrix techniques offer improved print-quality standards for multi-part forms. The only clear bastion of solid-font technology that remains today is WP letter-quality printing, where due to limitations on dot size and ribbon weave, matrix techniques can not produce the crisp, fine lines that are aesthetically necessary. Will this last stronghold of character printers remain? Experts expect it to fall into the mid-1980s to ink-jet technology with major inroads caused by multi-pass, impact-matrix printing (of the Sanders-type machine).

Matrix Mechanisms In 1980

There are two types of matrix printer: those with a set of hammers arranged vertically and those with a set of hammers arranged horizontally. With a vertically-oriented print head, vertical hammers traverse the paper from left to right, making dots.

With this method, all characters in one line are constructed together, and are finished together. The Printronix and Tally printers are examples of horizontal printing and are called line printers.

Since paper in horizontal printing is incremented one dot row at a time, it is possible with this printer to print lower case characters, such as g, j, p, and y, with descenders or tails below the character line and printed in the space between lines.

Non-impact technology costs range from very low (electrosensitive and thermal) to very high (laser and xerographic), with ink jet in mid-range. As with impact matrix, since all of these technologies store their symbol repertoire electronically, they all are inherently capable (when driven by appropriate control electronics) of a wide range of fonts, sizes and application-unique symbology.

As such, they are natural technologies to dominate their respective cost/performance ranges. In particular, casual usage single copy, transaction printers and teleprinter applications will be increasingly dominated by low-cost, non-impact units. At the high-cost/high-performance end, laser and xerographic page printers are rapidly reaching into the domain of what was formerly the high-speed (2,000 lpm) impact printer. These non-impact technologies should bring forward products in the 10,000-lpm-performance range at end-user price levels associated with 1200-lpm-impact printers by the mid 1980s. By the end of the decade, virtually all high-speed printing associated with centralized report printing may be done with laser or xerographic technology.

Will ink-jet technology replace the daisy wheel as the office automation/WP printer? Probably, since it offers all the font flexibility of matrix technology and is silent. With increasing emphasis on usage within an office environment, users want quiet printers.

Image generation technology will shift away from solid fonts to flexible-font printers within a few years. They offer flexibility, reliability and price/performance that will improve.

Control electronics evolution

One reason behind matrix-oriented impact and non-impact printers' success is the ability to economically print incrementally, i.e., they generate a symbol via dots or other segment increments. This would be impossible without LSI, RAM, ROM and μPs. It is only when the image generation mechanism is under μP control that the true range of flexibility (symbol size, shape, style and location) are realized. Although only the leading edge of applications are benefiting from this, the future is clear: with virtually unlimited symbology at system engineers' disposal, demand for application-significance will soon create a tremendous demand for intelligent printing devices. By the mid 1980s flexible μP-based output formatting units will drive the basic printer mechanics for a significant and increasing portion of the applications.

Interface evolution

How fast can new peripheral capabilities be assimilated? It depends on whether system vendors can provide supporting software. μP technology is an evolutionary catalyst: it permits high-level functions to be "installed" into the printer. In this fashion, systems software support requirements will be reduced to send only function command codes and parametric data (such as symbol selection, size, location). Will selection of high-level functions to be installed be limited to those which can be pre-programmed into a printer at the vendors' factory? No, since the natural evolution of networks and distributed data processing will be to down-line, load-application-oriented, output-generation firmware routines, and symbology repertoires to the printer. This provides an enormous shift of processing power from the host CPU to the peripheral with the attendant benefits of reduced host overhead, ability to edit reports and output locally to requirements of the final user location and ability to flexibly configure the output symbol repertoire as required by the immediate task at hand.

The 1970s saw the intelligent CRT; the 1980s will see the intelligent printer.

Significance to users

These advances will have an economic and application side. First, raw cost of hardware should decrease. Users will see only a portion of this decrease, since printer vendors will add considerable value with added intelligence (particularly for mid-range line printers). The most dramatic price breaks will occur at the low- and high-speed extremes due to non-impact techniques. Exact dollar projections vary due to inflation and other economic uncertainty (particularly the cost of plastic), but at the low end, we can expect a price shift similar to what CRT's experienced from 1974 to 1979. At the high end, a dramatic drop in non-impact page printer prices can be envisioned by mid-decade.

Most significantly, the productivity associated with information systems will increase dramatically because of the expanded usefulness of the hardcopy printer. Specifically, systems engineers will be able to:

- produce alphabetic symbols of any size, shape, font and at any location on the form,
- produce non-alphabetic symbols such as bar-codes and special handling markings,
- generate bar charts, pie charts and graphs instead of tabulated numbers for reports,
- produce multi part business forms directly on standard stock paper,
- generate all transaction documents in shipping/distribution applications including labels, pick/pack lists and billing/destination papers in a single integrated operation
- produce line drawings for CAD/CAM, process control and other engineering functions,
- produce curves and graphs for management reports and scientific data reduction

all on a single output device at a cost for less than that associated with similar applications today.

Information processing systems will continue to assume a greater and greater role in our daily lives in the 1980's. The adaptation of printer technology to the application requirements will assist in expanding those roles and create the opportunity for as yet unforseen uses. The challenge of the 80's, the age of flexibility for printers, promises to be exciting.

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Digitizers

Warren J. Ridge
Talos Systems, Inc.

1980 will see increased usage of digitizers

Of all computer related equipment, the digitizer is the most versatile as well as the least known, and floppy disks, CRT's, printers, plotters and mag tapes need not consider this upstart a threat to their popularity. Not yet.

The digitizer, simply stated, is a flat surface that senses the position of a pen or cursor on the surface, then registers the exact X and Y coordinates of that position. The coordinates can then be fed to a computer and used to perform a variety of tasks.

The pen is similar to the familiar porous tip pen and the cursor is a free-floating device that is attached by a simple cord (as is the pen) to the digitizer. The cursor has a large viewing window with cross hairs etched on glass to aid exact positioning. It might also have a small calculator-type keyboard with as many as 32 buttons. The keyboard labels unique points, calls up programs, utilizes multiple software routines without moving away from the point being digitized, and performs numerous other functions, all of which increase productivity and reduce operator fatigue.

THEORIES OF OPERATION

The three most common digitizers are electrostatic, magnetostricitve, or electromagnetic.

Electrostatic

This system employs an electrical field radiated from the tablet surface and picked up by a pen or cursor. The signal picked up influences nominal 10KHz sinewave signal source which drives the tablet creating an electrical field. If a difference occurs in the phase of the tablet-driving signal and the resulting signal-picked-up-by-the pen, then the signal source varies up to ±2KHz to null the difference. The frequency of the signal source varies as the pen is moved to various positions on the tablet surface. It is a closed-loop system and, because of high-loop negative feedback gain, the pen or cursor position cannot be moved without detection. The frequency of the signal source is "coherently locked" to the value defined by the pen's physical position.

Direct conversion to digital output from time period is performed without adding conversion errors to the electronic servo output. In addition, automatic alignment is employed to achieve high accuracies. Every time a pen position conversion is made, the entire writing servo is nulled to a zero condition and realigned automatically. This results in a short and long-term stability over wide temperature and environmental conditions.

The system is capable of detecting pen positions through various media that have low dielectric constants, such as paper, wood, most plastics, rubber, and glass. The tablet cannot be used to digitize in proximity with conductive materials such as metal or partially conductive materials such as pencil lead or certain felt tip inks. It can be used with printed pages, photographs, ballpoint pens, plastic-lead pencils, and most other common graphic media. Moisture will distort the operation of the tablet, but this effect can be removed by drying the tablet surface. The tablet is not affected by physical shock, magnetic fields, or acoustic noise.

Magnetostrictive

In this sensing method, a grid of regularly spaced magnetostrictive wires lies beneath the digitizer surface. A pulse is imposed on one end of the wires and a strain-wave is propagated down all the wires. When the wave is detected by the pen or cursor pickup coil, the time between the pulse start and pulse pickup is measured. This value determines the X and Y position of the pen or cursor.

Magnetostrictive sensing is not affected by conductive materials but magnetostrictive ranging does produce accuracy deterioration proportional to increased surface dimensions.

Also, there is a tendency to disturb magnetic bias – by placing a magnetic screwdriver on the digitizer surface, for example. Since magnetic bias is a factor in the propagation characteristics, the surface must be rebiased periodically with a large permanent magnet.

Electromagnetic

The electromagnetic technique uses a principle of magnetic coupling between the cursor and the surface. This technique defines information for the digital circuitry and determines the cursor coordinates. This surface also contains a grid of wires; but, unlike the other two methods, the pen or cursor is the transmitter and the surface the receiver.

The cursor or pen contains a small coil driven by an AC power amplifier. This coil can be considered the primary of an aircore transformer. The secondary is comprised of conductors within the surface area. Surface wires are tied together electrically on one side, providing a common return. On the other side, they are individually selected and connected to a second bus providing a scanned return. These returns are called surface output lines.

When the cursor or pen coil is brought into proximity of the scanned surface, a current is induced in each conductor. This inductor produces a signal voltage across the surface output lines in proportion to the distance between the conductors and the coil. As the conductors are scanned by the output control circuits, the signal at the surface output lines will contain all data necessary to determine the exact cursor or pen location.

When the surface output signal voltage is applied to the receiver circuits, a DC voltage is produced. The amplitude of the DC voltage is a direct function of the original AC signal amplitude. The polarity of the DC voltage is a function of the AC signal phase angle. The DC signal is applied to a zero crossing detector and the output pulse is coincident with the moment of phase angle change which occurs directly under the center of the pen coil. This pulse in the digital circuits produces an equivalent binary or BCD number which defines the pen or cursor location.

The electromagnetic technique is unaffected by conductive materials, temperature, humidity or other environmental conditions and never requires re-alignment or calibration. In the presence of a very intense, unshielded EMI source, inaccuracies may be induced. This can be corrected by moving the digitizer from the source of the EMI.

Surfaces and sizes

Digitizer tablet surfaces are manufactured in a variety of sizes to accommodate the many uses of the instrument. The most popular active surface areas are: 11″ x 11″, 14″ x 14″, 22″ x 22″, 30″ x 40″, 36″ x 48″, and 44″ x 60″. Custom surfaces are also provided when the need arises. Generally, the three smaller sizes are used for graphics input in conjunction with a CRT. The larger sizes are generally used for digitizing.

In addition to the many sizes available, there are other surface materials offered by the manufacturer for special uses. A hard, formica surface provides durability for heavy industrial use; an epoxy poured tablet with wires embedded can withstand heavy physical shock and environmentally harsh surroundings; a laminated glass surface with grid conductors silk-screened between glass layers affords increased accuracy potential because of the mechanical stability of glass; and plastic surfaces offer many uses to the hobby market.

Functional features

Flexibility of the digitizer is not restrained by sensing principle, sizes, and surface materials. Its use is further enhanced by another functional dimension. The epoxy and glass surfaces can be obtained with solid, back-lighted, or rear-projected features.

SOLID Solid surfaces are used for graphics inputs or normal digitizing tasks such as maps, sketches, drawings, etc., where materials being digitized are opaque. The larger sizes are usually mounted on a power drafting base and resemble regular drafting boards.

BACK-LIGHTED Medical applications prompted this design in which the digitizer surface is treated to provide partial translucency. A light-pan, mounted beneath the surface, provides illumination. With this instrument, a doctor can place a life-size X-ray on the surface and digitize the area of a growth. Periodic measurements can be made in this manner to determine exact growth characteristics. The use of the back-lighted digitizer has expanded from the medical area to all areas where such illumination will increase accuracy and decrease fatigue.

REAR-PROJECTED An optical coating is applied to the digitizer surface to allow an image from a projection source to focus on the surface. The digitizing surface is usually turned to a vertical position and a projection machine placed behind it. A typical use would be the projection of a 35mm aerial photo slide.

Operating modes and characteristics

Modes A digitizer will have at least one and sometimes all, of the following operational modes:

Point – When the pen switch or the cursor is activated a single conversion cycle is initiated. This mode is useful in menu selection where such a single coordinate conversion is interpreted as an instruction or selection. It is also used when a CPU is employed to connect coordinates in generating tracings and stroke writing operations.

Run – Sometimes referred to as "Stream mode", the digitizer will send a constant stream of data defining the immediate location of the pen when the pen is in the proximity of the surface (approximately 1/2"). The Run mode is used to output for a plotter or to position a cursor on an interactive CRT. The plotter mechanism or CRT cursor follows the pen position as it is moved over the surface.

Track – This is similar to "Run Mode" except the data stream is sent only when the pen or cursor is activated. Track mode is used when a reduced amount of data is desired and the data receiving equipment has instant response.

True Increment – When conversion of data is desirable, this mode is useful. The stream of data is inhibited if the pen or cursor location has not changed by a predetermined increment. Therefore, when the pen or cursor remains in one place, only one pair of coordinates is sent.

Characteristics Digitizer operating characteristics are often misunderstood and, unfortunately, are often used as determining criteria in selecting a digitizer. "Resolution" is confused with "Accuracy"; "Repeatability" is equated to "Linearity"; and "Accuracy" and "Repeatability" are mistakenly thought to be the same thing. Following is an explanation of each:

Resolution is usually stated in "lines per inch", e.g., 200, 400, 1000, and 2000 which specify the number of X and Y points per inch that can be distinguished. It does *not* mean the number of wires or conductors in the digitizer surface, but rather the capability of resolving the signal between the conductors into distinguishable elements. Therefore, a digitizer with 200 lines per inch resolution means that an identifiable position can be sensed every .005 inch and *theoretical* accuracy could be 99.5% within a 1" sq. area. At 1000 lines per inch, *theoretical* accuracy could be within .001" or 99.9%. The inaccuracy can never be less than the resolution.

Repeatability is the digitizer's ability to indentify the same position on the surface repeatedly with the same coordinates. The error recorded (and there is always an error) can be both long and short term. Short term error is termed "jitter" where the least isgnificant bit (LSB) dances up and down. Jitter is ususally caused by noise; e.g., thermal noise in the amplifiers, noise from a radiated field, or even noise induced from flouescent lights. Long term error is termed "drift", and is caused by thermal expansion of the surface, aging, electrical characteristic change in components, etc.

Linearity is the relationship obtained by moving the cursor on a straight line and moving it on a straight line drawn through plotted data points. The deviation from one to the other – usually expressed in RMS – is the non-linearity.

Accuracy is difficult to define because it is really a composite of such things as linearity, repeatability, resolution, temperature, humidity, atmospheric pressure, time and a radiated electrical field. It is the net result of **all** possible agents acting upon the system. All these things equate to "absolute accuracy", but for practical purposes a "relative accuracy" measurement is used. Relative Accuracy is the fidelity of a distance measured across the entire surface of the digitizer to a reference distance measured with highly exact instrumentation.

These characteristics become very important in selecting a digitizer for a specific use. The use function should determine the degree of error acceptable in the characteristics. For example, if a digitizer is used as a replacement for a joy stick or a light pen to move a cursor on a CRT, a digitizer with resolution of 2000 lines per inch; linearity of .003; repeatability error of .0004; and a relative accuracy error of .005; would be an extreme "overkill". Conversely, a 200 line per inch digitizer would be totally inadequate for mapping a computer-aided design system that requires close tolerance digitizing.

Smart ones and dumb ones

The advent of the microprocessor, has increased the versatility of the digitizer and most manufacturers now offer both smart and dumb versions. The smart digitizer allows the user to perform complex, high-speed calculations without CPU. With a display device of some type, the smart digitizer can become a special purpose, stand-alone terminal. Figure 1 is a typical menu format of clear acetate that is placed in any desired position on the digitizer surface. If the operator is digitizing map features and wants road mileage from one point to another, he enters the scale-factor from the map, digitizes the line length menu block and then moves the pen or cursor along the road. Then by digitizing the Answer menu block, the actual mileage is displayed. Areas of any polygon or volume calculations are calculated in a similar manner. To assure proper registration of the material to be digitized with the digitizing surface, rotating and translation functions are available. The digitizer origin (0,0) can be relocated to any position on the surface using the translation function. Then the X axis can be rotated about the relocated origin which, in effect, registers the digitizing surface to the material to be digitized. These features are extremely useful in cartography. An additional feature is the ability to scale X and Y independently.

A special-purpose menu can be created in PROM with any sized menu blocks to perform any desired function within practical limitations. In the field of *Medicine*, the digitizer traces outlines of whole human brain slices to compute particle size/density data. It can also trace a tumor outline from a life-size X-ray image. A doctor can prepare an optimal treatment plan from this tracing to kill or hinder the growth of the cancerous cells. In orthodontics, 250 points on lateral and frontal head X-rays are digitized. The computer then analyzes these points to determine the degree of cranial abnormality and a prediction of growth.

A cardiovascular specialist uses digitizers for many applications. Pressure waveforms, for example, are digitized and gradients across any of the cardiac valves can be calculated to determine valve areas. Measurements of cavity size, wall thickness, wall motion, and ratio of change can readily be calculated using digitizers.

Large *Mapping* systems, as well as many small systems can use digitizers as their primary data input device. A good recent example was an inventory project for the State of Washington where more than 20 million acres of forest lands were inventoried from Landsat data. County maps were registered to the Landsat scenes, digitized, and summary reports of the inventory results, by county and ownership class, were generated.

In the High Arctic, digitizers are used to detect, identify and track icebergs. Photographs of the radar PPI display are taken at intervals then projected on a rear-project digitizer. The results are then fed to a computer. These results track the identified icebergs and produce an iceberg drift forecast and a ship warning system.

Environmental studies often employ digitizers to reduce data from control chart recorders, record location of areas with high air pollutants, and to develop area and capacity curves for proposed lakes and reservoirs.

Geologists find the digitizer helpful in resolving seismic refraction data and collecting well log data. Tasks that once consumed weeks of tedious graph paper manual plotting are now completed in a matter of hours with digitizers.

Industry has many uses for the digitizer and is the largest single goup user. It is primarily used as a data input device in CAD (Computer Aided Design) Systems where the actual design of schematics, hybrid circuits and printed circuit boards is performed on the digitizer. The clothing industry also uses digitizers to optimize material use and control the laser cutting machines. When a pattern has been digitized, it can be displayed on a CRT and all the pieces can be rotated and moved around until waste is minimized. The digitized data then controls the cutting machines and the scaling capability permits easy changes from one pattern size to another. Other industrial uses include manufacturing production chart preparation, plant layout, inventory control, PERT charts, and building plans.

Prices

To determine the degree of economy one can expect from a digitizer system, the acquisition price must be known. Like other computer peripheral devices, the many shapes, sizes, and features preclude a single price answer. They can range from under $500.00 for a kit to over $10,000.00 for a fully-equipped model. The following table, can be used as a rough pricing guide:

Active Surface	Solid	Rear-Projected Or Backlighted
11" x 11"	$ 800 – $2500	$3300
14" x 14"	$2200 – $2800	$3700
22" x 22"	$2500 – $3500	$4400
30" x 40"	$4500 – $5000	$6300
36" x 48"	$4700 – $5300	$7000
44" x 60"	$5700 – $6300	$9000

For Smart Capabilities – Add approximately $1,000
For Hi-Accuracy Models (±5 mils) – Add approximately $1,000

The future of the digitizer

Coming soon are digitizer systems terminals with their own operating systems. They will have 10,000 lines per inch resolution; accuracy and linearity in the order of 2 mils; a MULTIBUS (Intel trademark) microprocessor system; 64K memory; and card slots to accomodate any peripheral controller.

The digitizer, in effect, will reverse its role as a "nice peripheral to have" and will become the core of a low-cost computer system for any graphics or digitizing use.

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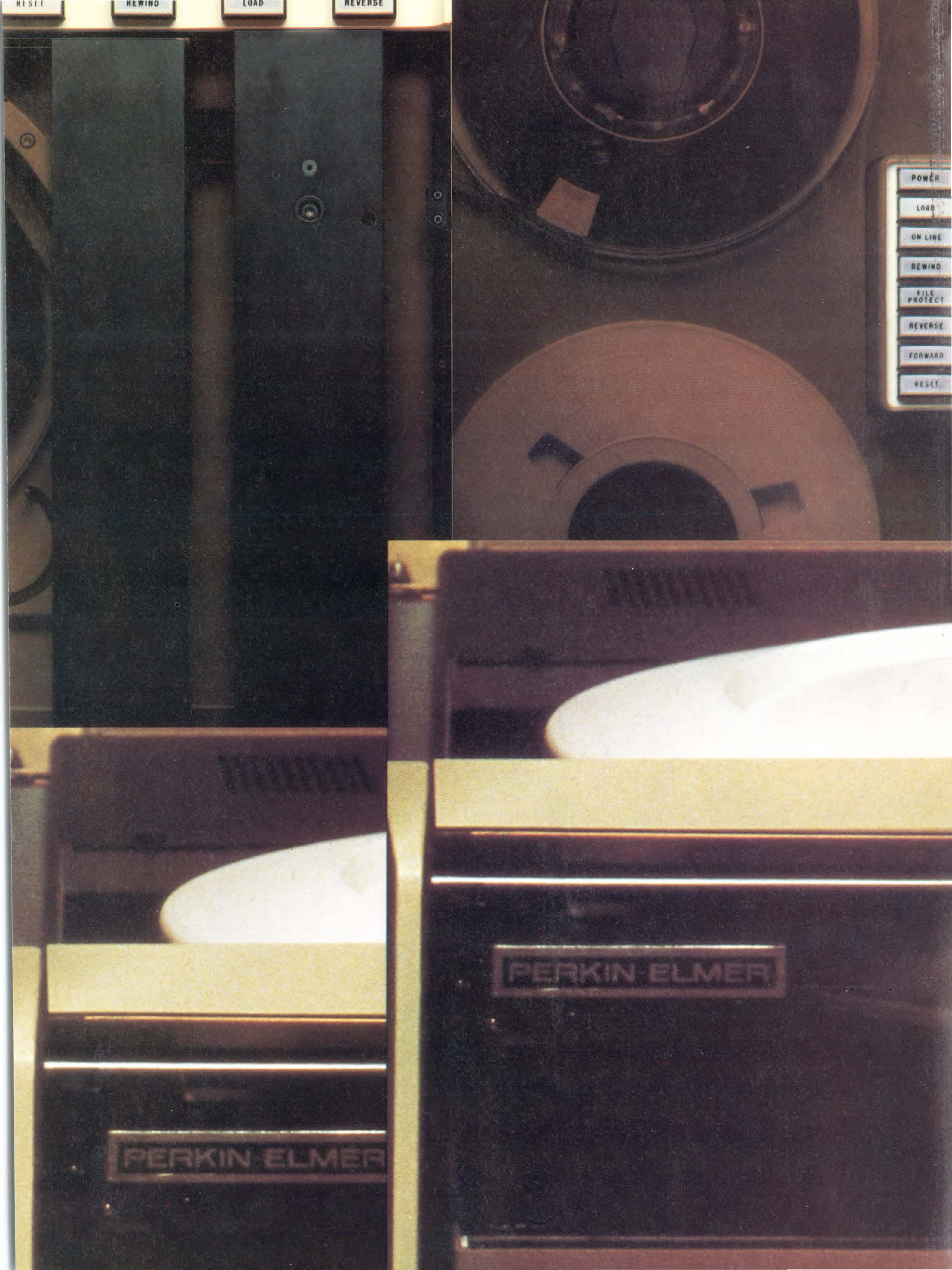
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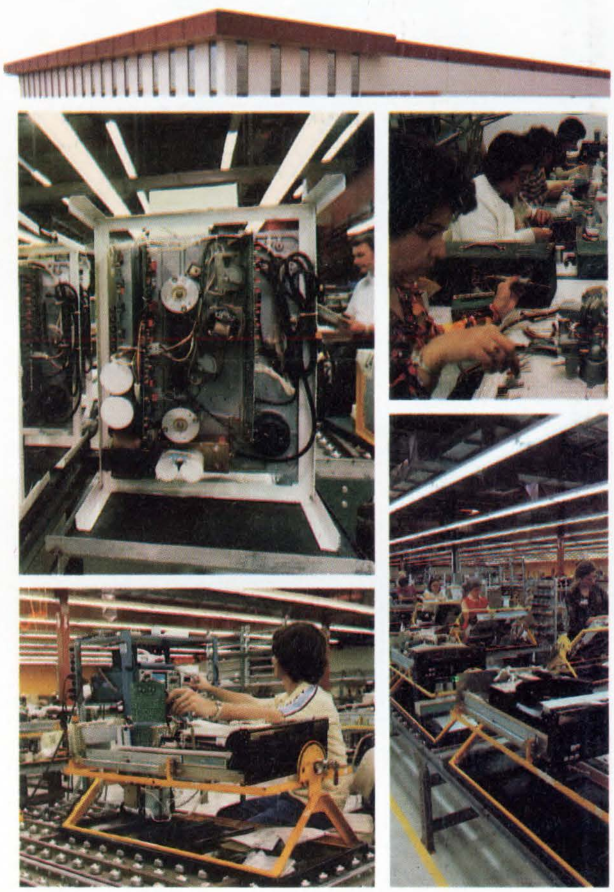

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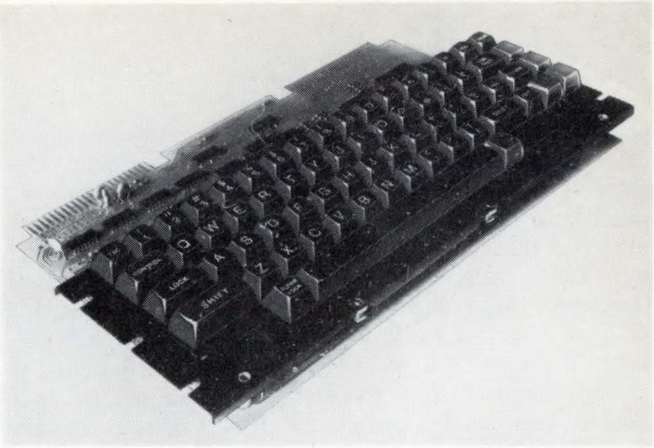

Dennis L. Sullivan

The 1980s will see steady evolution — not revolution

With the absence of emerging "new" keyboard technologies, the present period can be looked upon as a time for product refinement, both in the area of "encoding schemes" and "switch designs". There are however, keyboard suppliers introducing new "existing" technologies that their respective companies have not offered in the past but have been available through other vendors.

It is interesting to note that of the four or five major suppliers, most offer different technologies yet remain the leaders of the keyboard pack. There are certain switch technologies that are offered by more than one keyboard vendor, however, this reflects a trend and acceptance on the users part, and give direct evidence that the capacitance technology is by far the leading technology in terms of market share potential and direction in both total number of dollars and actual units.

Following the trail of the major keyboard manufacturers, you will also discover that there are five leading "switch" technologies on the market today including Capacitance (Solid State Keyboards), Mechanical (Hard Contact), Reedswitch (Magnetic Closure), Hall Effect and Core. Every technology can be dominantly associated with one of the leading keyboard vendors. Major suppliers don't offer "flat panel" or micromotion keyboards.

Capacitance keyboard trend

To assume there is a trend towards the capacitance technology would be an unfair blanket statement. Let's talk to the people who know – suppliers.

William P. Curry, newly appointed director of marketing at Key Tronic Corp., states that, "There is a definite trend towards solid state keyboards. The non-soldered capacitive switch available today doesn't cost you much more than the less expensive contact (open contact types). So, for a couple of dollars more, you can get a 100,000,000 cycle switch and basically the MTBF's that go with it, rather than the 10,000,000 or perhaps 20,000,000 cycles associated with contact."

"I see a trend towards capacitive keyboards, however, I don't think that there's any one technology that's going to take the marketplace by storm," states Ron Schmidt, marketing manager of Corton, a division of Illinois Tool Works. "As the solid state devices get less and less expensive, which they have been, offering more reliability than a mechanical, it's going to put an awful lot of pressure on the mechanical market," he added.

Robert Terwall, assistant keyboard manager of Cherry Keyboards, sees a definite price advantage to capacitive. "The reasons are basically two fold the inherent cost of the switch, it's cheaper, there's no precious metal plating and less assembly time. Secondly, the electronics associated with capacitive technology is also less."

Michael Clark, marketing director of Digitran, adds that, "There is a trend toward capacitive where quality is important, and the customers really want the advantages of long life, no bounce and no change characteristics with age."

The final synopsis states that no new technology other than capacitive has been introduced in the past five years.

Where should "intelligence" reside

An interesting question concerning the location of the intelligence crops up in the industry, and we find it a question with no definite answer, but with many varied options and resulting designs. The question is, "Should the intelligence reside on the keyboard itself", or, "Should the intelligence be located in the terminal?"

"Cherry feels the trend is towards more complex encoded keyboards that take on much of the burden that was previously carried by the host microprocessor," explains Robert Terwall of Cherry. "One of the reasons is the competitiveness of the terminal marketplace. Terminal manufacturers are selling things with so much software capability that their host electronics get too busy. In some cases, the keyboard is being asked to do things like direct LEDs and remove tabs for encoding and debouncing, and they really aren't even our parts, but they're using our electronics – free ride style."

Ed Sonderman, engineering director of Key Tronic states that, "In the higher volume keyboard production, a definite trend is being seen where the intelligence resides in the terminal. Microprocessors are becoming so powerful and so inexpensive, and the burden that a keyboard uses of the microprocessor is dropping so quickly with 8 channel detection, if you will, plus oriented detection, there's no reason any longer on high volume designs to have the encoding, scanning and validation reside on the keyboard. However, rather than try and solve where the intelligence should reside," Sonderman says that, "with Key Tronic's new "two-chip" drive and sense circuitry, the choice can be easily made by the design engineer."

Ron Schmidt from Cortron says that in their 1980 forecast, 30% of their production boards will incorporate μPs or their custom LSI chip. "Our chip will give you a 7-byte binary code output. It will tell you what key station went down. Then, your system, through the use of software, determines what that means. Now, you're not scanning or anything, but you're taking the binary code and converting that into the unique code for that board. The custom LSI chip is far less expensive than a μP."

There appears to be a short term trend towards intelligent keyboards, however, the long range direction seems to point the other way, but it's evident that there seems to be no real obvious choice either way.

Offshore competition

Rumors keep surfacing about offshore competition in the full alpha-numeric high speed data entry keyboard market and those rumors are arriving in various technology languages. The question is, where is the competition coming from, in what technologies and, how effective will they be?

"There are a number of rumblings from the Far East and half promises," states William Curry of Key Tronic. "We have not seen any hard evidence of shifts at this time. We're not sure what technologies will be offered if it materializes, certainly contact, probably capacitive, others would be in question as you would expect the targets are exceptionally high volume situations. The marketplace, however, and the nature of the keyboard business is such that the "bread and butter" of this industry is "50 of these, 75 of those, change this keytop", and "I'm sorry, I didn't mean for that switch to be there". Those are the sounds of a custom business requiring a good channel for service and customer response. That business we don't expect any real penetration from offshore sources." area that we would in time also expect to see offshore sources for terminals themselves."

Ron Schmidt feels that the reason offshore competition has been successfully kept offshore is that, "The custom keyboard business requires so much interface between the vendor and the customer, and everyone wants their own unique keytops and colors."

The majority of the industry agrees in the area of offshore competition and basically all arguments end up at the service door, customer relations or custom requirements.

Automation

In today's competitive keyboard marketplace, the main thrust is to remain a technological leader, but at the same time keep costs down. One way to accomplish that is the use of automation in the manufacturing plant. Key Tronic has recently made significant investments in automating their printed circuit board facilities, metal plating operations and additional manufacturing space. William Curry says, "Most of our efforts over the next couple of years will be in automating the mechanical assembly of the keyboard. Electronics are now so simple, a matter of three or four chips, that automation doesn't have a significable impact on your costs (assembly automation), but mechanical assembly is significant to us."

Cherry claims they have pretty much bottomed out in the area of mechanical switch assembly. "I think there are some refinements coming in wave solder capabilities and the sort of thing that reduces touch-up and cleanup time, but as far as slapping components together, I think we're there," states Robert Terwall of Cherry.

Obviously, the leaders are maintaining their commitment to the growth of the keyboard industry which is reflected in the capital investments being made to accommodate that growth.

Personal computers

Does the personal computing market trend look as if it will or could be a significant portion of the keyboard business in the near future? Today, an educated guess would show that less than 20% of the number of keyboards produced by the domestic keyboard manufacturers are in the personal computing or small business systems market. The biggest growth does appear to be coming from this area that is sensitive to what the keyboard market has to offer, a reliable method of entering data. Some suppliers think that the personal computing market is five years into the future before the large numbers are seen. "There could be a place for capacitive keyboards in the future personal computing market," suggests Robert Terwall.

"I feel that the personal computing market is an iffy area," says Digitran's Michael Clark. "In electronic funds transfer, POS and other market, their take-off time has been much slower than the industry originally forecasted. And, I think we're seeing that right now with the home computer. It has the potential to become the major user of keyboards, obviously as a consumer product," he added.

New Upstarts

Five years ago, there were new keyboard companies popping up and popping out as fast as they materialized. Today, it seems as if there are very few companies attempting to vie for a piece of the action. What has happened over the past few years that has had a significant trend-stopping effect on new keyboard manufacturing companies?

The plastics ante is one reason given by Key Tronic's William Curry. "The amount of capital investment required and time necessary to offer the keytop shapes, legends and plastic capability required by a keyboard company. It's an electronics business serving an electronics business and consequently, your customers really want you for your plastics capability. If you don't offer that, you're somewhat of a fish out of water."

"It's like everything else," states Ron Schmidt. "Six years ago, you would see hundreds of terminal manufacturers popping up all over the place, but there has been a "natural" shakeout in the marketplace. The strong survive. The biggest deterrent in both cases is capital investment in terms of technology, you must be able to produce inexpensively and have all the manufacturing processes to keep those costs down. Also, keytops are a huge investment."

Starting up your own keyboard company reminds me of trying to start up your own manufacturing plant for automobiles in today's marketplace. However, what about those large terminal manufacturers that have the massive volumes that might justify inhouse keyboard manufacturing, or is it that those companies presently making their own might turn outward to independent keyboard vendors?

Cherry's Robert Terwall thinks there is a pretty strong trend towards making the keyboard a purchase component. "It really requires an in-house engineering staff dedicated to keeping the keyboard electronics and cosmetics current," Terwall explains. "The second reason, I think, is that it becomes a management decision that there are better uses for that floor space than to make your own keyboards."

William Curry sees the same trend, but more in the medium and high volume areas. "Those companies that have historically bought switches and made keyboards are now turning to the keyboard specialists," Curry states. "There's been no shift at the highest of volume levels. The DECs, the IBMs, the people that take in excess of 200,000 keyboards a year or use in excess of 200,000 a year," he adds. "But in volumes even as much as 100,000 a year, I see the shift occurring. In this country it's almost complete and we're seeing an increasing shift in Europe."

The keyboard market is one of the most competitive areas in the electronics industry today. Even though there doesn't seem to be "new" technologies emerging, you can't help but feel that the reason the leaders lead is that there is always something on the back burner. Each of the keyboard manufacturing firms contacted indicated something was indeed on the back burner, still under lock and key of the research and development gang. But we can look for new and interesting developments in the future.

Keyboard Technology Forecast

Dick Kallage
Cortron

In 1979, several things occurred in keyboards:

1) Prices fell due to heavy competition in the keyboard market. Some manufacturers have reached "high volume" status offsetting their fixed overhead. There was significant technological improvements in all types of contactless keyboards.

2) We have also seen extensive use of μPs in keyboard design, resulting in easily "programmable" keyboard functions and "universal" designs for a given user.

3) Full travel keyboards are still not threatened by low or zero travel keyboards for most alphanumeric applications.

4) The structural design of keyboards – molded or metal chassis, PCB, encoding, etc. – was unchanged.

The next four years will see:

1) The probable emergence of low or zero travel keyboards into very low cost applications, (personal computers, engineering computers, calculators, etc.), as these markets develop.

2) Contactless keyboards will become more pervasive as prices continue to decline.

3) Expanded use of both very smart and very dumb keyboards.

4) Industry will experience extreme pressure on all phases of manufacturing costs.

5) Truly global suppliers will emerge who use the same technology worldwide and can also serve the global market with identical products, quality, service, etc.

Dick Kallage, CORTRON, Div. ITW, 400 W. Grand Ave., Elmhurst, IL 60126

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1979
1980
REVIEW
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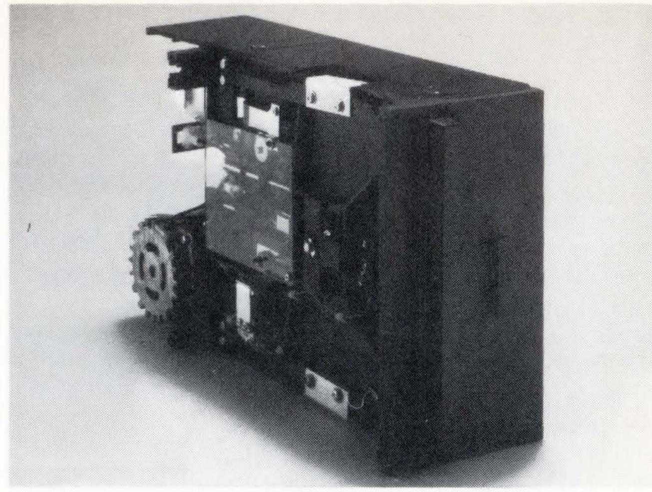
Floppy Disk Drives

Gary Goodman
*Remex Div., Ex-Cell-O Corp.,
Irvine, CA*



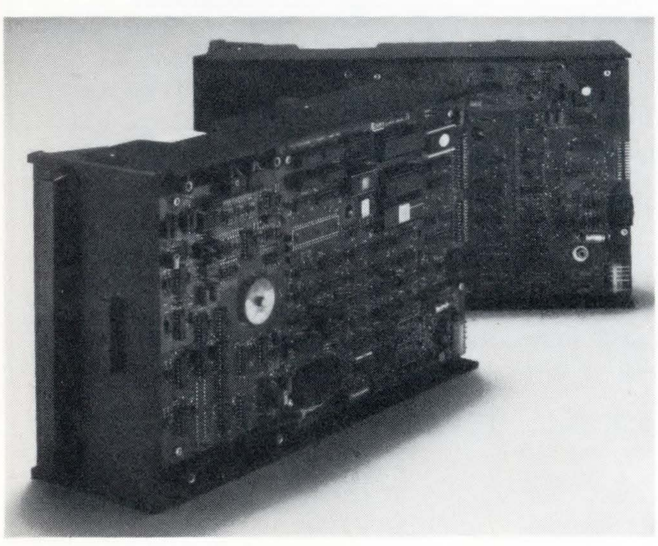
Can floppy disk drives survive the early 1980s?

Looking back at predictions made at the end of 1978 for the 1979 floppy disk marketplace, we can see it's been a year of surprises. A year ago, floppy manufacturers were saying they had worked out the bugs in dual head technology and that 1979 would be a year of volume production and big deliveries. Prices were expected to drop on all floppies, the big news in Winchester was 14-inch, and backup was something you did in your car.

A bullish year . . . but

Unprecedented demand for floppies was 1979's first bombshell. Substantial growth was expected, but early figures indicate an international market increase of 97.7% in response to the burgeoning microcomputer market, among other applications. It's been a bullish year – but for some customers it's also been unbearable.

As predicted, 1979 has been the year of the dual head, but not the year of large deliveries. Manufacturers have gone back to the drawing board more than once trying to get the technology to live up to its promise, which is considerable. Two read/write heads handling data on both sides of a diskette bring drive data capacity to one MB in a double density encoding scheme. The upgrade to double tpi and further bpi increased make a 5- or even 10-MB floppy a possibility, but not without solid footing in dual-head technology, which has proved trickier than anticipated.



Floppy disk drive reliability continues to improve.

Rough around the edges

Dual head problems involved severe media damage, caused by edges of the read/write heads gouging the diskette during head delivery. The difficulties arose from a combination of design defects – lack of a reference plane for the movable flexure heads, rough edges on the heads, excessive head delivery force and head "bounce and wobble" upon landing – problems neither discovered nor solved all at one time. Though manufacturers had already taken steps by the end of 1978, redesign continued throughout 1979. As the search for elusive reliability went on, each heralded improvement came under the gaze of an impatient and increasingly skeptical OEM marketplace.

Some of the slowdown resulted from overeager manufacturers' emulations of IBM. Having committed their early, IBM-similar market entries to costly tooling, many firms cannot institute the sweeping design changes necessary to solve their dual head problems. As a result, only a few dual head drive models today can withstand the rigorous "tap-tap" test standard for single-head OEM units. Some manufacturers argue that systems do not require this arbitrary level of reliability. No doubt, this is true at present. However, the high data capacity schemes of the future will place even greater demands on dual head positioning systems.

Happily, the upshot of all the agony of redesign and testing has been to establish in 1979 the parameters and viability of the dual-head. The initial IBM-design of a movable flexure head on both sides of the media was replaced, in most successful drives, with a combination head using one flexure and one stationary button head, a more reliable, flexible and economical design. To soften load force, special circuits on the loading solenoid of some drive designs control the heads' delivery rate and decrease impact; any bounce or wobble is settled before applying head force.

Another 1979 innovation to boost positioning reliability is the use of Fibreglass Reinforced Polyesther (RFP) as the drive frame material. On conventional aluminum castings, the temperature expansion coefficient of the frame differs from that of the media by a 3:1 ratio; the positioner must compensate for this differential to avoid data errors. FRP's

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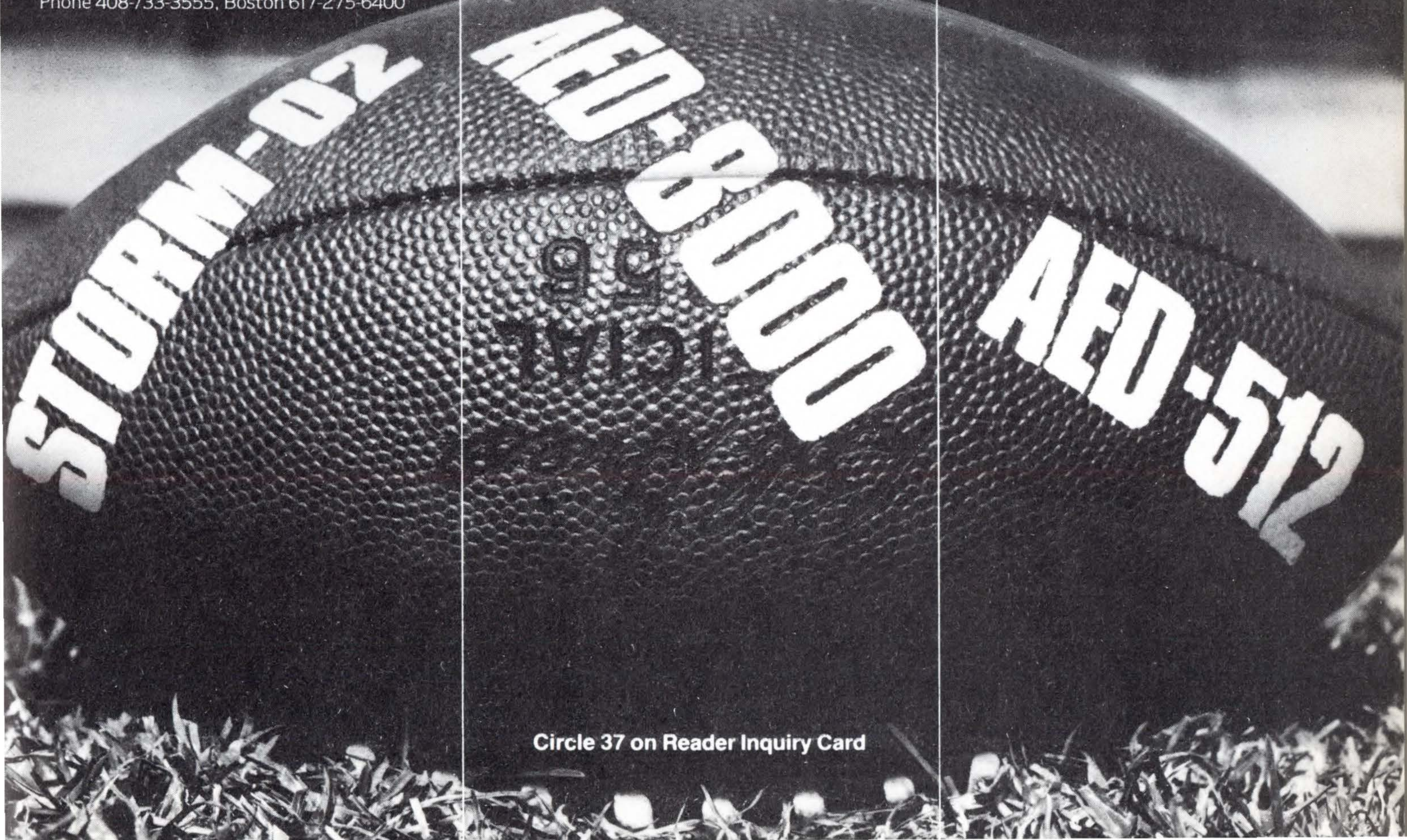

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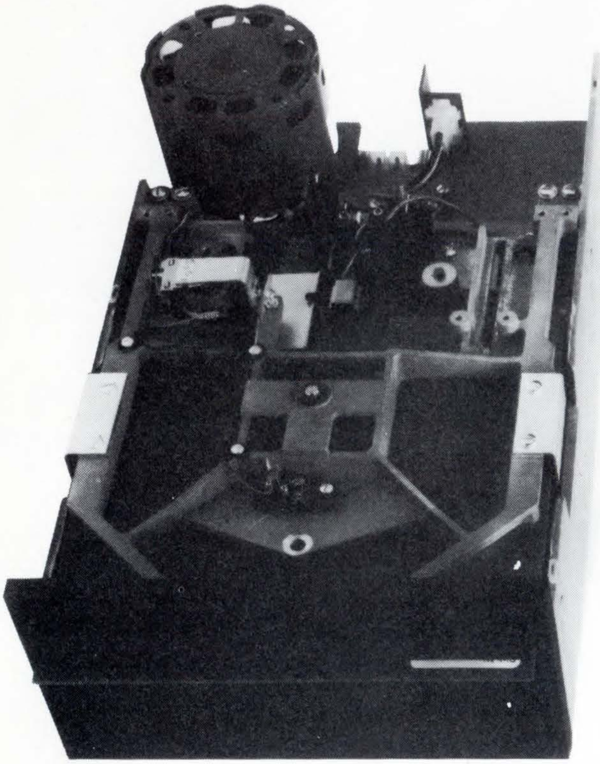
expansion coefficient is nearly the same as the mylar diskette's, eliminating one more demand on the positioner.

Dual head design, then, has arrived – one year behind schedule. As yet, not all drive models are created equal, but during the last half of 1979, buyers found dual heads that met and surpassed their test criteria. Now, all customers have to do is get them – and that's another problem.

As dual-head design glitches cleared, a second cloud appeared on the horizon – supply. With manufacturers in production mode, it is apparent that head supply, even at these early stages, cannot meet demand. At first (and to some extent still), the limitation was in produceability – the complex and sensitive head design caused unacceptably low



Drive mechanisms trend is toward reliability and greater simplicity.

yields. Most head suppliers refined their designs for easy manufacture, only to find a shortage of the ferrite head materials. A few drive manufacturers who made wise decisions early on head design and parts requirements are receiving a sufficient supply. Others are standing in line.

Open door policy

Along with other factors, the dual head malaise led to an increased demand for single sided drives to the extent that early industry leaders in floppy supply, such as Shugart, cannot meet demand for the standard drives. Other manufacturers have gotten a foot in the door for future customer requirements for dual heads, double track drives and other components. Shugart's 25%-across-the-board price increase opened the door wider (with no visible effect on demand), putting smaller volume manufacturers in a far more competitive position. And, in addition to increasing competition, acquisition of major floppy disk suppliers by large corporations raises questions of captive supply and on-going product availability to OEMs.

While not exactly making it anybody's horse race, these changes have pumped new vitality into the market – which can only benefit customers in quality, source availability and, eventually, cost.

In 1979, more manufacturers placed greater emphasis on the product and marketing requirements of the small- to medium-sized OEM buyer. Even while the big buyer's contracts have been coming up for grabs, the smaller OEM is representing a greater share of the available market.

Also significant to smaller volume buyers are "intelligent" drives with on-board single/double density controllers in both single/dual head configurations. With the controller mounted on the drive frame itself, the subsystems save space, reduce controller costs, eliminate phase lock loop design for buyers, and simplify the interface and reduce design time for systems engineers. Many subsystems are available packaged with power supply.

Overdue: 5 megabytes

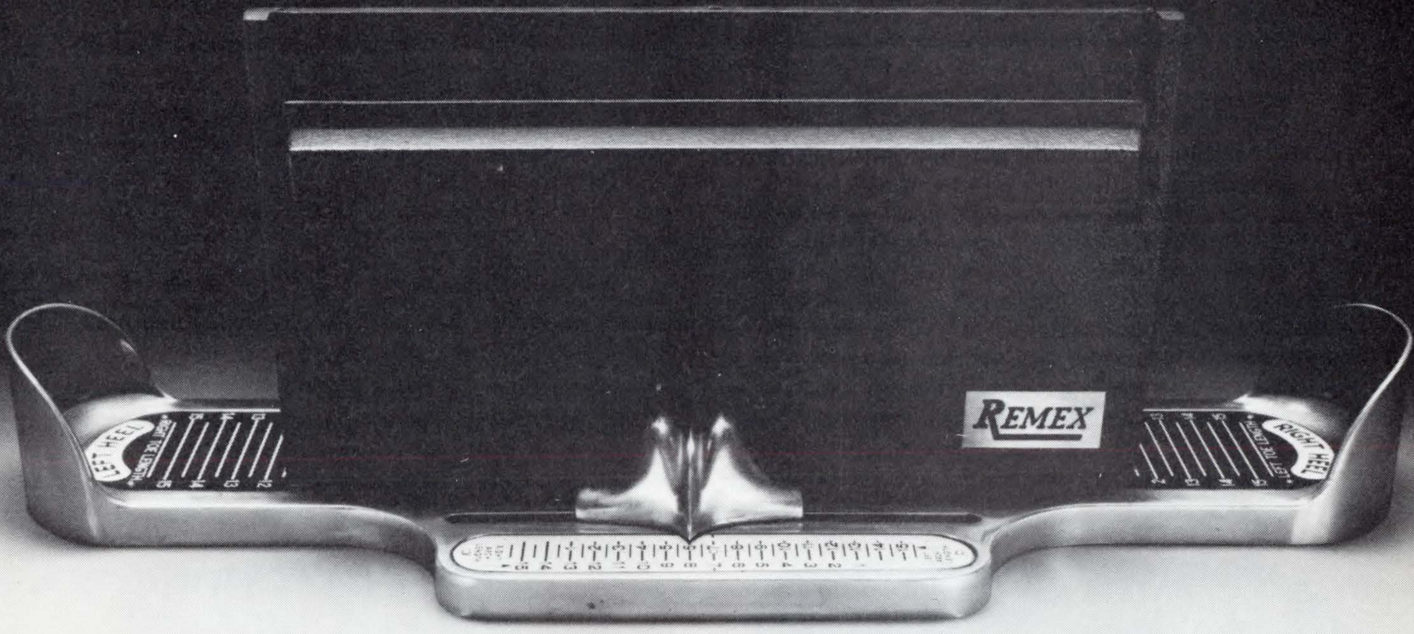
Prior to NCC, Burroughs announced that it was in countdown on a 5-MB floppy disk drive. While no product has surfaced, the announcement accelerated development plans for high capacity drives at all floppy manufacturers. The first step, no doubt to be taken in 1980, will be a 2-1/2-MB floppy, accomplished through doubling track density. The advance to double tpi, already accomplished on 5-1/4-inch single head drives, will soon be implemented on dual head mini-sized floppies. Implementation on the 5-1/4-inch drive is easier than on the 8-inch, in that expansion and contraction of both the drive and media in response to temperature and humidity are reduced. Consequently, head alignment on double tracks is far simpler to effect on the mini, even with poor quality media. All that has been learned about precise head positioning on dual head drives, however, plus improved media, makes track increase on standard 8-inch drives a solvable problem.

More complicated, however, is the move to 5-MB floppies. To quadruple density will require a combination of dual heads, triple tpi and an increased flux transition density of 50% – all placing great demands on a low-cost, removable, head-in-contact medium like the floppy. To get there with 8-inch drives will demand isotropic media (which expands uniformly in each direction), track following servos, or both. Some isotropic media is in development, but is this media of sufficient quality to permit increased tpi and bpi without the use of servos? Use of track following servos, only now in the second generation on hard disks, involves a number of trade-offs between capacity, reliability and system flexibility that may or may not find market acceptance. For one thing, the use of a track following servo limits the floppy to a range of fixed record sizes, thereby reducing device adaptability to user systems.

Presuming users will accept this limitation, manufacturers have two choices in implementing the servo. They can use a sample servo that intersperses the servo signal between fixed data blocks or a continuous servo that uses one full surface of the disk for the servo pattern. The latter (employed by IBM in large disks), which highly reliable and accurate, greatly reduces data capacity and thus is unacceptable in the long run for floppies. While a sample servo technique may reduce data capacity by as little as 10%, it increases servo noise (which must be overcome by filtering) and can accidentally erase the servo.

Maintaining seek times with a sample servo technique may necessitate the use of a device, such as an optical transducer, as an auxillary position reference, raising costs and continuing trade-offs. If high capacity floppies employ track following servos, users will have to buy pre-recorded

If the Shugart fits. . .



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media or build or purchase equipment that can lay down the servo. Both alternatives raise the floppy user's investment. With all these ramifications, costs on the entry-level high capacity drives may approach or exceed the cost of an 8-inch Winchester.

Full scale development of high capacity diskette drives will probably wait for an industry standard. While the Burroughs design, if well executed, could create a following, it would be swept away in the tide of IBM compatibility if the industry giant were to enter the market. Despite all obstacles, however, the 5-MB floppy may be a reality by late 1980 and from there, with embedded servo development in place, the next capacity jump is a short step.

Floppies and disks – friends or foes?

What is the relationship between floppies and low-cost Winchester rigid disks, specifically the compact 8-inch models that store from 5 to 20 MB and fit into the slot occupied by a standard floppy? Friend or foe?

Friend. Small Winchesters may supplant flexible disks in such applications as microprocessor development systems, but floppies will move into the I/O slot.

While the Winchester has significant capacity and reliability features it must, for now, remain non-removeable, to maintain low cost. And the floppy is its logical removable companion. Be it for I/O or data backup, the floppy offers natural disk-to-disk compatibility that simplifies controller design and optimizes operating speed and efficiency with the Winchester. While the floppy lacks the capacity to backup 100% of the Winchester's data, it does fall within the 6:1 ratio considered optimum for backup applications. In addition, since most systems require backup only on a transactional basis, the floppy is an ideal medium; it does not waste costly capacity to store small blocks of data.

At least one system designed for the microcomputer market demonstrated floppy/Winchester compatibility. Called Data Warehouse, it combines a 14-inch Winchester (which can easily be 8-inch), with two dual-head and double-density 8-inch floppies and controls all three devices with one highly intelligent, DMA oriented controller. The system, virtually a computer in itself, demonstrates the optimum performance achievable by taking advantage of the Winchester's and floppy's common command structure, architecture and operating characteristics.

No technology in 1980 – not Winchester, not bubbles, not streaming tape – will supplant the small, speedy, removable, random access floppy. The coming year's shipments are estimated at over two million spindles versus 1.45 million in 1979, and for some time the demand will continue to exceed the supply. But, as the market grows it will also change, and 1980 looms as a shake-out year for 8-inch drives, with some companies leaving the business and others increasing their commitment to a dedicated source. By 1980 the market will probably be dominated by three or four viable independents.

But with production moving up, R&D booming and healthy competition prevailing, the floppy disk future looks good – for manufacturer and customer alike.

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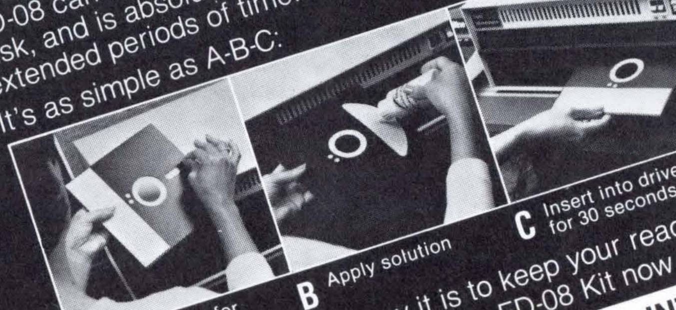

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8-Inch Hard Disk Drives

George Campbell and Beau Vrolyk
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New contestants to enter 8" Winchester arena

1979 was a special year for small system designers. It was the year that the much talked about 8-inch Winchester disk drive became a reality, bringing designers new capabilities. But how did the opportunity for 8-inch disk drives evolve?

Evolution of the 8-inch Winchester disk

Disk storage drives fall into four basic categories: floppy drives, small drives (2.5 to 20 MB), medium drives (20 to 80 MB) and large drives (over 80 MB). Floppies, which started at 250 KB, have expanded downward and upward in capacity. Today's two-sided double density floppy is approximately 1.0 MB, with a rumored 5-MB floppy on the horizon.

Traditionally, the small drive category has been characterized by cartridge drives. Early cartridge drives usually had one fixed and one removable disk, totaling 2.5 MB. The first step to greater recording density doubled the capacity to 5.0 MB; this remained the standard for years. However, recent use of greater recording densities has pushed capacities to the 10- and 20-MB range, and even higher with additional disks.

As the design point, and the resulting cost effectiveness of cartridge drives, moved into the medium size drive category, a capacity gap emerged in the small drive category. Because of new, higher density recording technologies, the 14-inch cartridge grew out of the small drive category. A new generation of drives using the newer recording technologies on a smaller size media (8-inch) has produced a number of 8-inch Winchester disk drives in the 5- to 40-MB capacity range, all about the physical size of an 8-inch floppy.

Right place, right time

The emergence of these new drives has been very timely. System designers now have at their disposal microprocessors of greatly enhaced performance. The increased bit densities of solid state memories have kept pace. LSI packages proliferate, offering increased functions. System designers can now pack, into a small desktop package, processing capability previously available only in floor standing units.

At the same time, the capabilities of newer desktop systems are outgrowing the capabilities of floppy disks as designers add multi-user options and software capable of sophisticated data base handling. Many designers frown on using larger 14-inch disk drives for the desired capacity and performance; the interest is in 8-inch Winchester drives.

Why was Winchester recording technology chosen for these new small drives? High recording density capabilities allow 2 to 7 MB of data on each disk surface, dependent on the head positioner and recording method used. The most reliable technology in use, it requires no preventive maintenance. In Winchester technology, a small lightly loaded head flies very close to the surface of a coated disk. The head lands on the disk surface when powered down and takes off on start-up, eliminating the need for head retraction mechanisms. But since the disk is non-removable, users must provide a means of loading and backing up data.

Classes of 8-inch hard disk drives

Several classes of 8-inch drives have evolved. The lowest priced drives, floppy replacements, use open-loop stepper motor band positioners similar to those used by floppies. Their data capacity per disk surface is about 2 MB and their interface is similar to a floppy's. They have a typical formatted capacity of about 4 MB in a single-disk versions and 8 MB with two disks. In keeping with their low price objective, part of the required electronics may be optional, or left for implementation in the controller.

A second class of drives uses a closed-loop servo track following positioner system, similar to that used in large capacity high performance drives. Their typical data capacity per disk surface ranges from 2.5 to 4 MB. Their interface is closer to that of large drives since they offer large drive features, performance and reliability, but with greatly reduced size and cost. Their typical formatted capacity ranges from 8 to 20 MB. Of higher performance drives, drives in this class offer the highest environmental temperature capability due to conservative recording technology.

With one exception, the third class of drives resembles the second class. By using the highest recording densities, they offer a per-disk surface data capacity from 5 to 7 MB. Typical formatted capacity ranges from 5 to 35 MB.

Head positioners

Perhaps the most critical drive component is the head positioning mechanism. The positioner moves the read/write heads back and forth across the disk, placing them over the data tracks. The positioner can be controlled in two ways:

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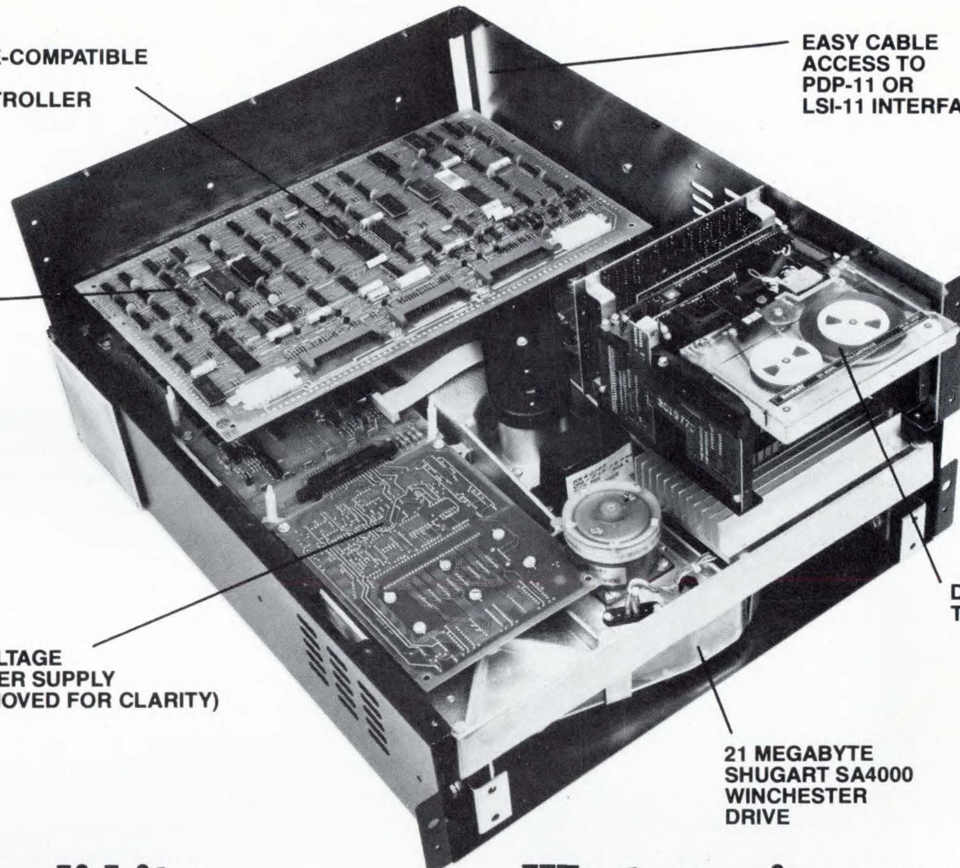

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via a stepper motor or a closed-loop servo sytem.

Stepper motors convert electrical pulses to small degree rotations of their shafts. A special steel band converts these rotations to linear motion and transmits them to the linear motion head assembly. Heads are moved to the required track by providing the stepper motor with the amount of pulses needed to move the heads that distance. Applying a small current to the stepper motor locks it and holds the heads in place. The simplest and least costly of positioner approaches, it provides the slowest access and can access the fewest tracks on a given surface.

Head positioners for higher performance drives are rotary or linear in motion, controlled by a closed-loop servo system. The rotary or swing arm positioner is actually a Voice Coil Motor (VCM) in disguise, inasmuch as the coil and bobbin are on the short pivot arm and the low inertia heads on the long arm, pivoted by ball bearings. This positioner saves power by optimizing the large driving inertia to the smaller load inertia.

This design's trade-off for saving power is potential misregistration, which affects maximum track-per-inch (TPI) capability. Misregistration is accompanied by skew, caused by the read/write head crossing the recorded tracks on an arc. With repeated reading and writing, misregistration can be multiplied by a factor of two (one for write and one for read) with adjacent track write interference.

Linear VCM positioners have no skew problems, and provide better tilt and structural integrity. The latter defines how wide servo bandwidth can be and still not be subject to the mechanism's vibrations and resonances. Wider servo bandwidths reduce the effects of misregistration resulting from friction, run-out and external vibration. Structural resonances can destabilize the servo, causing catastrophic motions. In a well designed linear positioner, these resonances occur at a frequency 1½ to 5 times greater than in a rotary positioner, permitting broader design margins relative to fast access times and elimination of misregistration. However, linear positioners, being longer, require more space, and can be more costly.

Both positioners use pre-recorded servo tracks to control head positioning. The servo head reads these tracks as it moves across the tracks during accessing. Based on the information read, the servo circuitry controls the VCM to position and hold the heads on the desired track. Closed-loop servo positioning provides faster, more accurate positioning than the open-loop technique. It also accommodates much higher track densities, resulting in greater data capacity. Its design trade-offs are that it requires a dedicated head and surface for the servo tracks, and additional electronics for the servo circuitry.

Servo-controlled brushless DC drive motors, some with integral electronics, require less than half the space of AC drive motors and need no belts or pulleys. Eliminating AC power requirements for drives using these new motors removes the prior 50-vs-60-Hz restrictions as well as high voltage at the drive, and makes them truly universal. DC motors improve data integrity due to improved speed regulations and reduce the AC motor's speed range of 4% to 1%, thereby improving the "data window." However, AC motors are less costly and are readily available in large quantities.

Electronics

Generally all drives include electronics for read/write, positioner control and drive logic and interface, and some for controller/formatter capability. Read/write circuitry includes pre-amplifiers, head selection, write current sources, AGCs, filters and limiters. Drives usually include data separation and encoding functions, but lower cost drives may offer them as addition cost options, or leave them for implementation in the controller.

Positioner type determines positioner support electronics. Open-loop stepper motor type positioners receive direction and step pulses from the drive logic electronics or the controller. Closed-loop servo controlled positioners require more extensive electronic support. Servo electronics enhances performance in keeping the heads on track during temperature change, resisting external influences such as shock and vibration, compensating for positioner friction and accommodating disk movement or runout. The servo surface provides an accurate clock signal that controls the linear bit recording on the disk surface more accurately than a crystal and provides greater potential linear recording densities. Other signals such as index, sector and home track, encoded into the servo signals on the servo surface, eliminate external transducers such as photocells and the mechanical adjustments they entail.

Drive control logic is too extensive a subject for this article, but system designers must understand that the capabilities of different 8-inch Winchester drives differ greatly in their functions, which range from data integrity and operational functions to drive status and diagnostic capability. Designers must insure that the drive they choose provides the required functions.

Any new technology lets designers improve on older designs; nowhere is this more evident than in the interface between a host computer system and the 8-inch Winchester disk drives. Falling prices and increased ability in microprocessors have allowed interface designers to assume a certain amount of intelligence on either end of the interface. The implementation is no longer limited to what can be built from a fistful of TTL gates. The 8-inch Winchesters are one of the first disk peripherals to feel the force of the microprocessor revolution.

Pressure to put more intelligence into all peripherals has been mounting, but with the introduction of the 8-inch Winchester drive, that pressure has been brought to bear on the disk drive industry. Over the next few years drive intelligence, self-diagnostics, whether it can queue up data and whether it can communicate with more than one host will be areas disk drive manufacturers will compete in besides access time, capacity and size.

Increasing cabling costs and dropping prices for intelligent silicon have provided motivation to use fewer wires to send more information. In past designs the cost of multiplexing interface lines has been greater than the cost of the lines themselves. Result: a large number of single function interface lines.

But onslaught of microprocessor technology has reversed this. It is now simpler and far less expensive to put a great deal of intelligence at either end of the interface and minimize wire interconnections. With further increases in density and yield, the move to more intelligence on the interface and more multiplexing will continue.

In current 8-inch drives the most common interface is a parallel command/status bus and high-speed data and clock lines. Nearly always implemented using a microprocessor, the parallel bus carries as much information as the drive manufacturer provides. At a minimum the bus usually carries cylinder number, device number, head number and various single-bit commands. The high-speed data and clock lines are usually sent to and from the host as a differential pair (the data being NRZ, as opposed to MFM, and operating anywhere between 3 and 10 MHz).

Now in its infant stage, the 8-inch Winchester drive is beginning dynamic growth in speed and capacity. As new

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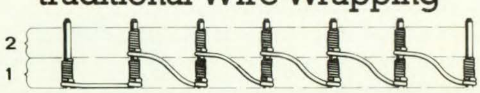

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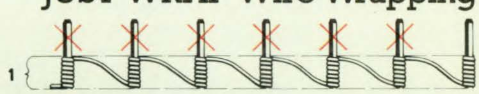

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technology moves into the marketplace, it will push the abilities of any interface to its limits. Here is where μP based implementation pays off.

The sky's the limit

Using a processor with a bit more capacity than necessary for the interfacing function creates the possibility of building an entire disk subsystem into the drive. The first step is to allow users to retrieve data in a parallel form asynchronously, which will decrease user dependence on the disk for timing. The next step is to allow users to ask for a logical record, freeing the system from tracking the drive's physical characteristics. Finally, disk drives will start implementing data base management systems, further reducing the load on the host and speeding total throughput.

It is always better to determine what data is needed and where it is as close to the data as possible. Following this rule ties up the smallest number of system resources for the shortest time. The move from having the host forced to run synchronously with the disk's serial data to receiving data parallel and asynchronously frees the host from disk timing constraints. This alone eliminates various data channel designs that queue up data from the drive, to allow the host to continue operating in a real-time environment.

Stepping from direct sector I/0, where the host must know where each record of each file is kept, to logical I/0, where the drive returns a record based on file name and logical record number, increases system throughput dramatically. The disk drive performs spare sector tracking, error recovery, error correction, directory manipulation and all overhead features of a file system, freeing the host to continue processing on other tasks until the data is ready – true distributed file processing.

The same reasons that make it clear that the drive should perform logical I/0 apply to implementing a data base management system within the disk. Again, the trick is to move the data as short a distance as possible, and decide early what is necessary out of that data. Thus the host sends the drive a set of file names, search arguments and operating limits on time and area. When the drive has found and formatted what was asked for, it returns the data to the host system. A host system operating a number of such drives could process multiple data bases, generate various reports and speed its throughput dramatically over a host system with the same number of standard disk drives.

When the low cost of hardware is considered, these arguments are quite forceful. In addition to offloading a cumbersome task from the host system, this technique forces a standardized file structure, access method and user interface. Rather than having software users creating their own incompatible data structures, the system is set up once correctly. It no longer matter what language, operating systime or user writes the data base. It is consistent and the disk drive maintains compatibility.

Along with intelligence, the 8-inch Winchester drives will increase in capacity. Through the use of evolving recording technologies such a thin film heads and plated media, small 8-inch drives with up to 200-MB capacities may appear in the next few years. Small system designers, for the first time, have a small, reliable disk storage peripheral that not only meets their needs today, but will grow in capacity and intelligence as their requirements expand.

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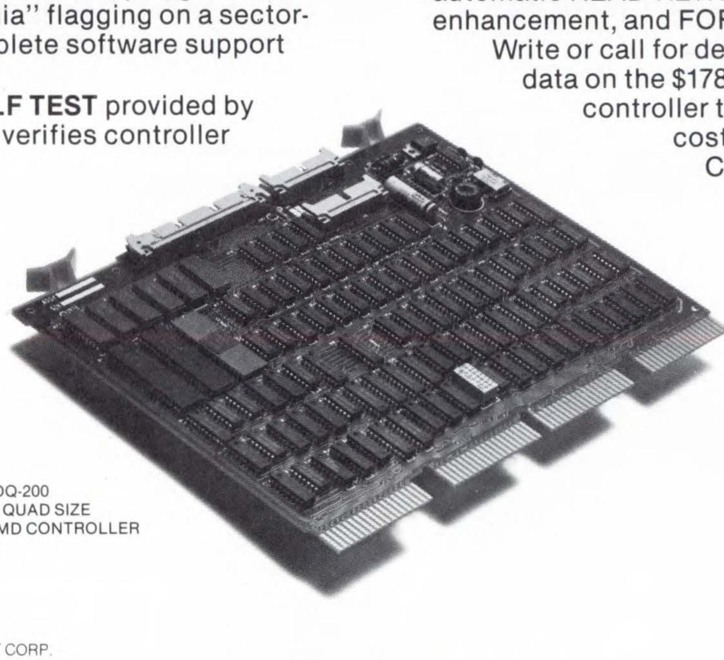

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Switching Power Supplies

Wally Hersom and Jeff Shepard
L-H Research, Irvine, CA

Performance parameters continue to improve

Switchers will become competitive with linears at ever-lower power levels. Currently, switchers compete effectively price-wise with linears at power levels above 100W.

Improved reliability has increased switcher use. Components developed specifically for switchers and better understanding non-linear-analog feedback and high-power switching circuits have helped; and it's not unusual for well-designed switchers to operate at 100,000-hr. MTBF.

Why choose switchers?

A number of technical parameters determine the choice between a linear or switching-regulated supply for a given application. The nondissipative characteristics, high-voltage energy storage capacity and high operating frequencies incorporated into today's switchers make their choice almost mandatory for applications requiring high efficiency, compactness, hold-over power or minimal cooling.

Since *linears are inherently low noise devices,* designers use them when low noise, low ripple or fast transient response are necessary. Linear supplies *enjoy an advantage in transient response time* resulting from their continuous (linear) response capability. In contrast, switchers must go through at least one-half cycle of switching frequency before responding to output voltage changes.

Increased switcher efficiency reduces cooling requirements.

The 60-Hz operating frequency, typical in most linear supplies, can interfere with the electron beam in CRTs. In applications that use a CRT and a linear supply, designers must take care to insure proper shielding of the CRT from the linear's 60 Hz interference. Because switchers normally operate in the 20-25 KHz range, they don't create this problem.

Major developments in power MOSFETs and continued improvement in ICs, transformers and capacitors will push the switcher operating frequencies from the current 20-25 KHz range up to 100 KHz. At these frequencies, supplies will use smaller components which dissipate less heat and provide improved transient response time – improvements that will enhance the already important advantages of switchers and lower price relative to linears. Major switcher improvements will occur in two areas – active and passive components.

Active components

Power-type MOS devices offer significant improvements in switching supplies because of higher switching speeds which are due to the majority-carrier nature of MOSFETs. With higher-frequency operation, smaller transformers, inductors and capacitors reduce supply bulk and lower cost.

In contrast to bipolar transistors (current-controlled devices), MOSFETs are voltage-controlled and require very little drive current. Many drivers that now use discrete components can switch to ICs. This simplified drive circuitry needed by power MOS devices will increase switcher reliability and lower costs.

MOSFETs' negative temperature coefficient makes them even more attractive for switcher applications. Switchers' most common failure mode is second-breakdown of voltage in power transistors. Now, since localized hot spots do not occur in MOSFETs, they are not susceptible to second-breakdown – a characteristic that will improve the already

high reliability of switchers.

Power MOSFETs suffer from the disadvantage of resistance as compared to bipolar transistors. However, power MOSFET manufacturers are overcoming this problem. In 1977, these MOSFETs offered typical on-state resistance of 4-5 Ω; in the last two years, makers reduced on-state resistance to well below 0.1 Ω, close to that of bipolar transistors.

The relatively low reverse-voltage tolerance of power MOS devices, which is improving less quickly, represents a major stumbling block to the widespread use in switchers. Large reverse voltage spikes appear in the high-voltage switching section of switching regulated power supplies. Power MOSFETs have very fast switching times, making these inductance-caused spikes a worse problem. Power supply vendors must pay more attention to placement and design of "snubbers" in circuits using power MOSFETs.

The change from bipolar transistors to MOSFETs will resemble the replacement of junction diodes by Schottky devices. But, power MOSFETs require further improvement to reduce their shortcomings in high-voltage, high-frequency switching applications. The industry must develop new design techniques to take full advantage of the improved performance.

The somewhat higher on-state resistance and relative sensitivity to reverse voltage spikes will initially limit MOSFETs to low-power applications, which put less demands on switching components, especially in the areas of MOSFET weakness. As MOSFET technology improves and switcher manufacturers gain design experience with power MOS devices, MOSFETs will replace bipolar transistors as the standard switching components used in switchers.

The first generation of switching-regulator ICs appeared three years ago and greatly simplified switching regulated supply design. Switcher prices dropped and reliability improved.

In 1979, manufacturers introduced the second generation switcher ICs – improved versions that provide more on-chip protection circuits, higher drive currents, single- or double-ended output, variable frequency capability and increased reference voltage accuracy. These manufacturers also made available IC "systems" that include a variety of support chips to work with the main pulse-width-modulator chip. Voltage reference chips provide very accurate (±0.25%) references. Specialized driver ICs provide higher output power. Makers offer separate ICs for protection functions, such as current sense, over-voltage-protection, under-voltage sense, power fail, current limit; and sometimes fault activation delay or logic-level fault-indicators (outputs).

What lies ahead in the 1980s? Expect continued advances in switching-regulator applications of ICs, off-the-shelf pulse-width-modulator ICs that offer more flexibility and increased capability, large switching-regulated supply manufacturers "rolling-their-own", using custom ICs that provide characteristics required by their *specific* products.

Passive components

As switcher operator frequency increases, power transformer leakage inductance will become a problem that will decrease the supply's overall efficiency. To maintain high efficiencies, power transformer manufacturers must refine their products to reduce leakage inductance.

High operating frequencies will mandate the need for smaller power transformers with fewer windings. This shrinkage of the size and number of windings makes designing transformers with better primary to secondary coupling necessary. Improved winding geometries will help achieve the necessary coupling between primary and secondary.

The industry will continue to improve ferrite cores which operate efficiently at high frequencies and high flux densities. Smaller power transformers will be possible at higher frequencies only if efficiency remains high and operating losses (heat) are minimized.

For a given level of ripple, output inductor sizes also decreases as the operating frequency increases. The output filter inductor is optimized at the primary ripple frequency; and its inductance strikes a balance between low output ripple level and fast dynamic response time.

Since switchers must wait for the next half-cycle of switching frequency before starting to regulate for changes in output voltage, it may take 3 or 4 cycles before the new level is stabilized. Therefore, for a given level of ripple, dynamic response time is proportional to operating frequency. If a 20 KHz switcher operates with a dynamic response time of 200 μs, a 100 KHz switcher will respond in 40 μs at equal output ripple levels.

Linears now enjoy a lower output ripple and faster dynamic response capabilities over switchers. By operating at higher frequencies, switchers hopefully can reduce that advantage.

Suppliers have developed **balance capacitors** for the power switching section of half- and full-bridge pulse width-modulated switching-regulated power supplies. Used in series with the primary winding, these capacitors are critically important in "balancing" the volt-seconds across the power transformer in both directions. Since it is not economically practical to precisely match power transistor switching characteristics used in each power supply manufactured, the capacitor performs a balancing function. Unless the volt-seconds are properly balanced, the power transformer core can saturate in one direction and cause the corresponding power transistor(s) to go into the second-breakdown mode. The balance capacitor helps to prevent second-breakdown from occurring.

The development of low ESR (equivalent series resistance) capacitors have also been important in the success of switchers. Although not all are specifically designed for switcher applications, low ESR capacitors in the input and output filter sections of off-the-line switchers help maintain high operating efficiency.

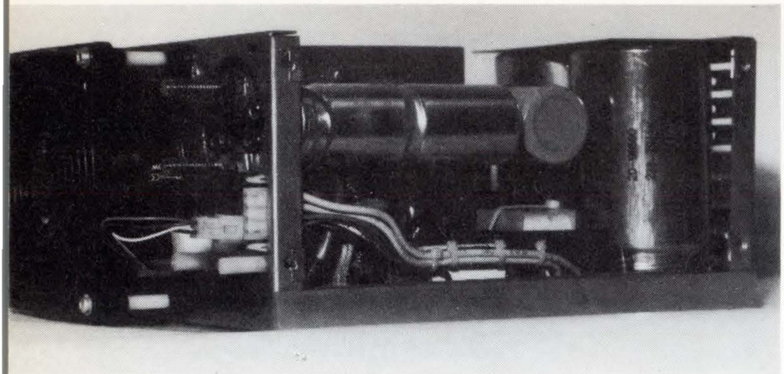
Since the output filter requires less storage capacity between ripple peaks at higher operating frequencies, the supply can use smaller capacitors and no longer needs large, relatively expensive electrolytic capacitors. Polypropylene film or similar capacitors, which are better suited for high frequency operation, will replace them. Polypropylene film capacitors are significantly smaller and less expensive than electrolytics.

Forecast for the 1980s

As already noted, switching-regulated power supplies will make a major advance by using MOSFET power-switching semiconductors in the 1980s. The transition from bipolar transistors to MOSFETs will not occur quickly; new power MOS technology must prove itself prior to wide-spread acceptance by switcher manufacturers.

Expanded use of ICs in control and protection circuits will also occur in the eighties. The development of power MOS devices, which require lower drive current, will open up additional opportunities to use ICs in switching-regulated power supplies. The increased use of ICs will result in the already high reliability of switchers.

Over the next 10 years, linear prices will increase (due to



With higher frequencies, switcher component size decreases.

rising material and labor costs), while switcher prices will decline. Switchers are expected to cost less than linears down to the 25-W level, and a large portion of the necessary savings will come from the increased use of ICs.

What will cause most switcher performance improvements? Primarily from the ability of the new power MOS devices to operate in the 100 KHz range. High frequency operation will result in a significant decrease in passive component size. Smaller power transformers, inductors and filter capacitors will cost less and will contribute to lower overall costs as well as increasing switcher compactness.

Another important result of high frequency operation is the ability to decrease the output ripple and increase transient response speeds. These two parameters represent the major advantage which linears have over switchers in certain applications. Although switchers may not equal the absolute performance of linears in these areas, the gap will be much narrower.

Typical p-p output ripple of a current-day technology switcher is 50 mV. As manufacturers develop new generations of MOS devices for application in digital circuitry, the industry standard supply voltage is expected to drop from today's 5V to between 2 and 3V. At outputs of 2-3 V, 50-mV ripple is excessive. The new switcher technology will allow reduction of output ripple and at the same time improve dynamic response characteristics.

Could high frequency operation of switchers increase EMI problems? Yes. The German organization, VDE, has already set maximum acceptable levels for EMI through its 0871 and 0875 specifications. A number of switching supply vendors can already meet the less stringent of these, VDE 0875; the more demanding VDE 0871 specifications is similar to the proposed FCC EMI regulations.

Rising electric power costs resulting from the energy shortage will strongly encourage the move to switchers. A 200-W linear (45% efficient) requires 444W of input power. A switcher (75% efficient) of equal output requires only 267 W of input power.

In the 1980s, switchers will co-exist with linears, but will take more of the market. Linears will primarily be used in special-purpose applications that require minimal levels of ripple or very fast dynamic response speeds. Switchers will be more efficient, more compact, offer low ripple and fast dynamic response, and cost less than linears.

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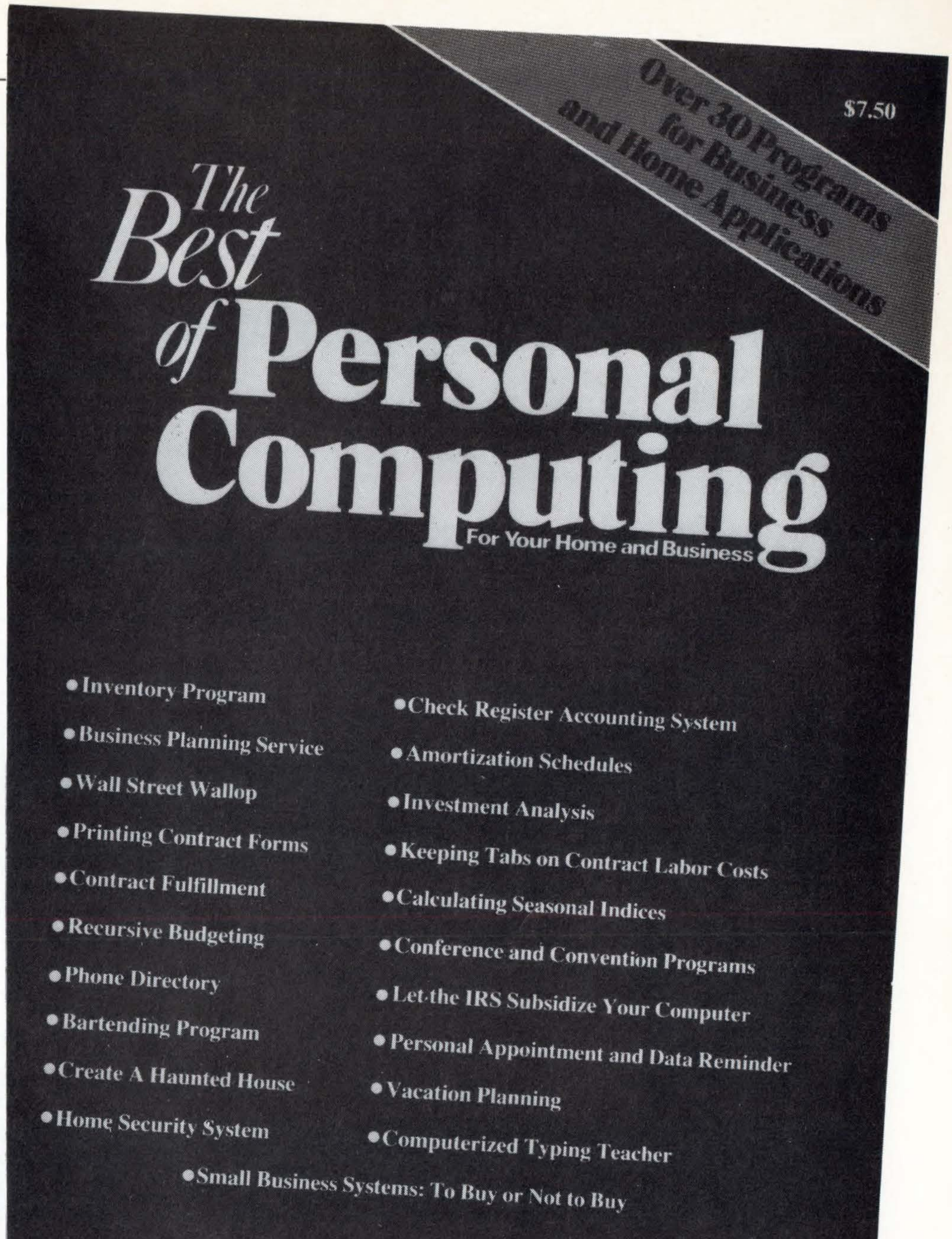

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1980
REVIEW
PREVIEW

μP Development Systems

By Martin J. Weisberg, *Director of Marketing*
Millennium Systems Inc., Cupertino, CA

Increased choices, greater universality and more usability to come

No other industry can claim advances in technology comparable to those in the semiconductor industry that have taken place in the last decade. An important element – perhaps the most important – has been the microprocessor "explosion". Microprocessors are now incorporated into products representing an incredibly wide range of industries and applications.

This pervasiveness has caused an aftershock for the microprocessor user who needs to understand how to adequately select, program and develop the microprocessor-based system.

While the microprocessor is *better,* it is also *different*. During the pre-microprocessor era, an idea became a product through a hardware-oriented process. By contrast, development (and performance) of a microprocessor-based product is primarily software dependent and requires an expensive array of tools. Another key difference can be summed up quite briefly: there are at least 20 different microprocessor types which may be appropriate for a given application! Moreover, there are many applications which are optimized by utilizing several different microprocessor types in a single system.

In addition, microprocessor technology does not stand still, as new and more complex central processing and peripheral IC's are introduced each year. The user's problems of selecting the right microprocessor(s) as well as developing a system is becoming increasingly complex.

These devices are now finding their way into the control systems of everything from sewing machines to satellites. And more and more companies are becoming dependent on microprocessor development systems for software/hardware development and integration. The increasing complexity and multiplicity of types of microprocessor and microcomputers has correspondingly increased the complexity of the development systems needed to support them.

The high cost factor and difficult selection process are forcing trends to a choice of universal systems that can be used with more than one microprocessor family. Most recently, instrument companies began filling the obvious gap in the market by introducing low cost, "add-on" tools for universal microprocessor support.

During 1980, two conflicting trends should continue to mature: increasing capability/price and decreasing capability/price! The common element will be support of multiple microprocessors and users. Users will be offered many more capability/price options than ever before and the pervasiveness of integrated electronics will increase in a widening circle of applications.

From multi-functionality to universality

Microprocessor development systems were conceived by semiconductor companies simply as a means to sell their chips. The systems were multifunctional only in the sense that they were designed to meet several needs in the marketplace, allowing users to:

1. Get quick exposure to the latest in microprocessors.
2. Do preliminary, microprocessor evaluation.
3. Do prototyping of trial circuits and debug them.
4. Develop software for the final products.
5. Train new engineers in microprocessor application.

Very quickly, users found that despite the power of dedicated systems, device-specific development systems locked them into one brand of microprocessors even though such systems had been designed to be upgradable to newer microprocessors. However, a beneficial by-product to the user was the lower cost of development. He could now prorate the cost over several generations of the same microprocessor family.

Recently, some semiconductor manufacturers added a limited degree of "universality". For example, National Semiconductor Corp. designed its specialized STARPLEX development system to also serve as a general-purpose computer system. When not being used to develop microprocessor applications, STARPLEX can be used to produce documentation or serve as a node in a larger network.

Incorporating a variety of components, (central, processor with 64k bytes of memory, dual floppy disks, video terminal, multifunction keyboard and printer in a single desktop enclosure) this system – even as a development tool – leans toward universality. It is designed to support the company's second-sourced version of the 8080. As in-circuit emulation capability is added, it can also be used with any microprocessor that has similar architecture and

instruction sets, (including the single chip 8048 microcomputer family, the 8085, and Zilog's Z80, as well as Nationals NSC800, which combines 8085 and Z80 approaches.)

True universality in development systems became a reality in 1977 when Tektronix introduced its 8001 and 8002A. Furthermore, the entrance into the field during 1979 by Gen Rad/Future Data (with its 2300 Universal Multistation Microcomputer Development Systems Series,) and Hewlett-Packard (with its 64000 Microcomputer Development System) has made universality a legitimate trend. These systems expand user functions with hard disk, high capacity memory and multi-user work stations.

Born also out of the need for lowering the cost of microprocessor development was the introduction in 1979 of inexpensive design aids such as the Millennium Series 1000 MicroSystem Designer, and the Series 2000 MicroSystem Emulator.

All in all, architectural approaches may differ, but the result is the same: development systems are becoming universal rather than dedicated to a particular processor.

Tektronix 8001/8002A: the first universal system

With the introduction of the 8001 and 8002, Tektronix Inc. became the first vendor to offer true universality. The 8002A is a full development system, including facilities for program development and assembly, along with in-circuit emulation for debugging. A smaller version, the 8001 is offered to those who already have program development equipment but who want to add in-circuit emulation. At present the 8002 supports the F8, 3870, 3872, 6800, 6802, 1802, 8080A, 8085, 8048, 8049, 8021, 8035, 8039, 80396 and Z80 eight bit microprocessors, and the TMS 9900 and SBP 9900 16 bit products. Plans are on the drawing boards to add several newer microprocessors and single chip microcomputers.

The 8002 is basically a multiprocessor, single bus (16 bit) system, in which two or more processors reside on the same system bus and are dedicated to various tasks during the development process.

The 8002 achieves universality by splitting into three functional areas, each supported by its own microprocessor. A "system processor" used to control the disk operating system as well as such jobs as file management and system input and output. A second "emulator" processor personalizes the system to the target microprocessor, and executes the program in the prototype system controlling the prototype input/output. The third CPU – the "assembly" processor – has only one job: it performs program assembly in a table-look up mode.

As many as two different slave or emulator processors can be installed simultaneously in the 8002, and then individually controlled through operator command. Since the master processor need not be changed to accommodate new emulator units, all operating system software remains the same.

The 8002 consists of:

- The basic system box, which holds the processor cards, random access memory, interface boards, and a programmer for read-only memory.
- A video terminal for interactive programming.
- A dual floppy disk capable of storing 300 kilobytes on each disk.
- A real time prototype analyzer.

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

By plugging a cable into the socket where the actual microprocessor will be inserted in the prototype, the user gains access to all its I/O circuitry, while using the system's memory for program storage. Finally, when the user is satisfied with the program, he transfers it to PROMS which can then be inserted in the prototype and debugged. The 8002 starts at about $14000.

Other Universal Systems

Like Tektronix' 8002, the Gen Rad/Future Data 2300 series has multiprocessor architecture. It differs, however, in its multibus emulator. In the 2300's multiprocessor, multibus architecture, each emulator processor has its own memory and processor/emulator bus, which permits independent and simultaneous operation with the system processor as well as other emulator processors. Since each processor has its own bus, a variety of different types of microprocessors can be handled. At present, complete support is available for the 8086, 8080, 8085, 6800, 6802 and Z80. Starting price is about $12,500.

HP's Entry

Unlike the multiprocessor based Tektronix 8002 or the Future Data 2300 series, the HP64000 system is centered around a 16 bit host processor, a 20 megabyte (expandable) hard disk, 64k bytes of RAM, 16k bytes of ROM, I/O and keyboard/display control. Slots accept the following options: a minicartridge tape drive for software loading and file backup; a universal PROM programmer with front panel socket; and an emulation and logic analysis subsystem. The subsystem contains an emulation control board and pod with the microprocessor to be emulated; 8 to 128k bytes of RAM, and a logic analyzer. The host processor and emulator run simultaneously without interference and with independent buses and memory. Currently the 64000 supports the 6800, 8080, 8085, and Z80, but it is designed to support most 16 bit devices. It also anticipates the requirements of 32 bit devices.

Four buses provide the 64000 with its flexibility: a main frame bus, I/O data bus, emulation bus and emulation memory bus. The mainframe bus carries most of the control, command, and other traffic. The I/O bus links the host processor, keyboard, tape drive and I/O ports. A pod and connector plug extend the emulation bus to user prototypes, as in other systems, with the logic analyzer dedicated to this bus. Finally, the memory bus gives both the emulating microprocessor and host processor access to emulation memory. Various combinations of the four buses are used during development, under control of the host processor. A minimum system consists of a 20 megabyte disk, a 64100A development station, and a tape cartridge unit with appropriate assembler. Prices range from $35k.- $127k.

Friendliness and Universality

All of the above-listed universal microprocessor development systems are different in approach, but they have, at least, one commonality: they are all moving toward the use of high level languages (HLL). Such languages will provide a more "friendly" interface between the user and his system. Among the leading possibilities for these HLLs are: various versions of Pascal, BASIC, PL/M, FORTRAN

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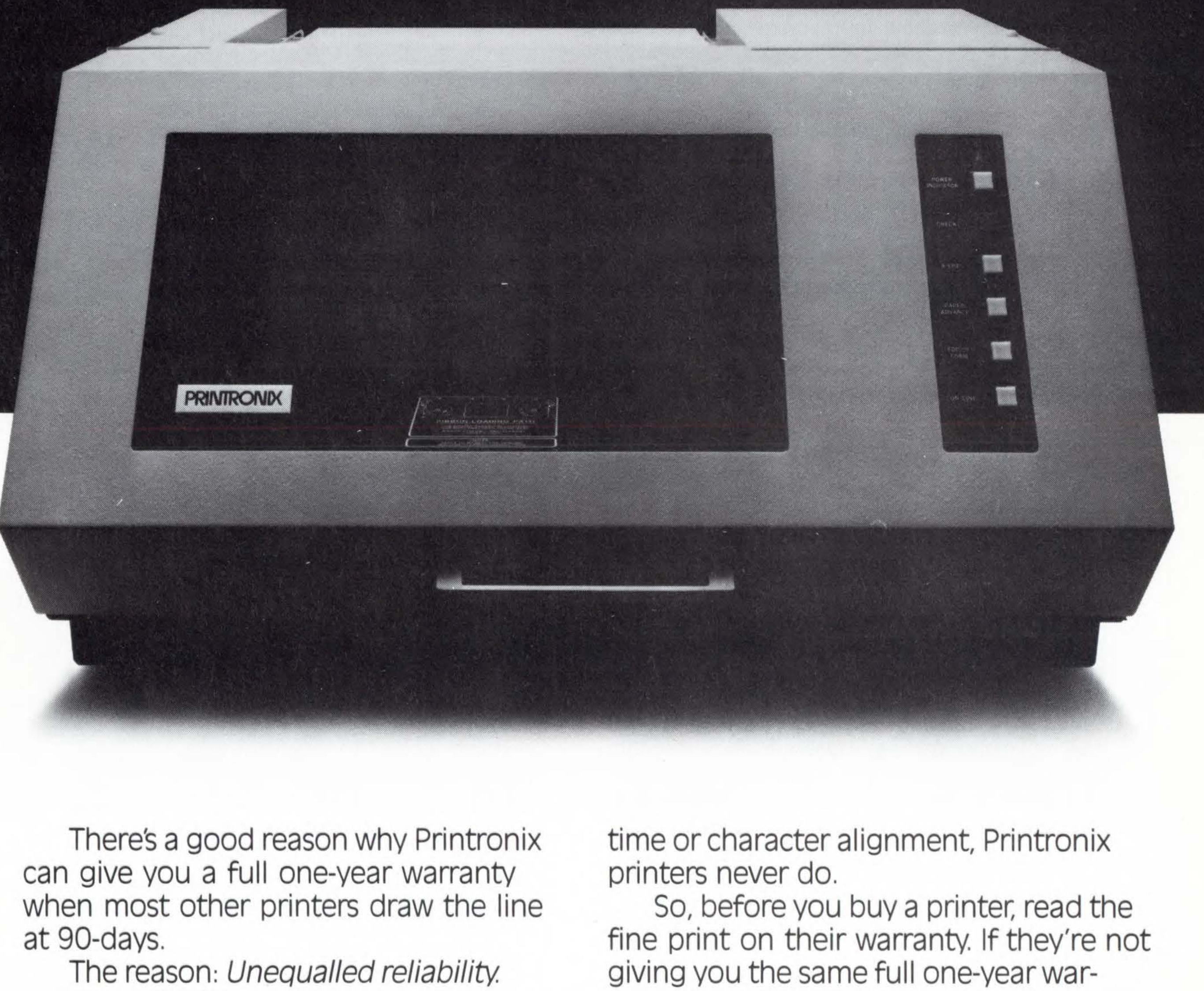

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and COBOL. Less common are Focal, FORTH, "C" and PLuS. Other useful languages, including various specialized HLLs, are also beginning to make an appearance.

Such HLLs are "friendly" because they are programmer-oriented and more easily used than assembly languages. Very few microprocessor characteristics penetrate to the level of an HLL, so a programmer doesn't have to worry about specific microprocessor quirks. An HLL that is easy to learn and use can boost daily code production far beyond that of assembly code.

Typical of these "friendlier" HLLs is a recently enhanced version of BASIC in compiler form, called Modular Development Language (MDL/μ) by Tektronix for its 8002 Microprocessor Development Lab. Although not yet implemented for all the microprocessors that the 8002 can support, the enhanced language permits full program development for the 8080A, 8085, 6800, 6802 and Z80.

This new language incorporates BASIC-like contructs because BASIC, the most widely accepted language in the field, already well known by almost everyone, is easy to understand and just as easy to use. Furthermore, its wide availability on microprocessors, minicomputers and even larger machines offers many opportunities for program transfer.

MDL/u is an extension of ANSI minimal BASIC, developed specifically for microprocessor-based product development. While BASIC satisfies the requirement for simplicity, speed is not its strong point, because it normally runs on an interpreter. MDL/u, however, uses a compiler, so each statement is translated into machine code once, not every time the statement is executed. The final executable code is therefore faster and often smaller than interpreted versions because of the resulting lower overhead.

In-circuit emulators

One of the most powerful features of a large microprocessor development system, both device-specific and universal, is its in-circuit emulation (ICE) capabilities.

To get ICE from the large system vendors, the user must first buy the development system – an expensive proposition. But there are many users who already have access to a computer system that can be used as a software development station. These fortunate users thus have no need to buy another computer or even a microprocessor development station. Companies with dedicated development systems may want to add universal emulation to protect their initial investment and expand the system's flexibility. But, in many cases engineers neither need nor can afford all the resources of a full next generation development system. Emerging, therefore, is a need for "add-on" type instruments which will provide full or limited resources to already existing "hosts".

Suggesting the future availability of add-on microprocessor development tools are two offerings from Millennium Systems: the Series 1000 MicroSystem Designer (uSD) and the Series 2000 MicroSystem Emulator (uSE).

With the Designer system, experienced microprocessor users as well as novices can evaluate microprocessor-based systems. The uSD is both an 8 and 16 bit universal prototyping instrument (simultaneous operation) as well as a training aid. It currently supports the Z80, 8080, 8086, and Z8000 microprocessors. Soon to be added are the 68000, 8085, 8048 and 6809.

This new instrument has many uses including development of trial circuits; debugging of software; and hardware/software integration. Features include hardware breakpoint, register and memory examinations. To explore hardware alternatives for a given chip set, the Series 1000 uSD provides a solderless prototyping area into which microprocessor signals are brought via a flat cable. A MicroCable, with limited emulation capability, is also available and can be plugged into the user system. Controls consist of a hexadecimal keyboard for program entry and a function keyboard on which any given key provides identical functions for all microprocessors. A 16 digit alphanumeric display shows operator prompts and messages.

A further capability of the uSD is its up/down link to a host computer. By adding various personality modules the instrument permits a design group to add support for all popular microprocessors to an otherwise dedicated microprocessor development system. The basic uSD provides up to 2k bytes of system RAM for interaction with the main processor. A built-in peripheral control processor is available for user control of the main processor, while retaining its ability to interact with the user via its own display and keyboards. This unit is priced at less than $2000 for 16 bit microprocessors.

The uSE, in contrast to the uSD, is a sophisticated high performance microprocessor emulator terminal that is designed to work with both general purpose computers and dedicated microprocessor development systems.

Connected to a host computer, the uSE course that computer to act as a microprocessor development system for the 6800, 6802, 8048, 8080, 8085 and Z80.

This high performance instrument operates at speeds up to 6MHz, which allows real time emulation of fast microprocessors. Real time operation of the uSE extends to an optional real time trace capability, a valuable debugging tool that lets the user track the step-by-step performance of his design at full-rated speed. The uSE further provides complete debug facilities, with 8k of RAM available to the user. Also included is the ability to allow DMA operation plus a high speed serial data link. The uSE is priced at less than $6000.

Conclusion

Approximately 28 million microprocessors were shipped in 1978 and this is projected to reach 160 million units by 1983! About 75 different types of microprocessors and microcomputers exist today as the industry steps up to the threshold of the 16 bit era. No wonder this has been called the "microprocessor explosion".

Astute designers today recognize the microprocessor for what it really is, a *component*. It is an amazingly powerful component, but like all other components, must be chosen and applied properly for any given application.

Development systems and design aids were initially the exclusive province of chip manufacturers. Beginning in 1977, though, and fully emerged in 1979, a number of instrument manufacturers have come into the market. They have produced a series of products to provide designers with greatly expanded capability and universality – the support of multiple microprocessors by multiple users.

Two clear trends are now apparent; high-end development systems for multiple users with high price tag; and low- and mid-price instruments for those users who only want to "add-on". The choices have never been better.

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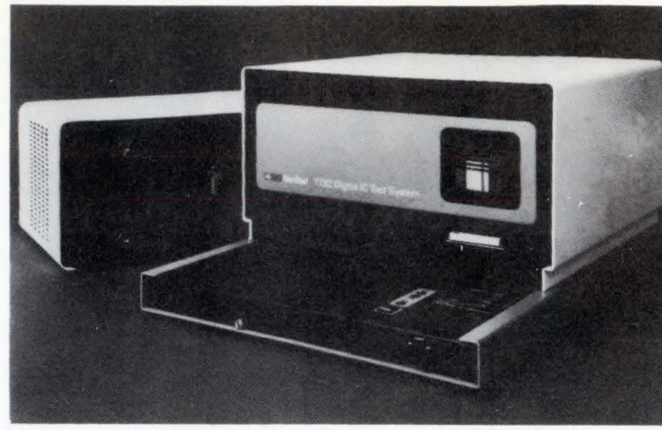


μC Software

Lance A. Leventhal,
Contributing Editor, Emulative Systems Co, San Diego, CA

Trend to management control of software will accelerate

1979 was a year of slow transition in hardware and software. On one side are the 8-bit μPs – used in fairly simple applications and needing limited support and relatively unsophisticated development systems. Many users are new-comers just discovering the fascination (and frustration) of software development. The other side of the transition encompasses 16-bit μPs with powerful instruction sets suitable for more complex applications; these 16-bit devices need more extensive support. Since most users of 16-bitters have worked on micro- or minicomputers before, they already are familiar with the problems of software development.

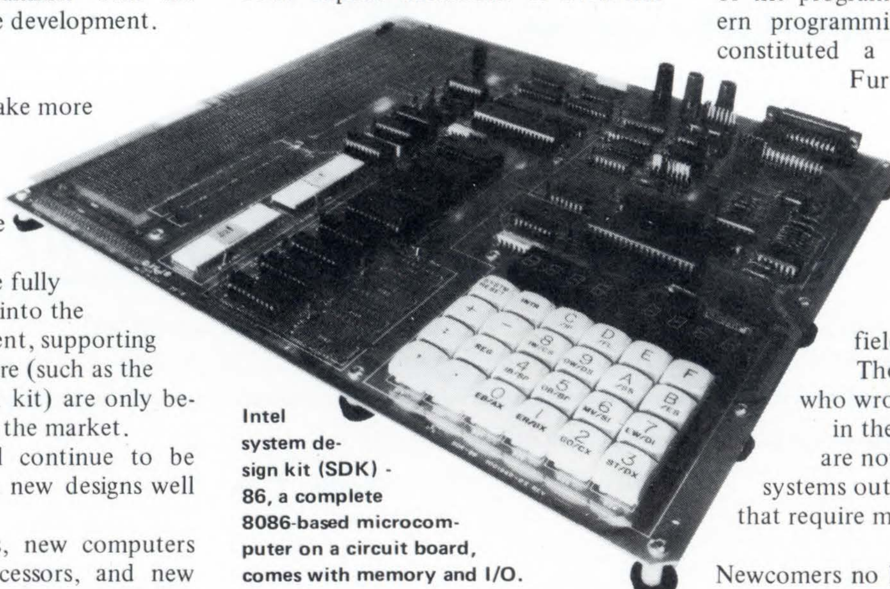
It will take time

This transition will take more than a year. Devices such as Intel's 8086, Zilog's Z-8000 Motorola's 68000 are not yet widely available, nor will they be fully supported until well into the 1980 s. At the moment, supporting hardware and software (such as the Intel SDK-86 design kit) are only beginning to appear on the market.

8-bit micros will continue to be widely used even in new designs well into the 1980s.

New applications, new computers based on 8-bit processors, and new supporting hardware and software will continue to appear well through the 1980s. Suppliers will offer much of this equipment and support on the basis of remaining compatible with 16-bit micros.

In part, further fragmentation of the μC area will occur. Larger applications will utilize the 16-bit micros, requiring extensive software and hardware support. Those involved in such applications will have to work with programming languages and software design techniques applicable to large-scale systems. On the other hand, smaller applications will continue to use 8-bit micros, often in specialized single-chip forms. These 8-bit micros will need low-level programming, since few programs will be very large or complex. Many of these projects will still utilize assembly language; others will use low-level systems languages, such as FORTH. However, the high cost of correcting software errors that have been copied thousands or even millions of times will lead to an increased concern with software reliability and testing.



Intel system design kit (SDK)-86, a complete 8086-based microcomputer on a circuit board, comes with memory and I/O.

The move toward maturity

In software, we see the need of what we might call the "Era of Innocence". The first μPs brought many new people into the world of software who quickly moved to "rediscover the wheel," because they were vitally concerned with writing clever programs that used every feature and instruction and made programs run a tiny bit faster to occupy a little bit less memory or perform precisely the functions of the hardware that they replaced. Did anyone worry about precisely how long it took to write these clever programs? Hardly anyone. Nor did many worry about those poor souls who had to maintain the programs. Could they ever figure out how all those clever programs worked? Fortunately, most of the programs were short and modern programming methods probably constituted a considerable overkill. Furthermore, there was no way to explain realistically modern programming techniques to designers who had never written, debugged, documented and maintained programs.

During 1979, the μP field continued to mature. Those hardware designers who wrote their first programs in the early or middle 1970s are now veterans with many systems out in the field – systems that require maintenance (and many need redesigning). Newcomers no longer find a raw frontier with little experience and few amenities; Designers have learned the need for adequate software and hardware tools and have learned what features really make those tools useful. No longer is the mere availability of an editor, assembler, debugger or operating system sufficient to grab people's attention.

Continuing forces

These forces from 1979 will continue to act in 1980:

- Ever-increasing manpower costs continue to oppose the trend of decreasing semiconductor component costs.
- Even faster μPs with greater memory capacity that can handle large-scale tasks and tolerate some inefficiency.
- Availability of larger and cheaper memory chips will make memory useage and cost far less important.
- μP users and applications will grow more sophisticated.
- Software development costs, software reliability and software maintenance will grow more important.
- High-level languages, operating systems and other sophisticated software for μCs will become more widely available.
- Processors better-suited to high-level languages, particularly to block-structured languages such as PASCAL, are emerging.
- Low-cost, high-performance peripherals, such as floppy disks, CRT terminals and printers are now available. Interfaces and software required by such peripherals are also widely available and many floppy disk systems offer a variety of interfaces.
- A shortage of qualified personnel, particularly those who understand both hardware and software, exists and won't be solved. In addition, rapid turnover of personnel complicates software development and maintenance.
- PASCAL, the "software superstar", which is widely supported and taught, has emerged; and, new versions are better suited to μP applications than the original version with its limited I/O.
- A demand for more features in software and larger programs is growing. Compounded by general inflation, this demand pushes non-semiconductor hardware costs and overhead expenses continually higher. More software provides a way to add more value to products without increasing material costs. Thus, improved performance, easier training and other cost savings can justify higher prices.
- Hard disks at reasonable cost have begun to provide much more storage than do floppy disks at only somewhat higher price.

Rules and warnings

The μP world is following many of the same principles that have long been noted (usually by Herb Grosch) in the world of larger computers.

- Programs always grow larger; in fact, they grow large enough to fill whatever memory is available. Somehow, no one ever comes back and asks for a new system that can do less than the old one! This year's 1K program is next year s 2K program – and the year after that, it's a 4K program.
- There is never enough memory or mass storage; no matter how much is available, you soon fill it and need more.
- There is never enough system software; whatever is around seems to require more just to make it work properly or connect with the other systems that are used or will be used.

For those who have been working in the μP field for a while, we issue a special note of warning. People with experience probably must work twice as hard as those who have none, just to keep up, because so much of your experience ties you to outmoded and obsolete methods (*obsolete* refers to a two years ago approach; *outmoded* refers to last year's!). In no way can you sit on your laurels in the μP field; those who fail to progress for any length of time find that catching up is next to impossible. EEs may soon be afflicted by a new form of "burnout", somewhat akin to that experienced by social planners and experimenters in the late 1970s.

Languages and development systems

PASCAL is the only really serious competitor to Bell Telephone Lab's C language; its attractiveness is based partly on its close connection with the UNIX operating system. UNIX will apparently be the basis for the new operating systems of the 1980s. But PASCAL should dominate μC software development, much as FORTRAN and COBOL have dominated the field for larger computers.

We note the increased power of these systems. New entries from Philips and Hewlett-Packard show the trend toward faster and more powerful systems, capable of supporting multiple users and of providing large amounts of storage, plus hardware and software support. Neither the new entries nor improvements in existing systems for 1979 offer any remarkable new capabilities; but they do show a general cognizance of the fact that μC development systems are full-fledged computers with some special hardware capabilities. We also note that there is much work to be done in making high-level languages more widely available on development systems. More suitable forms of these languages are necessary to handle the specialized control nature of many μP applications. A general improvement in the quality of the systems software provided with development systems is also essential. Furthermore, we should see more capabilities (such as Intel's Multi-ICE software), aimed at applications that require multiple processors.

Future trends

Will the 1980 trends differ much from the 1979 trends? It's unlikely. Designers will use μPs in ever larger and more complex applications. More designers will turn to high-level languages and to complete design systems that offer extensive integrated hardware and software tools. Investment in a particular type of device will increase, thus inevitably leading to a smaller number of multiply-sourced μPs dominating the market. We should note the increased size and strength of the leading semiconductor manufacturers. Companies such as Intel, Mostek, AMD and Zilog are rapidly becoming large interstate and even international companies. The size and sophistication of their software staffs has grown sharply.

One more important trend will appear: increased management control over software development. The high cost of development and maintenance will mean that management must provide standards for designing, coding, debugging, testing, documenting and maintaining software. If you're just beginning to grapple with costly and unmaintainable software, carefully examine Robert Tausworthe's writings; they provide a detailed description of procedures used at JPL.

Engineering reeduction will continue in 1980 – perhaps accelerate. If you learned to write simple machine and assembly language programs in the 1970s, you must now learn to write PASCAL programs in the 1980s and use sophisticated software and hardware tools that will become widely available. Do you wish for a stable technology? It won't happen. The pace of change appears to be as great as ever in 1980, and there is no end in sight.

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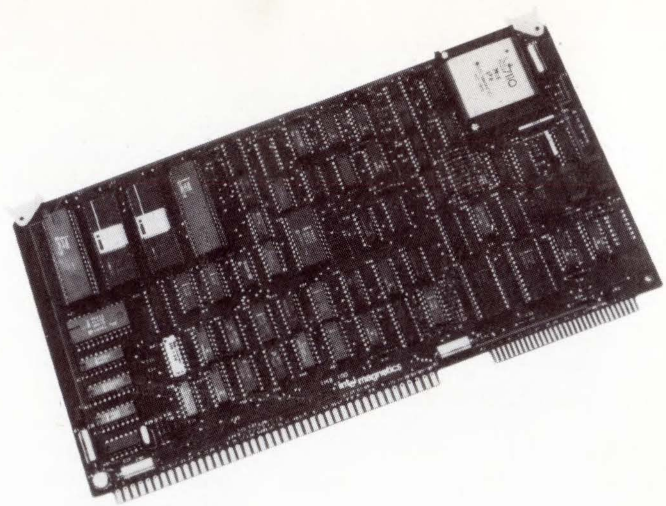
Magnetic Bubble Memories



Paul Snigier, *Editor*

Bubbles prepare for explosive growth

1979 was a learning period for magnetic bubble memory (MBM) manufacturers; 1980 will see volume production starting, with availability of support circuits for high-volume, fixed-media mass storage applications. Although MBMs remain a new and rare technology for designers, 1980 will see a significant transition begin as more designers attend MBM seminars and courses, gain initial hands-on bench experience with prototype kits and even begin product designs.

Designers will find bubble products in 1980 split between chip-level devices and board-level (subsystem) products. The former approach will offer flexibility; the latter, which will eventually predominate, will quickly open the use of MBMs to widespread use by the average designer.

Bubbles fill the gap in price and access time between RAMs and rotating mass memories. Main selling points are not price advantages so much as reliability and nonvolatility. Bubbles offer important advantages. Since they are free from mechanical failure, maintenance costs and downtime are less. They offer other advantages over disks: error rates several orders of magnitude greater, higher data density, smaller size and less weight. MBM application strengths are primarily on-line.

Advantages attract system designers

Here are some advantages that I feel will establish bubble memory's niche by late 1980. . .

Nonvolatility. Information is maintained even with power loss. Also, magnetic-field shield material wrapped around the package, protects data from externally-induced magnetic fields.

Fabrication. Improved yields result, since MBMs can be laid down with a two-mask operation; MOS dynamic RAM typically requires seven masks in fabrication.

Compatibility. Many techniques for manufacturing semiconductors can be applied without change.

Yield improvements result from loop redundancy. Since, during test phases, the best loops are noted and stored on-chip in an error-map loop (or spec sheet), the yield can exceed an equivalent yield for large MOS RAMs by tenfold. The result? Lower cost/bit.

Packaging flexibility. Unlike other mass storage, MBMs can be packaged with the μP, even on the same board, and thus is integral mass storage.

Low entry price, as an MBM system can be designed with a few chips for a few hundred dollars.

Fast access time (4-7 ms), particularly vs. slower floppy disks (220-500 ms).

Lower inventory costs due to MBM's modularilty. A firm's spare parts inventory will be much smaller than for disks.

Lower maintenance costs, since MBM offers higher MTBFs, lower MTTRs and require no scheduled preventive maintenance.

Higher reliability, with hard bit error rates at 10^{19} errors/bit and hard bit-error rates of 10^{12} errors/bit or better. Most errors are caused by detection failures and not bubble loss; and even with a high error rate, Intel's Fire code detects and corrects one- or two-bit errors in a burst of 5 bits or less. With a 10^{-10} probability of error, mean time between errors is only 55 hours, but when corrected is over 500,000 years.

Total committment. Massive R&D efforts by Bell, IBM and others guarantee continued rapid progress. Since bubbles are victorious over CCDs, EBAMs, etc., this ensures continued support in terms of device families, marketing and educational support, and continued research. Expect rapid improvements in going down the learning curve.

Availability. Manufacturer commitment is strong to create families of support chips and boards in quantities to meet OEM demand. Catastrophic difficulties (like plagued double-sided floppies) do not loom on the bubble horizon; and due to the diversity of approaches, any catastrophe would be localized.

Expandability and optimized memory size. MBM modularity lets you configure system memory to be increased in increments, thus providing cost-effective optimum memory for your system needs.

Economical expansion. By expanding the system in MBM blocks, cost/bit stays low.

Ruggedness. For severe industrial or environmental conditions (contaminated atmosphere, severe vibration, shock, continual-access, etc.), MBMs prove superior.

Smaller physical size. A 1 Mbit bubble system from one MBM maker now fits on 86 in^2 of board area.
Lower power consumption. One large active device consumes 12.6W with a 100% duty cycle.
Multiple-sourcing. Bubble makers are exchanging information and scrambling to multiple-source their lines. For example, Motorola is second-sourcing Rockwell's 256-Mbit products (and providing Rockwell support circuits), Siemens and Rockwell exchanged worldwide marketing rights to each others lines, Burroughs and Rockwell have agreements, and so on.

Will disadvantages be overcome?

MBMs suffer from disadvantages that will carry into the early 1980s. . .
Standardization and compatability with competitive products has been criticized, with the claim that some users' evaluation efforts have been complicated by the variety. Customer acceptance may set the standards for pinouts, lead spacing, signal levels, timing, architectural features (loop lengths, number of loops, R/W-bit delays, block replicate and major-minor loop methods), function timing, electrical parameters and the like.
Testing woes. With quarter-megabit MBM test times running over a minute/device, and since MBMs are serial in nature, increasing capacity creates test times that rise exponentially – not linearly. Although testers are now available, future parallel-testing systems will support numerous device interface circuits and provide error mapping and bad-loop masking for all devices. Forget about OEM testing systems for now.
Reliability overkill. Most applications won't need such long-term stability and high reliability. Do you need a century of data storage? No? Too bad; every bubble user gets it anyway.
Not cost competitive with other semiconductor memories; and, to do so, it must surpass a 3-to-1 cost/bit advantage. If MBM costs drop to 15 mc/bit, this could be reached (although it's unrealistic to expect semiconductor memory cost/bit not to decline also).
Non removability. Unlike a floppy disk, it's difficult to remove a MBM device and mail it or use it in a WP system. This limits bubbles to fixed-media, mass-storage users where removability is secondary.
Layout problems. For example, with low level analog signals under 4 mV near relatively high-amplitude (200-300 mA) current generator pulses – not to mention high-voltage (12V) surges – layout of components can create design headaches.

Bubble memory applications explode

MBMs will *complement or compete* with fixed/moving head disks and floppies in large product markets that exist now. Here are the applications. . .
Telephone switching systems represent a big market for bubbles (which explains Bell Lab's interest). Since phone EEs measure equipment life in decades, fixed head disks are unreliable for Ma Bell's digital and voice storage uses. PBX (private branch exchange), small switching systems for businesses, though not large enough for the large, central office-type fixed-head disk systems, can use MBM diagnostic storage systems. Voice synthesizers, private client-expense billing systems, portable systems are just a few applications. Is the phone market a captive market? Yes, but a fifth of the market is served by independents; and in certain areas (PBX, for example), competition is stronger.

Advantages	Disadvantages
MBM vs. Floppy Disk	**MBM vs. Floppy Disk**
Higher reliability Non-Mechanical Smaller Physical Volume Faster Access Simpler Interface Media Integrity	Storage media not readily changed
MBM vs. RAM	**MBM vs. RAM**
Non-Volatile More Bits/Device Reduced Board Space	Slower Access Slower Transfer Rate
MBM vs. ROM or PROM	**MBM vs. ROM or PROM**
Programmability More Bits/Device Reduced Board Space	Slower Access Slower Transfer Rate

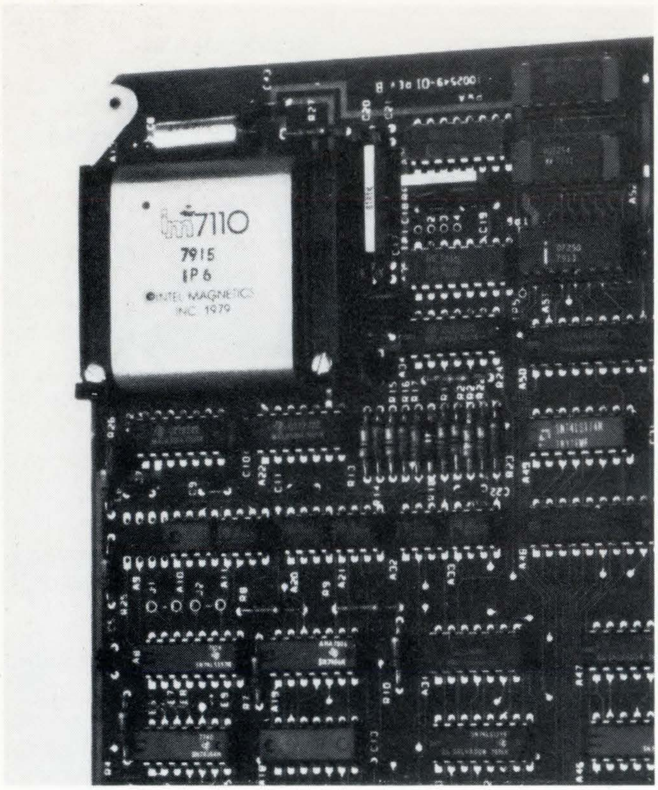
Here's how the advantages and disadvantages of magnetic bubble memories presently stack up against other memories on the memory hierarchy.

Aerospace and military applications will use a significant slice of MBM devices (perhaps an eighth), going *to replace mechanical memory devices* (primarily airborne head-per-track disk units). Due to reliability, bubbles are ideal for replacing satellite tape recorders (10 khr MTBFs), since satellite component MTBFs over 100 khrs are common. Thus, extra cost is irrelevant. Due to ruggedness, bubbles are suitable for tanks, back packs and poor environmental/mechanical-stress conditions. MBMs can replace special ruggedized cassettes now used for data acquisition and program loading.
Fixed-head disks will be obsoleted when bubble cost/bit plunges. Fixed-head disks offer faster access times, shock/vibration resistance and less moving parts than moving-head disks – advantages all exceeded by bubbles. Many fixed-head disk replacement applications will emphasize data reliability over speed.
Moving head disks, though costing less than fixed-head disks, suffer from slower access times. But, it is just this lower cost that will keep their cost/bit lower, so that on a cost-justified basis, system designers could not as readily justify replacing them with bubbles (as in the case of fixed-head disk drives). IBM, like Bell, does considerable bubble research; unlike Bell, IBM's payoff will one day be in disk replacement – not phone switching.

Floppy disk drives, despite higher cost/bit than moving head disks, provide lower entry costs. Due to this, and the removable aspect of floppies, bubbles will find this an obstacle in penetrating the floppy market.

CRT or video display terminals (VDTs) and printers. The floppy disk is superior to bubbles in VDTs because floppy's low cost and removability just cannot be beat. However, in portable terminals, bubbles offer an edge due to ruggedness, low weight and lower power consumption. The first commercial application of bubbles in the computer industry was TI's Silent 700 Models 763 Send/Receive BM and 765 BM Data Terminals. This was done for PR reasons to promote TI's bubble memories rather than from a cost-justified basis.

At present, 8″ Winchesters will be preferred in most high-volume VDT storage applications; floppies, in medium VDT storage; and EAROMs in low-volume storage applications. Bubble nonvolatility advantage is simply not necessary on most non-portable terminals. Floppy speed and



The Intel Magnetics IMB-100 is a completely-assembled 128K-byte, nonvolatile, one-megabit bubble memory development board. It utilizes one 7110 bubble memory module, an 8085A-based controller and standard components. The 6.75 x 12″ board is designed to interface with Multibus systems and plugs into any Intellec Series II μC Development System.

reliability (lower, particularly in heavy I/O uses) will not signal any big switch to bubbles in VDT applications.

Can bubbles aid VDTs as nodes in distributed dp networks? Possibly, since bubbles are suited for low-volume data and local editing and data entry. Or, used as track buffers in floppy disk drives, they could hold and organize data for sequential floppy recording, raising CPU throughput by holding a track called up while the present one is used. Then, there's the low user-intervention factor in favor of bubbles. These VDT applications will be those first susceptible to bubble inroads.

When MBM cost/bit plummets in the mid-1980's, the picture will change, with MBMs perhaps used internally, paralleling the floppy (or rigid) disk and the floppy architecture. The floppy? It will be relegated to an I/O and data interchange medium. At present, though, 1980 will see VDT makers taking a cautious attitude, and my impression is that they're waiting to see bubbles prove themselves (i.e., VDT makers be the guinea pigs).

In WP systems, in typesetting systems (such as the one setting this article) and in other systems using dual floppy disk systems, bubbles may begin to *replace one floppy*; but in one-floppy systems, rarely. Floppy's removability is hard to beat, since large numbers of diskettes are routinely removed for archival storage. Furthermore, floppy reliability is more than adequate for most office system uses. As for memory typewriters, bubble cost and non-removability are detriments. Floppies will continue to grow through the mid-1980s.

8″Winchester drives (and 4-6″ versions) will find wider usage; users will find the lower price of non-removeable disks very attractive over that of floppies in certain applications where archival storage is unimportant. With no panacea backup for 8″ Winchesters in sight – although streaming tape drives, backup Winchesters and floppy drives, etc. are solutions – the 8″ Winchester shouldn't make inroads where floppy drive low cost and low-cost archival storage are necessary. Where more mass memory is needed (16-bit micros, minis), the need will be satisfied by the 8″ Winchester (see "Systems Designer's Guide to 8″ Hard Disk Drives," by P. Snigier, *Digital Design*, August 1979). These disk drives are suited for uses that require data bases from a few 100,000 bytes to several Mbytes. With their quick-access, high-throughput mass storage intended for on-line applications, 8″ Winchesters are well-positioned to enter the small business, WP and modern office markets – markets ready to explode.

Although bubbles won't impact the low end of the 8″ Winchester market until the mid-1980s, 1980 should see system designers combining 8″ Winchesters and MBMs, using the bubble's fast access time in a cache store, reading several tracks at a time to increase system speed.

Small μP memories. Tape and disk, though low in cost for "large"-memory μCs, are costly for small μC memories. Thus, serving as backup for small semiconductor memory, bubbles may find use in certain smaller smaller-memory μC systems. How does it compare to other categories? I don't forsee it taking anywhere near what the others will take.

Miscellaneous applications include instrumentation, medical equipment, programmable calculators, consumer and automotive applications (voice synthesizers, mostly) POS, data collection, backup memories in μPs within cameras, ovens, satellite data recorders, phone-switching systems, computer network concentrators, etc.

Look what's coming in bubble memories

Looking into the future, I will hazard a technology forecast for 1980 and beyond. Here's what I see. . .

Japan will emerge as a competitor. Several Japanese semiconductor firms (Fujitsu, Hitachi, Nippon Electric, etc.) are actively pursuing the bubble memory business. However, this, in turn, is only part of a bigger picture, with Japan using semiconductors and bubbles as a springboard to launch an eventual all-out attack on the U.S. computer industry.

Dramatic increases in capacity will come soon. If bubble capacity quadruples every two years, then by 1981, the 4 megabit bubble will be sampled; by 1983, 16 megabits; and by 1985, 256 megabits. As for cost/bit, I won't hazard to guess; factors (not the least of which is the uncertainty of inflation) make this risky. But what is certain is that bubbles are poised to rapidly descend down the learning curve that is so characteristic of other semiconductor devices.

Bubble cost/bit should drop below 10 m¢/bit in the next few years due to volume production. But, on the other hand, with tenfold increases in density (and possibly simpler processing), contiguous disk devices should decline below 2 m¢/bit in seven years. A 100-Mbit storage unit could then cost $2k, making bubbles cost-competitive with small-to-medium-size magnetic disk storage drives.

Coilless drive technology. Eliminating coil assemblies (used in existing devices to produce rotating magnetic fields) will also allow for increased storage and increased operating speeds. To move the bubbles, a dual layer of magnetic coils wrapped around the chip generates a lateral magnetic field ("field access"). Bell Lab's dual-conductor magnetic circuit ("circuit access") technique eliminates bulky external magnetic coils. When will coilless drives be commercially available? Before 1984. This will cut package size by a third and increase memory density fourfold. Could this lead to another important development – lower-cost, removable bubble memory cartridges? If this happens, it will be a new ballgame: MBM erosion of *all* disk drive markets will come quicker than what I now anticipate.

Smaller packaging. With 256-kbit bubbles housed in 16-, 18- and 20-pin DIPs, on 1.5 in^2 area and with 0.4-in.-thickness will change, packaging and density improvements will certainly reduce package size.

Manufacturing improvements. But the real key to success involves: (1) new manufacturing (not so much pinouts and architectural) improvements and new device organizations that increase density, (2) better bubble detection and (3) improved material processing. For example, to improve yield further, planar-deposition approaches have been investigated; ion implantation is being researched (see "Largest Bubble Memory Exceeds 8 Mbits," by P. Snigier, *Digital Design*, October 1979). Ever-greater R&D money will be committed to following promising fabrication techniques, thus ensuring rapid progress.

MBM test systems are a big "fly-in-the-ointment." Since bubbles are both semiconductor and magnetic, this creates unusual test problems. In a nutshell, difficulties are severalfold: (1) MBM interfaces require drive far exceeding semi drivers, (2) new techniques must generate and verify data and handle error-processing, (3) testers must handle different types of I/O functions (due to lack of I/O standardization), (4) wafer testing woes abound, and other unappetizing problems must be overcome.

The MBM tester market will languish in the doldrums until 1985. 1980 will see bubble makers (and not users) buying test systems. But, when bubbles are in widespread use (1983), the user's market for testers will grow. But this shift will begin in 1981; by 1985, the market will be dual: makers and users. But for now, the test system makers (Fairchild, Megatest, Watkins-Johnson, ABC Electronics) will sell to MBM makers.

Change will come. Test systems, still in their infancy, will evolve as MBM organization changes. Test time difficulties will be solved, since testing, say one 8-Mbit chip could take half an hour today!

In summary...

Bubble memories are an explosive technology, and marketers and system designers who don't get on the bubble memory bandwagon will find themselves behind the eight-ball. But, bubble memories are no panacea: don't expect them to overtake magnetic media for far longer than other experts have been predicting. Magnetic media isn't at its theoretical limits. New developments in 8" Winchester hard disk drives, streaming tape drives, floppies, and new density improvements (including certain, yet-to-be-announced developments we've seen) will slow bubble erosion of the low- and high-end memory markets.

Bubble memories will be utilized by designers first in those replacement applications where nonvolatility, ruggedness and size constraints are paramount. Other applications will come later.

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1979
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Reel-to-Reel Tape Drives

Darell Meyer
Kennedy Co., Monrovia, CA

Trend to mass-storage system concept to accelerate

1979 was a renaissance year for tape transports; 1980 could be one of expansion. The tape industry readied annual growth rates of 15-20%. Increased sophistication of micros and small minis, plus increased main- and rotating-memory requirements, will open new markets for tape drives. Demand for tape transports are coming from both ends and the middle.

Let's examine the trends and their impact upon existing and future technology.

The "conventional" tape market

The need for tape storage units is threefold: they serve as (1) one-line data storage in applications such as telephone-calling data capture, (2) as backup storage for rotating-memory devices and (3) archival storage for long-term record keeping.

In early days, seven- and nine-track NRZI (non-return to zero interchange) drives, operating at 12.5 ips, with 200 bpi to 556 bpi data rates, were sufficient. But the wide acceptance of these drives has constantly haunted tape transport manufacturers.

Even though the last half decade saw a constant progression of technological advances, with improved recording techniques and higher speeds, most manufacturers continue to offer transports with dual mode or speed capabilities in order to accommodate the archival-storage requirement of tapes recorded a decade ago! Modern equipment employs tape transports with speeds to 125 ips using vacuum-column tensioning technology, for back-up and storage on high capacity new machines.

Although phase-encoded (PE) techniques were introduced in 1971, it's used in only half of shipped transports. The industry can produce units with 6250-bpi (or greater) recording density; yet, the conventional minicomputer transport market still requires dual-density, dual-endcoding mode technique.

The original seven-track NRZI transport market is far from dead; and, the much lauded phase encoded/group code recording (PE/GCR) market has yet to develop in any degree.

Is this surprising? Not really. Companies with huge libraries of 200 bpi NRZI tapes, going back for years, are reluctant to transfer data to more modern media; they want to load a tape and retrieve data. The cost of the transport to do this is more or less inconsequential in those cases.

Kennedy Data "Streamer" transport gives cost effective backup for high-capacity eight-inch disks and 14-inch disks.

Similarly, GCR, introduced by IBM in 1977 has not found great acceptance because of high cost and lack of compatibility with other systems. GCR requires four to six times the electronic sophistication of PE, with correspondingly-higher transport costs. However, these costs are economically justifiable in computer-output microfilm geophysical data reduction or other *systems that process massive amounts of data.* The user also must insure any other system using the data is GCR-transport equipped or spool the GCR to NRZI/PE tape.

As a result, tape-transport development for the conventional market has been a series of subtle advances – not startling innovations. For the past half-decade, tape design improvements have been aimed at better data integrity, longer tape life, reduced noise, lower power consumption and other barely-discernible features.

Improved materials

The circuitous path that tapes make in transition from supply reel to take-up reel takes a toll on the tape itself and upon its stored data. Modern materials such as "Tribaloy"-coating on R/W heads protects both head and tape from wear. In vacuum-column machines, air bearings and proper column location relieves the tape of both wear and stress when rounding bends. Capacitance tape sensing, within the vacuum-column, eliminates the "bang-bang" tape-stretching-procedure of previous machines.

Improved magnetic materials in servomotors and associated advances in semiconductor technology reduce tape transport power requirements. Switching power supplies are not common today, but will be used more. Subtle circuit redesign to coalesce transport electronics has improved reliability and reduced repair time.

As a result of these subtle changes, today's conventional tape transport users can expect a 5 khr head life, 4 khr MTBF and 0.5 hr MTTR. Recoverable errors are about one-in-10^9, while hard errors will be an order of magnitude less.

The relatively slow technology advancements of conventional tape drives will synergistically impact the design of new transports to support equipment using the Winchester disks. Developments used in previously-designed conventional transports are being incorporated in the new backup transports.

Winchester drive backup

During 1979, 8″ Winchester disks became a high activity item and a wave of the future. But, availability of backup transports with storage capacity and prices compatible to the 8″ hard disk drives is an important consideration in the acceptance of the new 8″ Winchester drives.

This year, established manufacturers quickly designed and introduced a number of new tape transports to support the new 8″ hard disk drives. Not to be shut out, smaller companies are moving fast to establish their position. In 1979, more than a half-dozen different transports appeared on the market; 1980 will see more. The products generally use two types of media – cartridges for lower-capacity 8″ hard disk drives and reel-to-reel transports for high-capacity 8″ and 14″ Winchester transports.

Cartridge backup

Most new cartridge transports employ a 3M-type DC-300 cartridge with 300′ or 450′ of ¼″ tape. Data recording is serial at 30 ips with a recording density of 6400 bpi. Several cartridge drives have four separate data tracks and use a serpentine technique in which adjacent tracks are recorded in opposite directions. Disks are dumped to, or loaded from, one cartridge track, then the tape is reversed to use the next track, thus eliminating normal rewind time. A 6400-bpi machine can store or restore 12 Mbytes of disk data in a little over 8 min. The maximum unformatted storage capacity for these cartridges is 17.3 Mbytes with 450′ tapes and 11.5 Mbytes with 300′ tapes.

Some manufacturers achieve greater capacities by using seven or nine data tracks along with higher tape speeds to achieve unformateed capacities above 50 Mbytes. Other drives employing proprietary cartridges handle ½″-wide tape in lengths from 500′ to 650′. These units have nine data tracks and stated capacities to 56 Mbytes. While they may meet backup requirements, proprietary cartridge machines, historically, have not found acceptance in conventional data processing applications.

All of the cartridge backup machines introduced in 1979 use existing technology; 1980 may bring further advances. Many companies are examining new ferrite-record-head designs that promise to boost packing densities above 10,000 bpi. Tight erase control is also necessary since it limits track spacing. It is necessary to erase and re-record specific tracks without effecting data on adjacent tracks. Various erase-head techniques such as tunnel erase are being developed which will allow narrower erase paths, permitting closer track-spacing. Within the next few years we may see cartridge transports with as many as 16 tracks on 0.25″ tape which will more than double current-storage capacity. The major disadvantage of cartridge drives is media compatibility.

Records stored on DC-300s cannot be transported to non-cartridge-drive-equipped mainframes to retrieve the data, as can a standard IBM-compatible reel. For this reason, the major movement seems to be for ½″, reel-to-reel streaming tapes.

Streaming ½″ tapes

"Streamer" is a name originally coined by IBM for their model 8809 tape transports and now generally used to describe low-cost, ½″ reel-to-reel transports. They are called "streamers" because they run continously at speeds from 75 ips to 125 ips, allowing users to dump the entire content of a disk onto tape in one run.

Because the streamer tape drives are new designs, they incorporate modern μP technology and important developments used in conventional tape transports over the past few years.

The significant innovation is tape control. Sophisticated streaming tapes have no capstan or mechanical-tension-control devices such as tension arms or vacuum-columns. μP-based routines monitor tension and speed, calculate the amount of tape on each reel in order to differentially drive individual motors at the proper speed to maintain constant tension. Some less sophisticated models under development may incorporate a single-tension arm.

Replacement of mechanical tensioning elements with electronic controls has a significant impact on transport costs. Without the labor-intensive machine shop and assembly work, streamer prices can be on the same order as the Winchester disks that they back up. Electronics are inherently more reliable than electromechanical equipment, so operating time is increased and repair costs reduced.

Virtually all backup reel-to-reel tape transports introduced in 1979 employ only 1600-bpi densities using nine-track PE techniques. A few continue to offer dual-mode dual-density capability, but this is reflected in higher transport cost.

The units normally have two speeds, 100 ips for high-speed recording and 12.5 ips in a start-stop mode. Kennedy's "Data Streamer Transport" is typical; others have slightly higher start/stop speeds. With a 10.5″, 2400′ reel, the Data Streamer Transport's capacity is 46 Mbytes. It stores or restores 12 Mbytes of Winchester disk data in about 72 sec. without pausing between data blocks.

The μP-control circuits also include routines which are activated when errors are encountered. The μP ramps the tape to a stop and reverses it at low speed to a position where it can ramp up to a speed before encountering the erroneous data block.

Streamer developments in 1980

In coming years, advancements will accelerate. Streaming drives that offer 3200/1600 bpi will be readily available at near single-density version prices. With the requirement for back-up, as opposed to interchange, higher density solely for backup is acceptable. Higher technology devices using thin-film heads, track densities up to 18 tracks on ½″ tape, and 30,000 bytes/in. will be possible.

Rapid advancements will occur in tape drives; no longer will all the attention be placed on disk peripherals. The solution for mass storage is a system concept – not a device concept – and 1980 will see the continuation of this trend.

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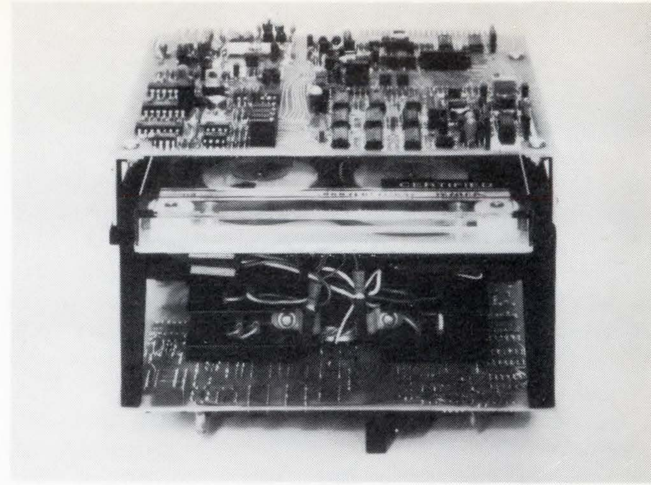
Streaming Tape Drives

William Valiant, *Data Electronics, Inc.*
San Diego, CA



Backup for 8" Winchesters promises rapid acceptance

The Winchester-8″ fixed disk drives require removable-media back-up systems that provide a save-and-restore function. "Streaming" is the key to efficient Winchester disk back-up.

Manufacturers have announced and demonstrated streaming tape drives, 1/2″ nine-track format and 1/4″ cartridge-type. Both types provide a continuous or flow-type process, as opposed to incremental tape motion. Specifically, tape motion does not stop after transmission of a physical unit of data (a block). Normal motion control stops the tape after each block.

While both 1/2″ and 1/4″ approaches merit consideration, the 1/4″ tape cartridge approach offers advantage of a format specifically designed for streaming. The 1/2″ approach must work around non-streaming format. The streaming cartridge drive provides a means of using essentially all of the available tape in the cartridge for data storage, because it eliminates the traditional starting and stopping in inter-record gaps. The information is recorded in what appears to be a continuous stream on the tape. This format further allows the drive to use a tape speed increased from 30 to 90 ips, because starting and stopping becomes very infrequent and therefore the associated distances are not important in tape utilization calculations. Consequently, a 450′ tape cartridge (7-track) requires only 1 min/recorded track at the 90-ips tape speed. The appears to present to the outside world 3150 continuous feet of tape.

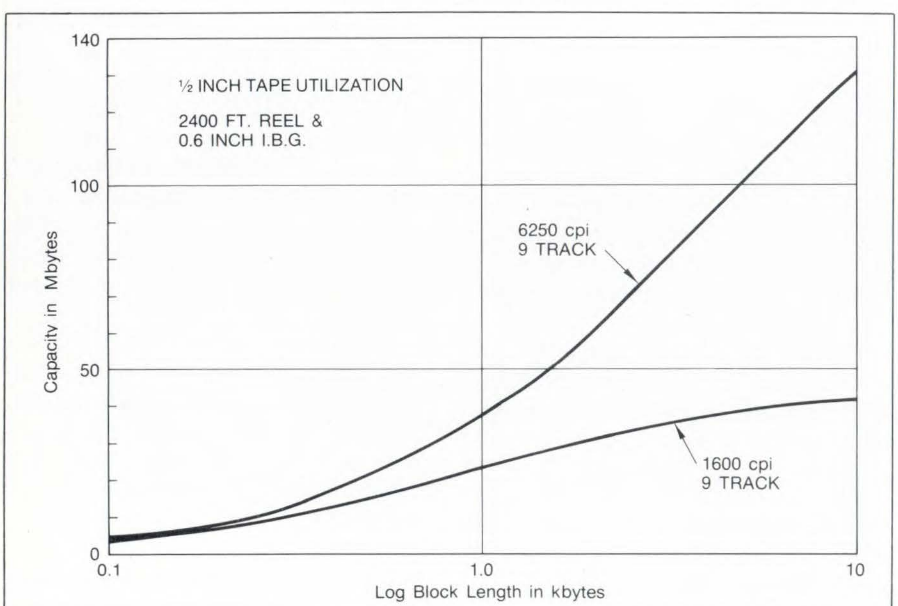


Fig 1 As the block length of the high-density 1/2-inch tape drive decreases, the tape utilization suffers a rapid deterioration.

Increasing tape utilization

Increasing the tape utilization means putting more data in the same physical tape area. Traditionally, tape formats use interlock gaps to provide a physical area to stop and start the tape. The minimum and maximum gap sizes are fixed by industry interchange standards. It is self-evident that these gaps represent a loss in time, if the tape is stopped between blocks, and a loss in efficiency in the use of the recordable media.

Let's examine efficiency, particularly as the linear recorded density increases. If the block size remains constant (i.e. a fixed number of bytes, such as 1024) and the density increases from 1600 to 6250 cpi, the tape use efficiency decreases (in the example, from 51% to 21% with a 0.600-inch interblock gap). **Fig 1** illustrates tape utilization with 1/2″ tape. An increase of nearly 4-times in linear density does not follow a 4-times capacity increase. In fact, not until blocks are greater than 4000 bytes does a 2:1 improvement in capacity occur. (See **Fig 2** for 1/4″ cartridge tape utilization.)

Two clear solutions to the tape utilization problem are possible: an interblock gap-size decrease (which eliminates industry-standard interchangeability), or a block size increase (which may demand other format changes to assure reliability). The maintenance of industry standards will require the continued use of standard interblock gaps and will not, therefore, allow for the increase in tape utilization. The block size increase to very long blocks requires format changes. These changes are due to the fact that self-clocked codes can fail if a dropout occurs – clock information must be continuously available. The probablities of such a failure go up as the block length increases.

Increasing the transfer rate

When the recording density is fixed, only an increase in tape speed can increase the transfer rate. Further, if the interblock gap size is fixed, an increase in speed dictates an increase in tape acceleration. Since format standards fix the distance required for acceleration from 0 to maximum speed, the only variable is time. And time must decrease as the speed increases. An increase of four times in tape speed dictates an increase of 16 times in acceleration ratio (**Fig 3**).

The effect on the performance of the servo system that significantly increases the acceleration is obvious. In addition, the motors must undergo technological improvements and the system needs a much greater cooling capacity.

By developing the streaming, manufacturers have eliminated these requirements and still provide high transfer rates. Eliminating stopping between blocks also provides much lower accelerations that lower the heat produced and makes for longer life.

Cartridge eliminates interblock gaps

As already noted, 1/4" cartridge streaming tape drives eliminates the traditional interblock gap and provides an essentially continuous recorded block. Within the recorded bit stream, the system separates data into blockettes and inserts between each blockette an address, resync, and error detecion and correction characters. Therefore, the media space is nearly fully utilized for the recording and the unnecessary interblock gaps are eliminated. The result is a capacity per serial recorded track of 5 Mbytes of data (formatted capacity) that can be transferred to the host system in 1 min. (data transfer rate is 675 x 10^3 bps). **Fig 4** shows the comparison to tape utilization for the two approaches.

To further improve the time to

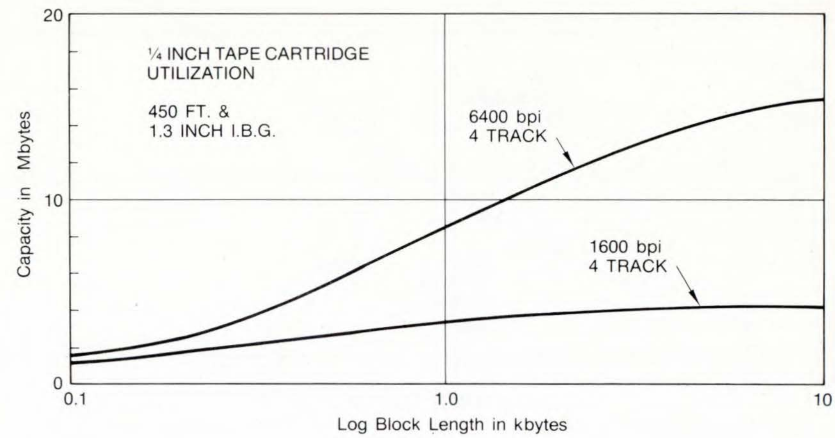


Fig 2 Block length affects tape utilization less in 1/4-inch digital cartridge drives.

GAP SIZE: = .6 inch = Constant

ACCELERATION DISTANCE = .20 inches = D

t = time for acceleration
v = Velocity
A = Acceleration

At 25 in/sec:

$$\Delta t = \frac{D}{V} = \frac{.20 \text{ in}}{\frac{25 \text{ in}}{2 \text{ sec}}} = 16 \text{ E-3 sec.}$$

$$D = \tfrac{1}{2} At^2$$

$$A = \frac{2D}{t^2} = \frac{2(.20)}{(16 \text{ E-3})^2} = 1562 \frac{\text{in}}{\text{sec}^2}$$

At 100 in/sec:

$$\Delta t = \frac{.20 \text{ in}}{\frac{100 \text{ in}}{2 \text{ sec}}} = 4.0 \text{ E-3 sec}$$

$$D = \tfrac{1}{2}At^2$$

$$A = \frac{2D}{t^2} = \frac{2(.20)}{(4.0 \text{ E-3})^2} = 25{,}000 \frac{\text{in}}{\text{sec}^2}$$

or 16:1 Acceleration ratio

Fig 3 Acceleration calculations show that increasing the tape speed by 4 times requires a 16 time increase in acceleration.

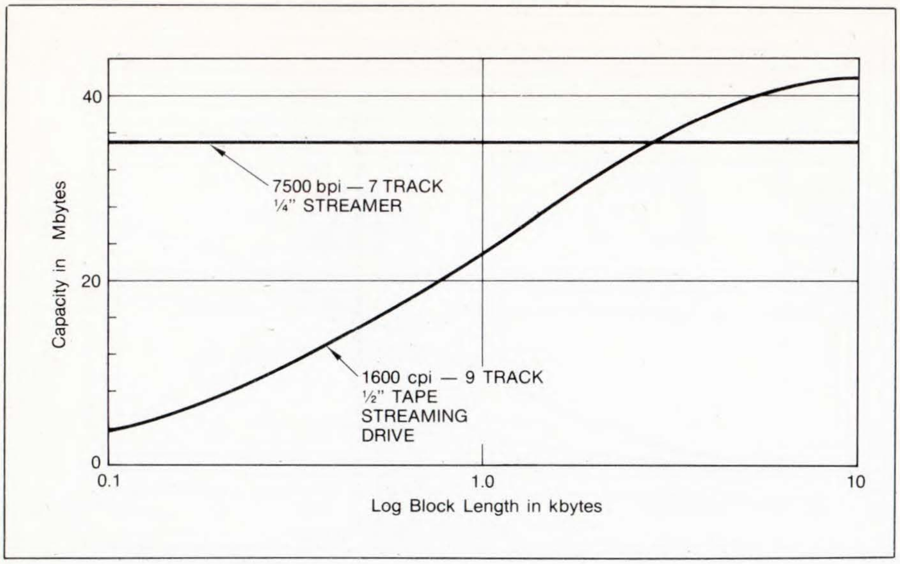


Fig 4 Streaming digital cartridge drives demonstrate maximum tape utilization.

transfer the data to the host system and maintain the economical bit serial format in the 1/4″ cartridge drive, the system writes the data in a serpentine fashion on the tape. Each odd track is written in a forward direction and each even track in a reverse direction. This scheme eliminates the need for unnecessary rewinds between tracks **(Fig 5)**. By adding three new tracks to the historical four tracks, you improve the capacity of the 1/4″ tape cartridge. Since new tracks are used in the reverse direction, they preserve the form of the previous four-track format. The resultant capacity of 35 Mbytes of formatted data per cartridge can be transferred to or from the Winchester.

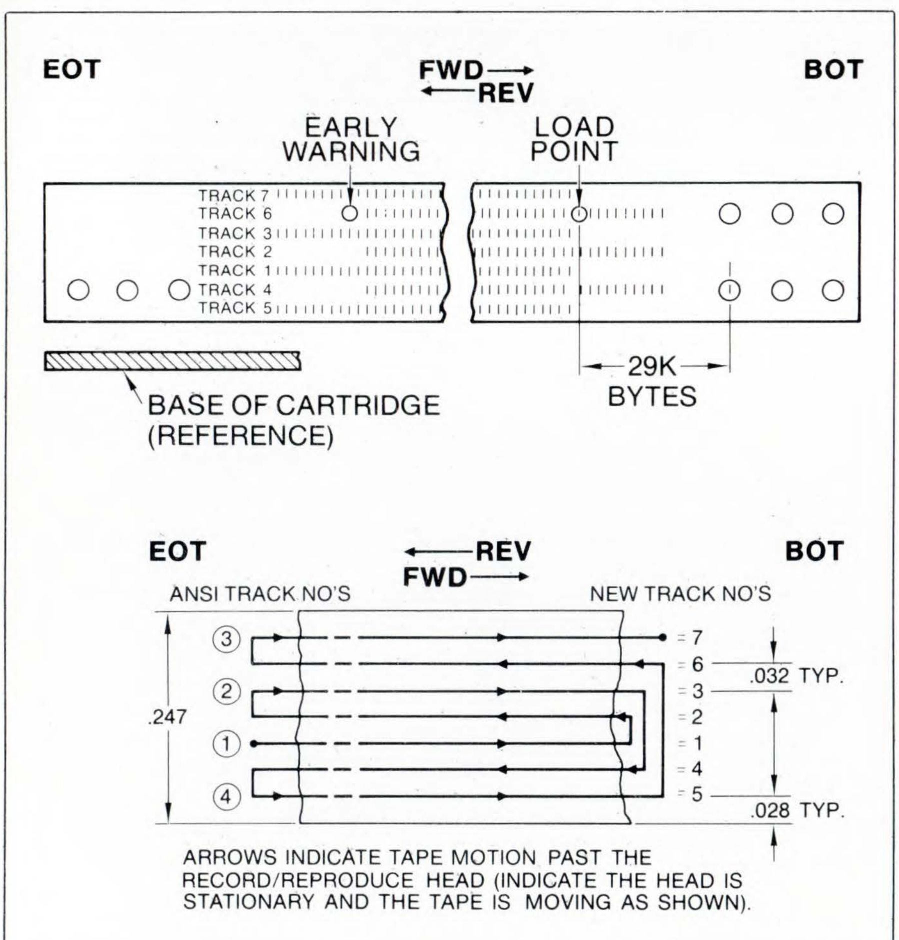


Fig 5 The 7-track serpentine tape format with bidirectional recording eliminates the need for track-to-track rewind time.

Lowering costs

Streaming eliminates the high performance rapid start/stop tape drive electronics and mechanics. This elimination reduces system costs, because lower-performance servo systems can drive the tape at high speeds. Lower power supply output wattage requirements and the subsequent elimination of associated heat dissipation, in the power generation as well as motor and amplifier inefficiencies, also cut system costs.

Tape drive systems use quite expensive materials that add up to 50% at the magnetic head and drive motors. Reduced motor performance still maintains high transfer rates at a much lower price. Further, high acceleration-rate drives require technological changes to achieve higher speeds in shorter times — such as vacuum columns to replace buffer arms. These changes in technology affect the price of drives markedly, because support items like vacuum pumps, and accurate guides further increase costs.

The mechanics of the 1/4″ tape cartridge of the system limits system acceleration. Therefore, cost reduction depends on motor selection and performance levels.

Better performance, lower cost

Streaming tape drives provide many advantages. For disk backup applications of from 10 to 100 Mbytes, these drives are the current choices. Some disadvantages include a limitation in file management and lack of fast direct tape control by the host system. However, these are not significant in most streaming drive save-and-restore operations.

Streaming tape drives meet the considerable pressure to reduce the installed cost of the back-up system to less than the disk drives with which they mate. Furthermore, these tape drives now offer a higher tape utilization, greater storage capacity and transfer rate have acturally occurred in these new peripheral devices — all at a price that has been cut in half.

1980 will see new product entries at lower prices.

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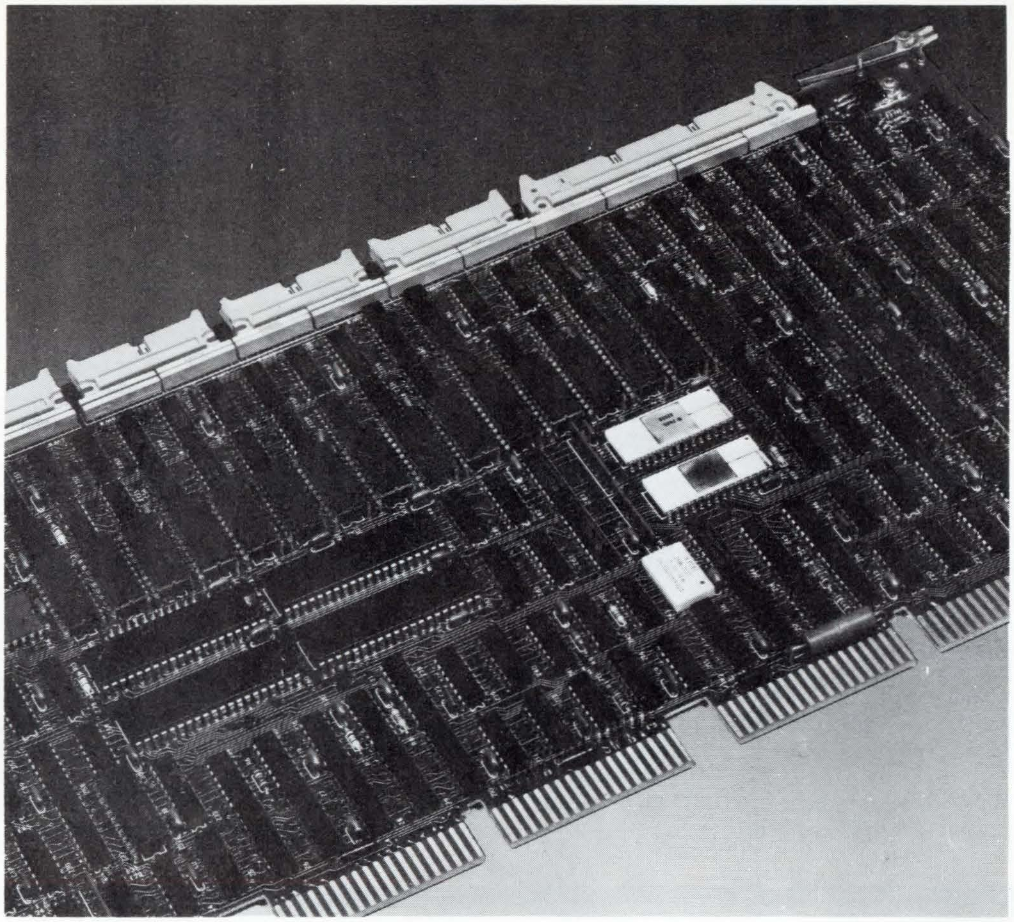

ONE-BOARD PDP-11 SMD CONTROLLER, SOFTWARE COMPATIBLE...A FIRST!

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One-board means you need only one hex SPC slot. One-board means easy insertion and optimum air flow.

One-board with its attendant features of minimized interconnections and low component count means lower power, complete accessibility, higher reliability...and best of all, lower cost.

If you're interested in one of our one-board S33 controllers, or a whole bunch of them, we'd like to hear from you. If you operate in the LSI-11® world, still contact us. Our LSI-11 cousin of the S33 is on the way.

DEC, LSI-11 and PDP are registered trademarks of Digital Equipment Corporation

DATARAM CORPORATION

PRINCETON-HIGHTSTOWN ROAD CRANBURY, NEW JERSEY 08512

TEL:609-799-0071 TWX:510-685-2542

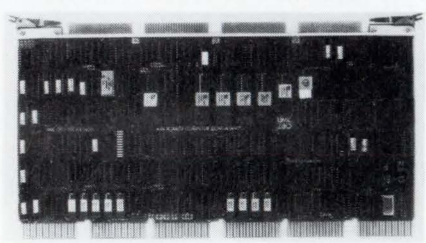
Circle 17 on Reader Inquiry Card

New Products

VAX-11/780 TAPE SYSTEMS interfaces the VAX-11/780 to a TC-130, (Western Periph. Div. mag. tape controller) and handles up to 8 industry-std. tape drives. Complete TX-130/VAX tape subsystems including a single 45-ips dual-density 800-1600 bpi drive (from $7,600). Systems up to 125 ips dual density are available. VAX users can purchase a VMS driver/TC-130 controller package for their industry-std. drive for $3,500. **Western Peripherals Div.**, Wespercorp, 1100 Claudina Pl., Anaheim, CA 92805. **Circle 126**

DISK CONTROLLER MCD-1, an intelligent controller, interfaces all μP-based CPUs and a variety of Cartridge Disk Drives in the 3 to 12 Mbyte range. Up to 4 drives may be daisy chained together for a max. of 48 Mbytes on line storage. The Controller is based on the Signetics 8 x 300. Data format, 128 x 8 bits/sec; max. data rate, 2.5 MHz; format time, 70 sec/platter (404 track by 32 sector); transfer time, 100 ms. max. **Business Communication Sciences, Inc.**, 14770 E. Firestone Blvd., La Mirada, CA 90638. **Circle 136**

UMG-Z80 PROCESSOR BOARD consists of a set of μP systems, memory systems and support software. It's built around the Z80 and interfaces to a



PDP-11 UNIBUS, is valuable in data communications, I/O processing and control applications in which a minimum impact to the PDP-11 is desirable. It is also valuable for custom interfacing onto the UNIBUS. **Associated Computer Consultants**, 228 E. Cota St., Santa Barbara, CA 93101. **Circle 129**

3300/3400 GRAPHICS LONG-LINE ADAPTER option makes it possible to remote digital devices up to 600′ from the main controller. In graphics computer applications, individual workstations can be remoted from the graphics controller to permit more flexibility in choice of remote sites. It can be supplied with the graphics display system or field retrofitted. **Vector General, Inc.**, 21300 Oxnard St., Woodland Hills, CA 91364. **Circle 128**

NOVA 1200 OPTION BOARD. Model 2010 CPU Option Board updates Data General NOVA 1200 and D-116 computers to accept the complete instruction set for Data General's NOVA 4 Series. Used with existing NOVA 1200 memories, it also boosts NOVA 1200 speed by 25%. If existing memories are replaced by a 32KW Memory Board, NOVA 1200 speed goes to 800 ns (about 40%). Option Board, $1,800. **Quentin Research, Inc.**, 610 Hawaii St., El Segundo, CA 90245. **Circle 127**

Product Highlight

Programmable Calculator Boasts "Solve"/"Integrate" Functions

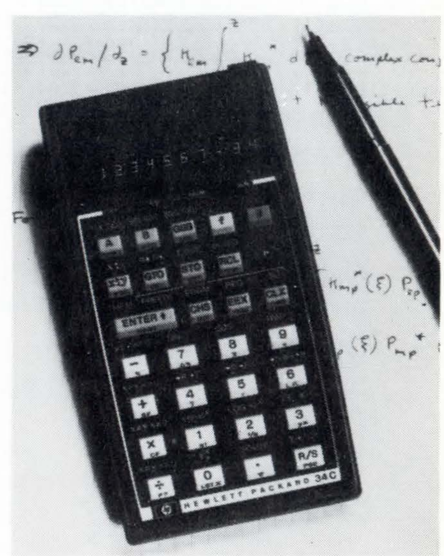
Model HP-34 C, the most powerful programmable scientific model in the "E" Series, features "solve" and "integrate" functions and its 20 data registers are automatically converted to program lines as needed. It has up to 210 program lines with a programming capacity of up to four keystrokes/line (or 370 keystrokes/program), full program-editing capability and other advanced programming features.

A continuous-memory feature retains user programs and data even with power off. This saves time and reduces chances of error, since indefinite storage of frequently-used programs (and conversion constants) eliminates the trouble of rekeying each time.

The "solve" algorithm lets you find real roots of a wide range of equations with a few simple keystrokes – usually a chore that often required a computer (or, if done manually, was a laborious trial and error job). The "integrate" function finds the definite integral of a function (a calculus operation which also can require the aid of a computer). Both "solve" and "integrate" capabilities are the most advanced and powerful on a handheld calculator.

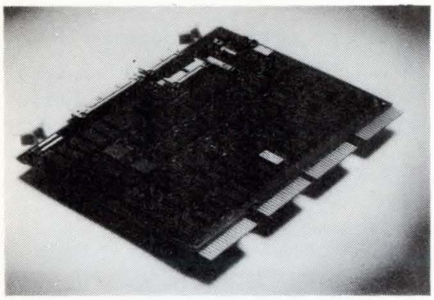
Other advanced programming features include line and label addressing, indirect storage and recall, conditional-unconditional-indirect branching, insert/delete editing, subroutine capability, user-definable keys, addressable labels and loop control.

This programmable comes with a large applications book containing 10 commonly-used programs for mathematics, finance and recreation. There are four optional books in math, statistics, student engineering and surveying. **Hewlett-Packard Co.**, 1507 Page Mill Rd., Palo Alto, CA 94304. **Circle 192**



New HP-34C from Hewlett-Packard features easy-to-use "solve" and "integrate" functions comparable in power to those found on large computers.

LSI-11 SMD DISC CONTROLLER interfaces any two removable media or Winchester drives and cuts cost/space/power requirements 40-50%. Model DQ-200 controller includes proprietary μP and all electronics for operation, automatic self-test firmware diagnostics and interface through the SMD interface cable to both LSI-11



and any industry std. disc, w/o external power or chassis. Its soft sector format provides 20% more disk storage thru variable sector size and number of sectors/track for highest utilization of disk storage and more convenient data base structure. **Distributed Logic Corp.**, 12800-G Garden Grove Blvd., Garden Grove, CA 92643. **Circle 130**

DIGITAL PLOTTER Model 281 provides a rapid, accurate graphical representation of measured values, design data and calculated data using up to 8 color pens. The programmable pen changing feature incorporates up to 8 separate pens using either multi-color fibre tip pens and/or Koh-I-Noor Rapidograph drafting pens of varying line thicknesses to provide high quality plots. Firmware features include circle interpolation, character plotting, generation of axes and grids, various line types, window plotting and off-scale data handling. **Soltec Corp.**, 11684 Pendleton St., Sun Valley, CA 91352. **Circle 135**

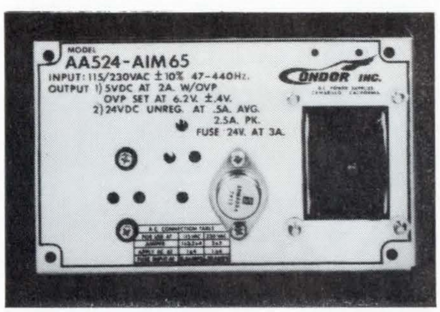
UA/11-C UNIBUS ADAPTOR enables users to connect multiple UNIBUS-compatible devices onto DEC's LSI-11 or PDP-11/03 systems. Features include: DMA or programmed I/O peripherals on either LSI-11 Bus on UNIBUS may access memory or peripherals on either their own or the other bus and since the UA/11-C is transparent, the programmer need not know to which bus a device is attached. **Associated Computer Consultants**, 228 E. Cota St., Santa Barbara, CA 93101. **Circle 143**

F6846 COMBO CHIP is a user-defined ROM-based peripheral element with 2K x 8 ROM, a powerful programmable binary timer and 8 bidirectional I/O ports on the same circuit. It's F6800 series bus-compatible. **Fairchild Camera and Instrument Corp.**, Box 880A, Mt. View, CA 94042. **Circle 144**

PDP-11 MEMORY MODULE 94234 Core Memory Module is fully compatible with inherent reliabilty and non-volatility. It's fully compatible and fits into your PDP-11/70 rack and gives you up to 512 Kbytes in a 10.5″ enclosure housing two supplies, one back plane, one controller circuit board, 2-8 memory modules (in pairs), 4 interconnect cables and 4 terminator circuit boards. **Control Data Corp.**, 8001 E. Bloomington Freeway, Bloomington, MN 55420. **Circle 145**

VDT. The IQ 120 has a 1920 char. screen memory, lower case, RS232C extension, switch selectable transmission rates from 75 to 19,200 bps, cursor control, addressable cursor, erase functions and protect mode. Expansion options include block mode and hard copy capability with printer interface. It incorporates a 12″ CRT formatted to display 24 lines with 80 char./line. **Soroc Technology Inc.**, 165 Freedom Ave., Anaheim, CA 92801. **Circle 146**

DEVELOPMENT SYSTEM DCS/80, an industrial-quality Multibus Development/Control System, includes dual 8″ floppy disks, 5-slot Multibus backplane and power supply. It fits a std. 10.5″ rack space. The DCS/80 Floppy Disk Controller is an intelligent Multibus-compatible system containing its

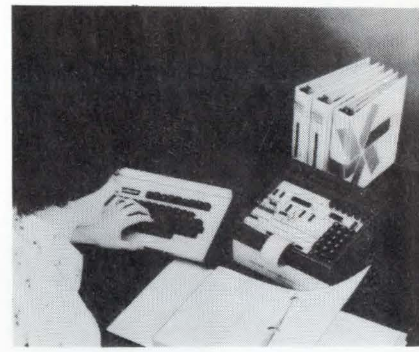


own 8080, permitting concurrent operation with the main CPU as well as extensive system error reporting. CP/M supports high-level languages (such as Fortran, Cobol, Basic). CP/PLUS DOS has batch processing, logical-to-physical device mapping, supports up to 933 files/diskette, etc. **Distributed Computer Systems**, 223 Crescent St., Waltham, MA 02154. **Circle 131**

DEVELOPMENT SYSTEM. No other development system is said to offer such a comprehensive combination of hardware/software features. This 2300-9300 Advanced Development System provides all development tools for 8080, 8085, 6800, 6802 or Z80-based product design and test. 24.25D x 16.75 W x 11.72″H. 74lbs. **GenRad/Future Data**, 6151 W. Century Blvd., 1124 Los Angeles, CA 90045. **Circle 142**

OPEN FRAME POWER SUPPLY Model AA 524-AIM65 can be used in Rockwell's AIM 65 μC or any 5V 2A logic power requirement with a companion lamp, relay or printing voltage requirement. \$39 (1-9); \$31 (100). **Concor, Inc.**, 4811 Calle Alto Camarillo, CA 93010. **Circle 281**

μP TRAINER ACCESSORY converts the ET-3400 Microprocessor Trainer into a personal computer. The ETA-3400 Accessory provides uses beyond a trainer – up to 4K of additional RAM, new monitor in ROM, tiny



BASIC interpreter in ROM, audio cassette interface for mass program storage on cassette tapes and serial interface for a VDT. **Heath Co.**, Dept. 350-910, Benton Harbor, MI 49022. **Circle 132**

TAPE STREAMING backup, archival storage for 8″ Winchester drives at 576″ kbit/s transfer rate (30.2 Mbytes/cartridge) on 1/4-in. tape stores on 8″ hard disk's contents in 7 min. A faster version of this "Streamer", termed the "Streaker" (34 MB), transfers data at 648 kb/s, but lacks error correction. Density equals 6.4 kbpi on stnd. 1/4-in. ANSI/ECMA cartridge. Operation is FIFO. Both use a 7-track bidirectional is FIFO. Both use a 7-track bidirectional head. Streamer, 7″W x 7″H x 8″D. Streamer, \$1219; Streaker, \$885 (OEM qty). **Data Electronics, Inc.**, 370 N. Halstead St., Pasadena, CA 91107. **Circle 140**

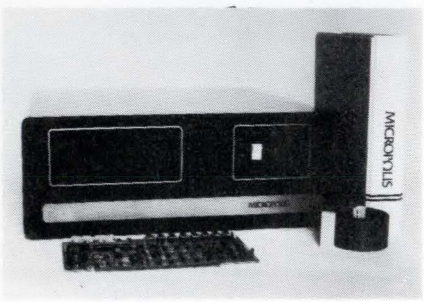
IC SOCKET CATALOG. This "Cambion Design Engineering Guide" includes both established and new DIP-socket families and includes complete data and tips on selecting IC sockets for your applications. **Cambion**, 445 Concord Ave., Cambrdige, MA 02238. **Circle 141**

DISK DRIVES BROCHURE, "Ball Data Storage for Nova/Eclipse", provides features and specs for Storage Module-type disk drives in 3 capacities: 50, 80, 100 MB. All come in either rack-mountable or pedestal-based configurations. **Ball Computer Products**, 860 E. Arques Ave., Sunnyvale, CA 94086. **Circle 150**

New Products

VIDEO DISPLAY IQ 140 provides the operator a full command over data being processed by means of a wide variety of edit, video, and mode control keys, etc. The detachable keyboard, with its complement of 117 keys, is logically arranged into 6 sections plus main keyboard to aid in the overall convenience of operation. **Soroc Technology, Inc.** 165 Freedom Ave., Anaheim, CA 92801. **Circle 148**

MULTI-TERMINAL OS. This 8″ rigid disk drive subsystem includes a multi-terminal OS. Designed for small business system builders and end-user add-on markets, "MicroDisk" subsystem includes the industry's only 3-platter



drive with up to 31.2 Mbytes of formatted storage capacity, an intelligent disk adapter-interface card, supply and modularized software package. It interfaces to S-100 bus and is fully supported for immediate plug-in use on 8080, 8085 and Z80 systems. **Micropolis Corp.**, 7959 Deering Ave., Canoga Park, CA 91304. **Circle 133**

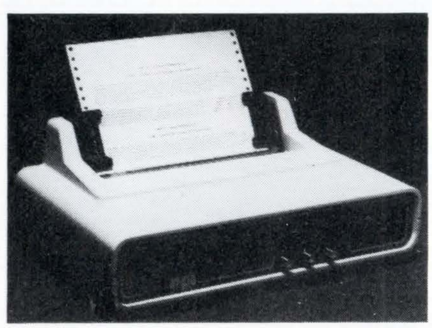
10MB DISK SYSTEM is plug compatible with the TRS-80, Apple and all S-100 bus-type computers, the Corvus intelligent disk system adds cost-effective mass storage, while maintaining total compatibilty with existing hardware and software. It has an IMI 7710 disk drive with two 8″ hard disks, intelligent disk controller (Z-80 based) with comprehensive disk diagnostics, intelligent personality-module and associated software for each type of computer. $5,350. **Corvus Systems,** 900 S. Winchester Blvd., San Jose, CA 95128. **Circle 152**

80-COL. IMPACT PRINTER Model 800 has a metal enclosure that provides a rugged skin for industrial environments. To simplify interface, it handles the four most popular disciplines – just add the right cable – at 15 baud rates up to 19,200. 5 print densities, from 72 to 132 characters per line, provide format flexibility. Up to 10 char. sizes are possible. **Base 2,** Box 3548, Full., CA, 92634. **Circle 154**

GENERAL PURPOSE BOARDS accept Cambion wire-wrappable DIP sockets and various board mounting hardware. You determine where you put them, how many and what types. Printed "Overlay" and "Underlay" drawings, on clear vellum stock, are available to you, without cost, and are the key to creating you own "customized" prints. "OVERLAY" forms are pre-printed on vellum stock (for see-through traceability) in Manufacturing Print format, with individual Cambion board layouts in actual size, showing pre-drilled board mounting hole locations, edge connector patterns and all board details. There are 3 series of GP Boards. Each series has 4 different size boards, with 70-pin edge connectors, fitting standard Cambion card files. **Cambion,** 445 Concord Ave., Cambridge, MA 02238. **Circle 147**

PDP-11/03 & LSI-11 MEMORY. The 94111 MOS RAM has block address selection via switches for the standard configuration of 16K or 32K x16. It is pin-to-pin, voltage, signal, hardware and software compatible with LSI-11 and PDP-11/03 systems. **Control Data Corp.,** Computer Memory Div., 8001 E. Bloomington Freeway, Bloomington, MN 55420. **Circle 149**

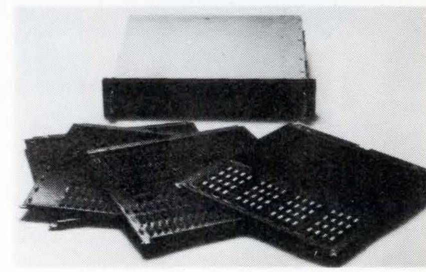
MATRIX IMPACT PRINTER Model 88T features 100 cps bi-directional printing and print line formats of 80, 96 or 132 col. A full u&l case 96 char. ASCII set is printed in a 7 x 7 matrix



for crisp, clear printing on the original plus-two copies. Double-wide char. are software-selectable and can be intermixed on any line for message highlighting. $749. **MPI,** 2099 West 2200 South, Salt Lake City, UT 84119. **Circle 137**

DISK CONTROLLER NOVA. The "Garnet," a single-circuit board, mounts within Nova CPUs and used in a stnd. emulation format, supports up to 4 10-Mbytes disk drives in a daisy-chain configuration. While Data General's controller offers a 2-word data buffer, this controller features a full 1 Kword buffer. Garnet is a fully featured emulation of DG's 10-Mbyte 6045 Disk system controller. It makes use of a 2901-bit slice processor for its expanded control capabilities. Easily installed, Garnet plugs into a Nova or Eclipse stnd. I/O slot with existing wiring and cable, and is fully software compatible, including diagnostics. $925. **System Industries,** 525 Oakmead Pkwy., Box 9025, Sunnyvale, CA 94086. **Circle 138**

DIGITAL RASTER DISPLAY CONTROLLER system for OEM use, GCT-3400, the first ultra-high resolution fast-response, monochrome Digital Raster Display Controller designed for OEM Systems, sells for under $7,000.



It provides a full screen high-density raster pattern of 768 horizontal lines 1024 pixels/line) – a total of 786,432-pixel locations. Each location can be individually addressed by the GCT-3400's Programmable Graphics Processor responding to macro-instructions from the host computer. A raster refresh rate of 60 frames per second – twice the speed of conventional video systems – permits flicker-free display. **Genisco Computers,** 17805 Sky Park Circle Dr., Irvine, CA 92714. **Circle 134**

μC I/O SYSTEM combines the latest and best in I/O modules with plug compatibility to SBC. Opto 22 I/O Systems are available in plug compatible racks holding eight, sixteen or twenty-four modules. These highest quality input/output modules are available for 5, 15, or 25-volt logic – all employing 2500 volts RMS photo-isolation. **Opto 22,** 5842 Research Dr., Huntington Beach, CA 92649. **Circle 151**

ATE SEMINARS/EXHIBITS. Two major technical conferences with specialized workshops and technical papers cover a variety of test and measurement topics for users of instruments and systems. The "Test Instruments Conference" program and workshops include: logic analysis techniques, theory and applications of phase measurements, signature analysis, power supply testing, waveform analysis, spectrum analysis, building ATE systems using IEEE-488 equipment – and much more. "ATE Seminar/Exhibit" program and workshops include: digital testing philosophy, how to get started in ATE, testability, burn-in, functional vs in-circuit testing, LSI board test, ATE interfaces (software), field test diagnosis, digital diagnosis – and more. Both are on Jan. 7-10, 1980 in Pasadena, CA. **Call** Sheila McDonagh at (617) 232-5470. **Benwill Publishing Corp.**, 1050 Commonwealth Ave., Boston, MA 02215. **Circle 139**

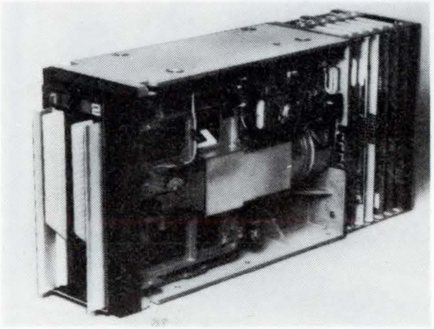
8080/8085 COURSE. This hefty 10-volume course, "8080/8085 Assembly Language Programming," is one of the more thorough and exhaustive, yet easy-to-read courses on the market. Although this individual learning program is tailored for individual study, it is well-suited to classroom instruction. Instead of using the *teaching* method, this text works toward tasks *learned* when needed, and reinforced to insure future retention. This course, unlike many other smaller texts on the market, was designed by both μC experts and professional educators. It includes numerous questions (with answers). Specific Behavorial Objectives, introduction and Unit Activity Guide precede each chapter, which in turn is broken into several Self-Test Reviews and a Unit Examination following each chapter. Appendix A describes the H8 assembly language; Appendix B, number systems and codes. Also includes: a separate 90-page "Programming Workbook," plastic Opcode/ ASCII table, and one final examination kit to be graded by Heath for CEU credit at course completion. **Heath Co.**, Benton Harbor, MI 49022. **Circle 179**

10-MBYTE 8" HARD DISK system provides 50 times capacity and 10 times the speed of currently available μC storage devices. Plug-compatible with TRS-80, Apple- and S-100 bus-type computers, this intelligent disk system adds cost-effective mass storage to these computers. It has an IMI 7710 disk drive (with two 8" Winchesters); Corvus intelligent disk controller, Z-80 based, with comprehensive disk diagnostics; intelligent personality-module and software for each computer. Each drive has 100 M-bytes of formateed storage. Up to four drives can be supported in a simple daisy chain. $5350. Add-on disk drives, $2990. **Coryus Systems**, 900 S. Winchester Blvd., San Jose, CA 95128. **Circle 175**

PM DC-MOTORS suited to computer peripheral design (and other uses) provide: end caps of machined aluminum for efficient heat transfer and precision tolerances; bearings of double-shielded ball bearings (lubricated for life), shaft of stainless steel (with wide selection of std. diam. and extensions. **Clifton Precision,** Marple at Broadway, Clifton Hts., PA 19018. **Circle 187**

CASSETTE TERMINAL Model 6801 is a dual-cassette OS capable of reading, writing and copying data at switch-selectable rates from 110 to 9600 baud through a full duplex, asynch. RS-232C interface. Connected to a serial port of a PDP8 or PDP11 and given the proper address, it emulates the typ. paper tape reader/punch and performs functions of program load, data logging, assembly, edit or duplication. Select one of two TI Silent 700 modes, and tapes can be written, read or copied that are completely compatible with the 733ASR (but at much higher data rates). **Raymond Engineering, Inc.**, 217 Smith St., Middletown, CT 06457 **Circle 191**

6-M BYTE FLOPPY. The dual floppy drive MD 122 uses two 8" flexible disks, each storing 3 Mbytes of formatted data. A high performance voice coil actuator is shared between the two disks, giving the unit its avg. time-to-



data of 158 ms. The combination of fast access, high storage capacity and twin removable media allows the MD 122 to serve as either a main file unit or a load/dump device for fixed disk drives. $1950 (OEM qty.). **Burroughs OEM Marketing Corp.**, Burroughs Pl., Detroit, MI 48232. **Circle 177**

MATRIX PRINTER. Model 8300 features a straightforward design and continuous-duty 7-wire head with a life expectancy of 100 million characters. With a 7-bit parallel interface, this 80-col., dot matrix unit prints bi-directionally at 125 cps; its sprocket paper feed mechanism accepts multi-ply pin-feed paper in any width from 4.5" to 9.5". Paper is loaded from bottom or rear and print line position is adjustable. **C. Itoh Electronics, Inc.**, 5301 Beethoven St., Los Angeles, CA 90066. **Circle 186**

TAPE STREAMING BACKUP – archival storage for 8" Winchester drives at 576-kbits/s transfer rate (30.2 Mbytes/ cartridge) on 1/4" tape – stores an 8" hard disk's contents in 7 min. A faster version of this "Streamer", termed the "Streaker" (34 MB), transfers data at 648 kb/s, but lacks the error correction of the first version. Density for both equals 6.4 kbpi on stnd. 1/4" ANSI/ECMA cartridges. Operation is FIFO. Both use a 7-track bidirectional head. Streamer measures 7" x 7" x 8" D. Streamer, $1219; Streaker, $885 (OEM qty). **Data Electronics, Inc.**, 370 N. Halstead St., Pasadena, CA 91107. **Circle 182**

μC SYSTEM. This complete system provides a solution to the mass storage problem of μCs. In a package smaller than a briefcase, it provides an intelligent controller, disk and personality module. It's for the TRS-80, Apple (including Apple Pascal), S-100 Bus and LSI-11. Features include: fully compatible hardware/software, 10 Mbyte disk: IMI-7710, proven Winchester technology, Z-80 based Corvus disk controller, comprehensive disk diagnostics, up to 4 disks per system and system $5350, add-on disk $2990. **Corvus Systems, Inc.**, 900 S. Winchester Blvd., San Jose, CA 95128. **Circle 185**

LOGIC ANALYZER. The 308 Data Analyzer, reportedly the first instrument combining capabilities of a state and timing logic analyzer, serial data analyzer and signature analyzer into one compact (8 lb.) instrument, provides 8 channels at 20 MHz with 252-bits/channel memroy size. The 8-channel parallel word recognizer provides internal triggering upon recognition of preset digital-system state and is expandable to 24 channels with the optional P6406 Word Recognizer Probe. **Tektronix, Inc.**, Box 500, Beaverton, OR 97077. **Circle 180**

CASSETTE DRIVES. With only two moving parts, the MFE 250B boasts MTBFs of 15,000 hrs. The servo-controlled reel-to-reel tape handling results in a constant tape speed within ±1% and a low bit-to-bit jitter of ±3%. It includes a RAW head as a std. feature to improve data integrity. Power: ±5V at 5W. Continuously-variable speed from 2-120 ips. Data transfer rate up to 32 kbps ANSI/ECMA-compatible. **MFE**, Keewaydin Dr., Salem, NH 03079. **Circle 189**

8" WINCHESTER fixed disk drives, are described in this data sheet. It details similarities between the Shugart SA850 floppy disk drive and SA1000, enabling simple and inexpensive enhancement of existing floppy-based systems. **Shugart,** 435 Oakmead Pkwy., Sunnyvale, CA 94086. **Circle 176**

DATA ACQUISITION BOOK. "Principles of Data Acquisition and Conversion" by Eugene L. Zuch is a 242 pg. book with a useful glossary of 200 most-commonly-used data acquisition terms. $3.95. **Datel-Intersil, Inc.**, 11 Cabot Blvd., Mansfield, MA 02048. **Circle 181**

New Products

COAX MODEM transmits dc to 2 Megabaud data up to 50,000′. Model 30-0078 transmits/receives high-frequency asynch. data on coaxial cable at dc to 2 Megabaud. It makes possible implementation of a single high-speed data highway for processor-to-processor communication, remote multiplexing of distributed I/O functions, networking of terminals and computers, and moving large packets of data in local area networks. PC card, 2" x 4-1/2". $240 (100). **Computrol Corp,** 15 Ethan Allen Hgwy, Ridgefield, CT 06877. **Circle 225**

MORE-COMPACT HP 3000, begins at $49,750, Applications written in any of the three family-members' five common languages will run on any other without modifications. Full HP Distributed Systems Network (DSN) capabilities now apply to all, including remote data base access, file sharing, and program-to-program communications. Every HP 3000 is now delivered ready to execute programs written in any of five high-level languages. **Hewlett-Packard,** 1501 Page Mill Rd., Palo Alto, CA 94304. **Circle 153**

OSCILLOGRAPH SE6300 offers 12″ resolution and uses 8″ or 12″ paper by simply inserting a new chart supply spool. No mechanical switches and reduction gear boxes. Front panel keypad switches step each function range up or down, with LED readout of the range selected. All functions are externally programmable, permitting full remote or computer control. Chart drive is servo controlled at 13 speed, from 0.5 mm/s to 5 m/s. **EMI Technology, Inc,** 100 Research Dr, Stamford, CT 06906. **Circle 272**

PROGRAMMABLE COMMUNICATIONS INTERFACE. The 28-pin 2661 Enhanced Programmable Communications Interface is pin and register bit-compatible with Signetics previously-released 2651 PCI, provides binary serial interface for asynch. or char-oriented synch. data systems. It interfaces directly to all 8-bit micros and can be used in polled or interrupt-driven system environments. $14.50 (100-999). **Signetics,** 811 Arques Ave., Box 9052, Sunnyvale, CA 94086. **Circle 259**

Z80 ANALYZER PROBE accessory to the Model 532 Intelligent Logic State Analyzer, Model 54, simplifies logic state analysis of the Z-80. This is significant because the Z-80 does not output convenient clock or strobe signals, thus making analysis of address and data information with a logic state analyzer extremely difficult. The Model 54 (Z-80 Interface Board) and the Model 532 Logic State Analyzer (with dual clocking capabilities) solve this problem. Model 54 clips directly on to the Z-80 and generates signals required to directly capture program flow. **Paratronics Inc.,** 122 Charcot Ave., San Jose, CA 95131. **Circle 178**

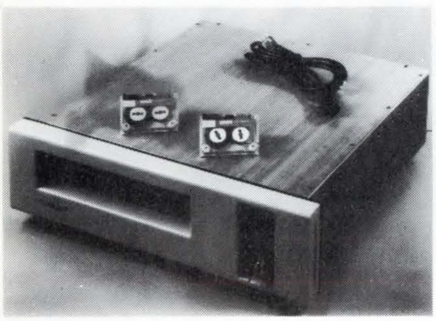
"MICROPROCESSOR COOKBOOK" by Michael F. Hordeski is a chip-by-chip comparison of the most popular modern µPs – including programming, architecture, addressing, instruction sets, and applications. 266 pp. paper, $5.95; hard, $9.95. **Tab Books,** Blue Ridge Summit, PA 17214. **Circle 183**

2655PROGRAMMABLE PERIPHERAL INTERFACE general-purpose I/O IC (now available from Signetics) features 3 8-bit ports (24 I/O pins) that can be individually programmed to function as I/O or bidirectional ports. Interface with a µP is via an 8-bit bidirectional data bus. Although designed for use in 2650-based micro systems, the 2655 can be easily inter-

faced to all other micros. Port R/W access time is 300 ns. **Signetics,** 811 E. Arques Ave, Sunnyvale, CA 94086.
Circle 267

"GRAPH ALGORITHMS" presents a comprehensive view of graph theory coupled with these combinatorial methods. All of the recent progress concerning efficient algorithms for graph processing have been incorporated, yet the algorithmic aspects of this book have not been permitted to spoil the mathematical elegance of graph theory. $17.95. **Computer Science Press, Inc.,** 9125 Fall River Lane, Potomac, MD 20854. **Circle 184**

DEC LSI-11 users 11/Blue7 mounting box with power supply has improved control panel, backplane and TU58 support. It accepts up to 8 of dual-ht, LSI-11 modules (7 option slots after



insertion of LSI-11/2 or LSI-11/23 CPU) and supports DEC's Model TU58 dual drive tape cartridge device as a front panel-mountable option. 11/BLUE7, an improved version of DEC's rank-mountable BA11 assembly, has quality features not found in the original product. **Transduction Ltd.,** 1655-4 Sismet Rd., Mississauga, Canada, L4W 1Z4. **Circle 173**

DISK SYSTEM. Incorporating SA-4000 disk drives, Model 604 features include: 14.5 or 29 Mbytes/unit (unformatted), Winchester technology, compact size (19″ RETMA rack-mounting using only 7″ of panel space), low heat dissipation, 7.1 M/bits/sec transfer rate, optional head/track storage (144 KBytes), plus an MTBF of 5000 POH typ. usage. Interfaces exist for hp 2100, 21MX and 1000 series of minis, and DEC LSI-11/PDP-11. $6950. **Dicom Industries, Inc,** 715 N. Pastoria Ave, Sunnyvale, CA 94086. **Circle 245**

IMAGE ARRAY PROCESSING system IP 5000 stores up to 1MB of data for single or multiple image arrays, has complete independence between refresh memory and host computer addressability of memory, includes memory management and data control for direct high-speed access to refresh memory, includes a powerful, pipe-line processor to perform high speed image array processing and statistical analysis and performs pixel replica zoom of 2:1, 4:1 or 8:1 in real time. **DeAnza Systems Inc.,** 118 Charcot Ave., San Jose, CA 95131. **Circle 170**

PLOTTING SYSTEM CoMPLoT CPS-11, a plotter and plotter controller, is said to give the highest resolution of any 11″ digital plotter on the market, plus 4-switch-selectable step sizes (in Eng. or Metric) ranging from 200 to 1000 increments/in. The pen moves at 4000 steps/sec. (240,000 steps/min). Flat plotting surface and Z-fold paper let you see what you're plotting. $5390. **Houston Instruments,** One Houston Sq., Austin, TX 78753.
Circle 190

μP COURSE. Covering 8085/Z-80 and STD BUS is a fundamentals course that requires no previous micro experience. It's a hands-on, problem-solving approach using traditional engineering techniques which result in fully documented, producible products. **Pro-Log Corp,** 2411 Garden Rd, Monterey, CA 93940. **Circle 271**

Unique, patented circuits make an extraordinary difference..at ordinary prices.

Black Demon switching power supplies utilize a pulse width modulated power conversion circuit to achieve 70,000 hour MTBF at 80°C baseplate for AC to DC models. At 40°C baseplate, where most companies specify 70,000 hour MTBF, ours is 350,000. Black Demons also feature an exclusive, patented one-transistor switch circuit controlled by a single DC voltage, eliminating the core saturation failure mode problems experienced in conventional switchers. It all adds up to a better buy at essentially the same prices as the others.

AC to DC Models 5.25 to 48V / 1.5 to 10A

Input Voltage: 95-130 VAC, 47-440 Hz, single phase or 130 to 180 VDC. (220V nominal AC input is optional)
Efficiency: 74% min. @ 5V output / 80% min. @ 48V output
Reliability: 70,000 Hr. MTBF @ 80°C Baseplate / 350,000 Hr. MTBF @ 40°C Baseplate

Model No.	Output Voltage*	Maximum Output Current**	Minimum Efficiency	Maximum Power Loss (Watts)†
AS 5-10	5.25 ±0.2%	10 A	74%	18.5
AS 12-5	12.00 ±0.2%	5 A	77%	18
AS 15-4	15.00 ±0.2%	4 A	78%	17
AS 28-2.25	28.00 ±0.2%	2.25 A	80%	16
AS 48-1.5	48.00 ±0.2%	1.5 A	80%	18

DC to DC Models 5.25 to 48V / 1.2 to 10A

Input Voltage: 10-14 VDC, 20-32 VDC, or 38-56 VDC
Efficiency: 62% min. @ 5V output / 80% min. @ 48V output
Reliability: 68,000 Hr. MTBF @ 80°C Baseplate / 320,000 Hr. MTBF @ 40°C Baseplate

Model Number	Input Voltage (VDC)	Output Voltage* ±0.2% (VDC)	Maximum Output Current**	Minimum Efficiency	Maximum Power Loss (Watts)†
1 DS 5-10	12	5.25	10 A	62%	32
2 DS 5-10	28	5.25	10 A	70%	22.5
4 DS 5-10	48	5.25	10 A	72%	20.5
1 DS 12-5	12	12	4.5 A	63%	32
2 DS 12-5	28	12	5 A	73%	22
4 DS 12-5	48	12	5 A	75%	20
1 DS 15	12	15	3.6 A	63%	32
2 DS 15	28	15	4 A	74%	21
4 DS 15	48	15	4 A	76%	19
1 DS 28	12	28	2 A	64%	32
2 DS 28	28	28	2.25 A	76%	20
4 DS 28	48	28	2.25 A	78%	18
1 DS 48	12	48	1.2 A	64%	32
2 DS 48	28	48	1.3 A	78%	17.5
4 DS 48	48	48	1.3 A	80%	15.5

*Optional voltage features available. See Literature.
**10% minimum load required for regulation.
Output voltage is limited for safe operation at less than minimum specified load.
†These specifications apply for nominal input voltage and maximum load.

Operating Specifications-All Models

Line Regulation:
±0.05% or ±10mV maximum (whichever is greater) over specified line range at half load.

Load Regulation:
0.2% or 10mV maximum (whichever is greater) from 10% minimum load to full load.

Ripple:
0.8% or 100mV peak to peak maximum from all sources, whichever is greater. (33 KHz typical)

Transient Response:
2% or 0.35V maximum over/undershoot with return to regulation in less than 250μ seconds after a 50% to 100% or 100% to 50% load change at a 1A/μ second rate.

Temperature Coefficient:
0.015%/°C maximum.

Temperature Range:
Operating: 0°C to +80°C baseplate @ full rated power. Storage: -55°C to +85°C.

Additional Features

Electromagnetic Interference:
Input and output filters and internal noise cancellation suppress radiated and conducted interference.

Remote Error Sensing:
Standard on all units.

Short Circuit/Overload Protection:
The unit will withstand a short circuit or overload of unlimited duration. Normal. operation automatically resumes upon removal of short or overload.

Output overvoltage protection:
The output is internally limited to 130% of rated output voltage in event of internal failure.

Input Overvoltage Protection:
The unit will withstand 150% of nominal input voltage indefinitely. Normal operation resumes upon removal of overvoltage.

Reliability: See Tables at left.
@ 80°C to baseplate MTBF is 68,000 hours;
@ 40°C baseplate MTBF is 320,000 hours.
Calculations per MIL-HDBK-217B (π_E factor G_B with appropriate π_Q factors) are based on maximum input voltage and full rated output current.

Send for Literature Detailing Optional Features.

WARRANTED FOR 5 YEARS!

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Phone: (206) 641-3535

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Wisconsin, Milwaukee
Phone: (414) 527-1500

ADTECH POWER

Europe: ADTECH INTERNATIONAL, Subsidiary of Adtech Power, 46 BD, Roger Salengro, 78200 Mantes La Ville, France. Tel. 47/5301+
DISTRIBUTORS: Call Kathy Nelson, Distributor Products Group, (714) 634-9211, for the name of a distributor near you.

Black Demon Switchers are also manufactured in Europe. See Ad on next pages.

ADTECH POWER, INC., 1621 S. SINCLAIR ST., ANAHEIM, CA 92806. (714) 634-9211 ● TELEX 68-1498

Circle 42 on Reader Inquiry Card

Moving?

1. For FASTEST service attach old mailing label in space below.

If mailing label is not available print your old Company name and address in this box

Please allow 6 weeks for change to take effect

2. Print your NEW business address here

NAME
TITLE
COMPANY
ADDRESS
CITY STATE ZIP

3. Mail to: Circulation Manager
Digital Design
1050 Commonwealth Ave.
Boston, MA 02215

New Products

GRAPHIC TERMINALS support light pen, joystick, tablet, digitizers and other graphic peripherals. Each DYNAGRAPHIC Terminal comes with a built-in Terminal Support Software package and offers a Host/Terminal FORTRAN Software option. This allows "non-computer" people to generate and interact with sophisticated

graphic displays using Light Pen and Keyboard and simple FORTRAN calls for their applications programs. **IMLAC Corp.**, 150 A St., Needham Heights, MA 02194. **Circle 172**

LIGHT PEN. Model LP-700 provides: completely self-contained electronics, single-voltage (+5) supply, light and activation TTL-compatible output levels optional, luminous sensitivity of 1.0 ft. L (adjustable) and response time under 30 ns. Push tip, slide button. **Information Control Corp.**, 9610 Bellanca Ave., Los Angeles, CA 90045. **Circle 188**

GRAPHICS DIGITIZER. Designed for graphics input, Class III provides high durability and convenience. The digitizing surface is thin, only 1/2" thick, making operation natural. This low-profile surface is constructed of hard formica encased in a sturdy frame so it takes heavy-duty use. It comes equipped with a completely electronic pen with no mechanical parts to wear out. The pen tip is tapered to improve work visibility. It offers 400 lpi resolution, switch selectable point and run modes, and a choice of 3 interfaces, 16-bit parallel binary and BCD, RS-232C or GPIB. **Talos Systems, Inc.**, 7419 E. Helm Dr., Scottsdale, AZ 85260. **Circle 162**

COLOR GRAPHIC/image system 5216 hardware enables users to reconfigure from alphanumeric/graphic displays to sophisticated image-processing and analysis applications. The 5216 has a comprehensive software package. Includes 2D and 3D packages, image and analysis program, and interactive list processing software. Peripherals and accessories include keyboards, joysticks, track balls, graphic tablets, graphic printers, cartridge and floppy disk drives. **Aydin Controls**, 414 Commerce Dr., Ft. Washington, PA 19034. **Circle 163**

TAPE DRIVES are available in sizes from 7 to 10-1/2" with speeds ranging from 12.5 ips to 75 ips and recording densities up to 1600 cpi. Also, Super Series cartridge disk drives come in front-loading and top-loading configurations. Storage capacities are from 2.5 to 20 Mbytes. **Perkin-Elmer**, Memory Products Div., 7301 Orangewood Ave., Garden Grove, CA 92641. **Circle 169**

LOW-PROFILE SOCKETS 703-53XX series has a Kapton sealing strip which is punched over the socket pins to seal off each pin cavity in the basc of the socket body to prevent solder from rising, or wicking up the socket pin in wave soldering. It adds a dielectric barrier, preventing shorting of long IC leads to the PC board's etched circuitry. **Cambion**, 445 Concord Ave., Cambridge, MA 02238. **Circle 171**

EMULATOR TERMINAL MicroSystem Emulator-Series 2000, when connected to a host computer, lets that computer serve as a μP development system to solve hardware/software needs with microprocessors emulated (6800, 6802, 8048, 8080, 8085A, Z80A and soon 8049, 8041, 8035, 8039, 8748, 8021). The Emulator can be used as a terminal with dedicated μP development systems from Intel, Motorola and Zilog, thus allowing any such system to support a variety of μP types offered by other manufacturers. It operates up to 6MHz, allowing real-time emulation of fast μPs. Real-time operation of the Emulator

extends to an optional real-time trace capability – a valuable debugging tool that lets the user track the step-by-step performance of his design at full-rated speed. Real-time trace capability also provides a record of 128 past operations so that program faults are quickly uncovered. Series 2000, $4500; emulator cards, $1000-$1500. **Millenium**, 19020 Pruneridge Ave., Cupertino, CA 95014. **Circle 156**

"6502 ASSEMBLY LANGUAGE PROGRAMMING," by Dr. Lance Leventhal contains: (1) over 80 programming examples with standard format, including flowcharts, source programs, object code and text, (2) each 6502 instruction full explained, (3) 6502 Assembler conventions. (4) programming the 6502 interrupt system, (5) 6502 I/O devices and interfacing methods and more. 550 pgs. $9.50. **Osborne/McGraw-Hill**, 630 Bancroft Way, Berkeley, CA 94710. **Circle 155**

TAPE CARTRIDGE sysems offer: (1) up to 15-mb capacity (6400 bpi) on one 3M 1/4" DC-450 Cartridge, (2) software compatible to DEC TM11/TU10 1/2" tape system and (3) true DMA 24K byte data rate. TS-160 Data Cartridge Magnetic Tape systems have controller, drives, cabling, mounting hdw, documentation and diagnostic software. **Western Peripherals, Div. of Wespercorp**, 1100 Claudina Pl., Anaheim, CA 92805. **Circle 159**

GRAPHIC TERMINAL. Graphic 7 provides the whole picture by drawing bright, crisp vectors and symbols rapidly, Benchmark tests with actual time measurements show it excells at refresshed cost/performance. It interfaces directly to mainframes via an RS-232 time-share link. The Graphic 7 dual μPs will handle the graphics. **Sanders Associates, Inc.**, Daniel Webster Hwy., Nashua, NH 03061. **Circle 160**

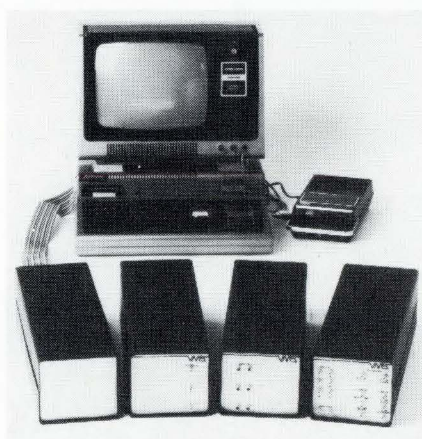
COLOR PLOTTERS. Model 1453 gives 4-pen, programmable multiple-color plotting; 1553 is a one-pen plotter with high-speed/high resolution. Both plot at 10 ips. Both give multi-colored graphics over a plotting area of 11" by 144'. From $6K. **Nicolet Zeta Corp.**, 2300 Stanwell Dr., Concord, CA 94520. **Circle 161**

"USER'S GUIDE", a free 78-pg. booklet, contains articles that focus on: designing with μPs (for non-computer experts), engineering design approach to μPs, μP architecture, 6800, 8080/8085 and Z80 architectures, single-chip μPs, Pro-Log's STD BUS, etc. **Pro-Log Corp.**, 2411 Garden Rd., Monterey, CA 93940. **Circle 157**

MICRO BIN provides mounting space, power and control for four LSI-11/2 or LSI-11/23 series modules in a small, form-factor package. Featured in the micro bin are: four slots for double height 5.2 in. X 8.9 in. modules; LSI-11 (Q-bus) backplane; power and cooling for modules; mounting hardware; control panel; and external connection for optional remote restart switch. **ACS, Inc.**, 100 Fourth Ave., Garden City Park, NY 11040. **Circle 276**

EDIT BUFFER accessory (EBA) provides users with off-line text editing capability on TermiNet 200 KSR and 1232 KSR printers. The EBA allows reception, temporary storage, and transmission of messages or data entered from the printer keyboard or the communication line. The EBA has 21 commands offering full editing capability, with or without line numbers, including string and line deletion, alteration and insertion. Storage capacity is provided by 4K, 16K, 32K, or 48K bytes of solid state memory. 4K buffer – $460. **General Electric**, Data Communication Products, Waynesboro, VA 22980. **Circle 285**

VIDEO PROCESSING MODULES. Beginning with a colorizer configuration, having a 4-bit resolution for each of three channels – R, G, and B, the devices operate in conjunction with a general purpose μP. The units include an A/D converter, D/A converter and R.G.B. encoder. The configured modules will internally generate a color



display which facilitates the education of the user in R.G.B., as well as their combinations, in four sequential vertical columns across a standard color monitor. This will produce 4096 colors. The unit has the ability to update the colorizer signal every 60th of a second. **G.E.S.I.**, 1440 San Pablo Ave., Berkeley, CA 94702. **Circle 278**

STATISTICAL MULTIPLEXER, Supermux 480, is for use in networks serving printers and terminals with XOFF capability. The unit reduces CPU load and eliminates errors and data loss due to line delays and ' "hits". The 480 cuts data communications costs by replacing multiple telephone lines with a single, higher speed facility and eliminates transmission errors by temporarily storing data, checking for errors and, if necessary, retransmitting. Four channel model, $1500; 8 channel, $2500. **Infotron Systems Corp.**, Cherry Hill Industrial Center, Cherry Hill, NJ 08003. **Circle 291**

Advertisers' Index

Sales Offices

New Products

LSI-11 MEMORY. Adding one Bank-Switch Controller BSC-256 ($300), adds 2MB; two add 4MB. Add another RMA-032 (32K-by-16-bit RAM), $1200; RMS-016 (16K-by-16-bit (ROM), $300. **Digial Pathways Inc.,** 4151 Middlefield Rd., Palo Alto, CA 94306. **Circle 158**

RASTER-SCAN SYSTEM provides clarity and conciseness afforded by monochrome resolutions as high as 1280 x 1024 and full-color versions to 1024 x 1024 pixels. Since these systems can be expanded from a single monochrome memory plane to a number of planes that support the full range of gray scales or colores required, users can start-out and add-on as needed. Monitor control module operates up to 12 monitors, mix TV/Video and remotely monitor – as well as fill areas outlined in the bit-map memory – and allows RS232 interfacing with a keyboard, trackball, joystick or graphics tablet. **Genisco Computers,** 17805 Sky Park Circle Dr., Irvine, CA 92714. **Circle 166**

CUSTOM IC prototypes in 6 wks. for $5k (or less) are possible becuase the circuit components (the first layers) are in place when you start designing; you connect them to make the circuit for your application. The form etches the sixth layer (interconnections) to produce your circuit. Once we'll make productions runs from 5000 to half a million parts. Monochip Design Kit, $59. **Interdesign,** 1255 Reamwood Ave., Sunnyvale, CA 94086. **Circle 165**

"PARALLEL MODE HIGH DENSITY Digital Recording – Technical Fundamentals," discusses the merits and shortcomings of 3 encoding schemes, with emphasis on E-NRZ. Separate chapters deal with data formatters and multiple recorder synchronization which provides a good working knowledge of high-density digital record/reproduce systems. 88 pp. $15. **Bell & Howell Datatape Div.,** 300 Sierra Madre Villa, Pasadena, CA 91109. **Circle 174**

HARD DISK DRIVES. Available in 3 configurations up to 70 Mbytes. This family of devices grows to 300 Mbytes. Because the fixed media Series 5300 utilizes advanced Winchester technology it offers low cost-ownership. **Kennedy Co.,** 540 W. Woodbury Rd., Altadena, CA 91001. **Circle 168**

IMAGE PROCESSOR. This system has 12K firmware and up to 48 Mbytes of dynamically allocatable refresh image memory and graphics. Its field upgradeability through options such as expandable memory, video input and output, as well as TV rates for videotaping. Vision One/20 provides stand-alone full feature image processing and interfaces to numerous host computers. Dynamic refresh memory partitioning allows for different applications. Real-time roaming, with window sizes 512 x 512 pixels or larger, through the data base, as well as 2X and 4X zooming and 3 x 3 convolution at 70 MIPS are implementable in real-time. **Comtal,** Box 5087, Pasadena, CA 91107. **Circle 164**

IMAGE PROCESSING SYSTEM, GMR-270 provides you a pipeline image processing tailored to fit your application. It combines the best features of the GMR-27 line of high-speed graphic display systems with a special package of image processing features. Features include: convolution, image multiplication and ratioing, zoom and pan, 512 x 512 panning window on a 1024 x 1024 image, function memories, pseudo-color tables, and plug-compatible interfaces for most minis. **Grinnell Systems,** 2159 Bering Dr., San Jose, CA 95131 **Circle 167**

Designers' Notebook

Designing Power Supplies To Cope With Brownouts

Low-voltage brownouts create a difficult problem for engineers using linear-regulated power supplies. The line voltage range directly affects the amount of power that the linear regulators must dissipate. Regulators designed for low line voltage dissipation consume large amounts of power at high line potentials. A new class of devices – three-terminal switching regulators – avoids this dissipation problem. When the power line voltage varies, the regulators automatically adjust the input current to keep the dissipation constant. The designer can now combat brownout conditions with these self-controlling power conservation devices.

Available in the 60W to 360W output range, these regulators cover +4.5 to +30 V at up to 12 A (3T12AP) and –4.5 to –30 V up to 5 A (3T5AN). Each unit converts unregulated high voltage (+10 to +40 V), low-current dc power to regulated lower voltage, high-current with little loss. The load determines the input power to this device, not the input condition.

As an example of how to use switching regulators to design a supply which operates at low line potential, consider the 12 V, 10 A supply in **Fig 1**. Assume the supply should operate from a max. line voltage of 135 V to the min. line voltage possible. To calculate this minimum, you must determine the ratio of min. to max. input voltages for the regulator and set this equal to the ratio of low-to-high line voltages. In this example for the 3T12AP, input ranges from +5V (3V above the output) to +40 V (rated max). Setting this ratio equal to line ratio and solving for the unknown low line voltage, $15/40 = X/135$; $X = 51$ Vac. Even for a brownout 51 V is conservatively low.

You can calculate nom. rms transformer output in a similar manner by using nominal 115 V for ac input and noting that 40 V is transformer secondary peak potential. Calculate rms ratio from $(X/40)/\sqrt{2} = 115/135$, where $\sqrt{2}$ indicates ratio of the sine wave peak to its rms value. Then, X= 24 Vac. You must size this 24-volt step-down transformer to accommodate increased current and power dissipation at low line voltage.

Designing a multiple-output supply brownout operation, such as the ±5 and +12 V unit (**Fig 2**) follows the same method, except that it uses the 3T5AN regulator to derive the neg. output from a pos. input. In this supply, the most pos. voltage determines the lower regulator input limit. Since the most pos. voltage is the same as in the first system, the regulator input range is the same and brownout performance is identical.

Forest Sass, Boschert Inc., Sunnyvale, CA.

Rate this design: circle 7L, 7M or 7H on Reader Inquiry Card.

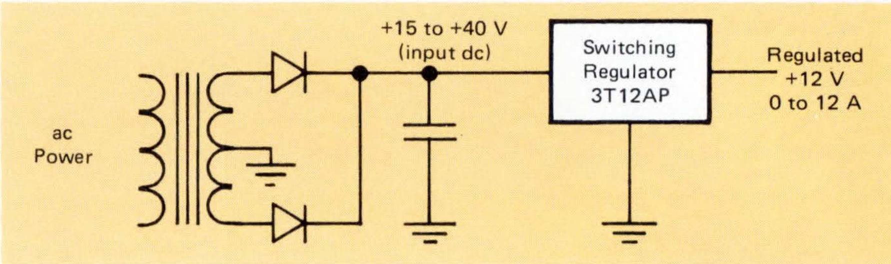


Fig 1 3T12AP switching regulator provides a regulated output and maintains constant input power by reacting only to the load. If the input drops, the transferred power remains the same and the input current increases.

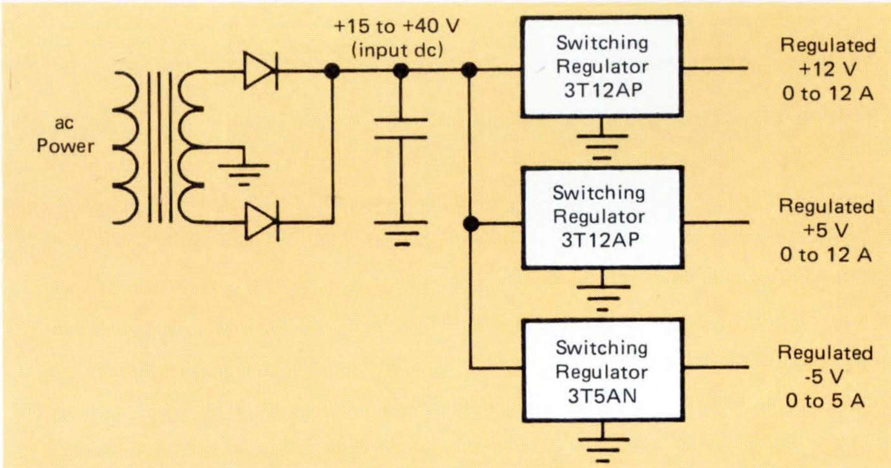


Fig 2 The addition of several regulators can provide multiple output voltages. Note that -5 V output is derived from the positive dc input.

Bi-Directional Handshaking Over A Single Wire

Handshaking is a bidirectional proposition. After a computer signals a controller, the controller must somehow pass an answer back to the computer. We have for several years been successfully using bidirectional communication over a single signal line to effect handshaking between a computer system and its peripherals. The accompanying figure details this scheme.

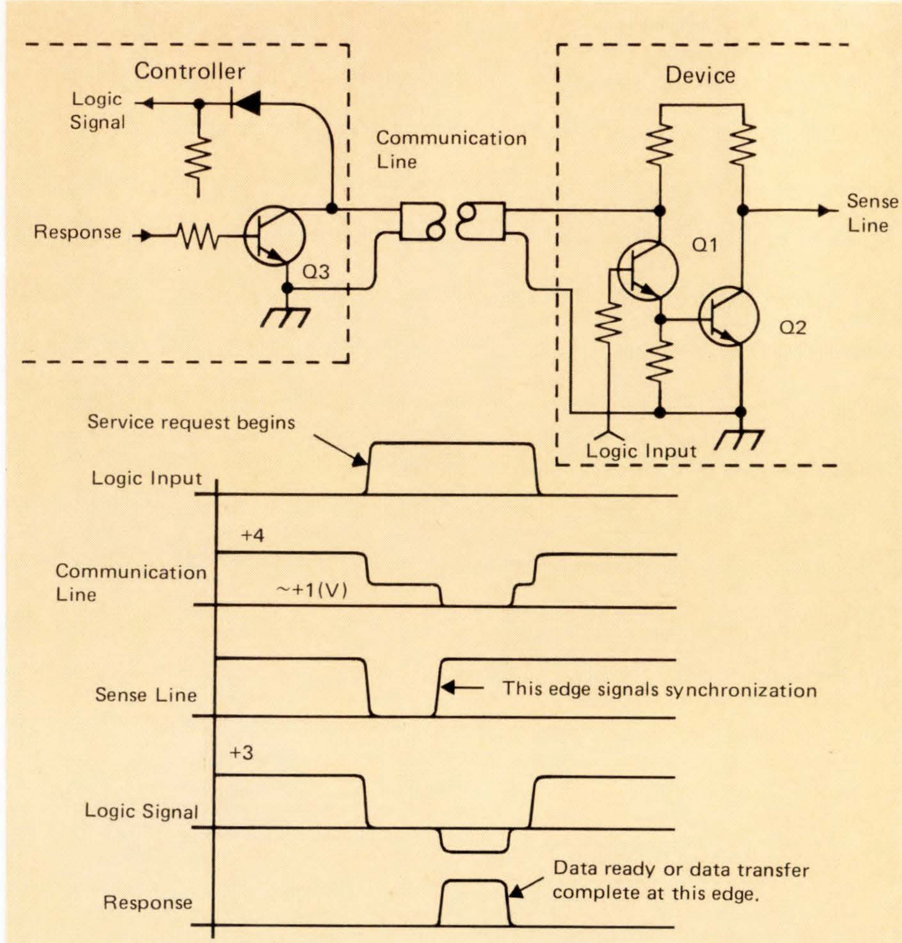
Operationally, the sequence begins with the service request at the device going HIGH at the logic input, supplying base current into Q_2. The collector voltage at Q_1 (the communication line) is the sum of the base-emitter voltage of Q_2 and the saturation collector-to-emitter voltage Q_1, approximately one volt. Thus the communication line drops to about one volt. Simultaneously, the collector of Q_2 (the sense line) drops nearly to ground.

At the controller end, a diode in series with the signal from the communication line results in a logic signal to be sensed by the controller. The controller responds to this logic signal by raising the response line, supplying base current to Q_3. The collector of Q_3 (the communication line) drops nearly to zero volts, robbing collector current from Q_1 (and the base current from Q_2) at the other end of the communication line. This results in Q_2 switching off and the rise of the sense line.

In summary, the logic input at the device end has signalled the controller by producing the logic signal at the controller end. The controller's response is to switch the sense line at the device end. The handshake is complete.

John Meng, Lawrence Berkeley Lab, U. of Cal., Berkeley, CA.

Rate this design: circle 8L, 8M or 8H on Reader Inquiry Card.



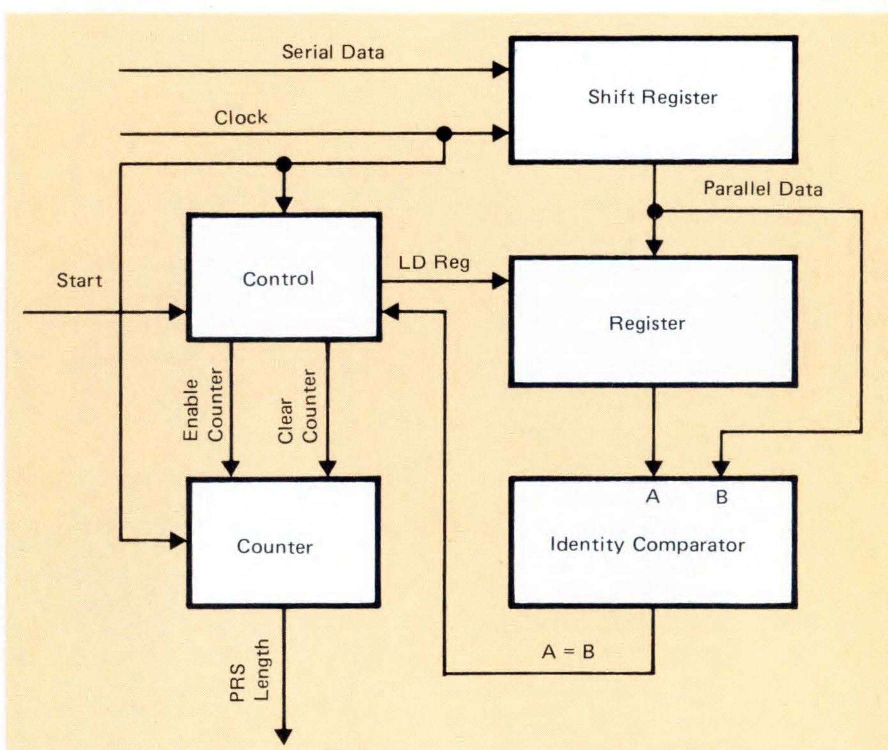
One handshaking sequence over a bidirectional communication line.

Pseudorandom Sequence Length Calculator

The way this pseudorandom sequence (PRS) length calculator device works is as follows. Upon receipt of a start, the contents of the shift register are synchronously loaded into the register (at the non-data shift edge of the clock) and the counter is cleared. The comparator output (reclocked to eliminate decoding glitches) is applied to the counter enable. As long as the comparator doesn't indicate identity, the counter counts each clock period. When identity occurs, the counter is stopped and then contains the number of clock periods necessary for the PR sequence to repeat, i.e. the length. I have not attempted to show minimal (probably 2 – 3 chip) design of the control logic.

Robert W. Landley, RCA/Government and Commercial Systems/Missile and Surface Radar Div., Box 997, APO San Francisco.

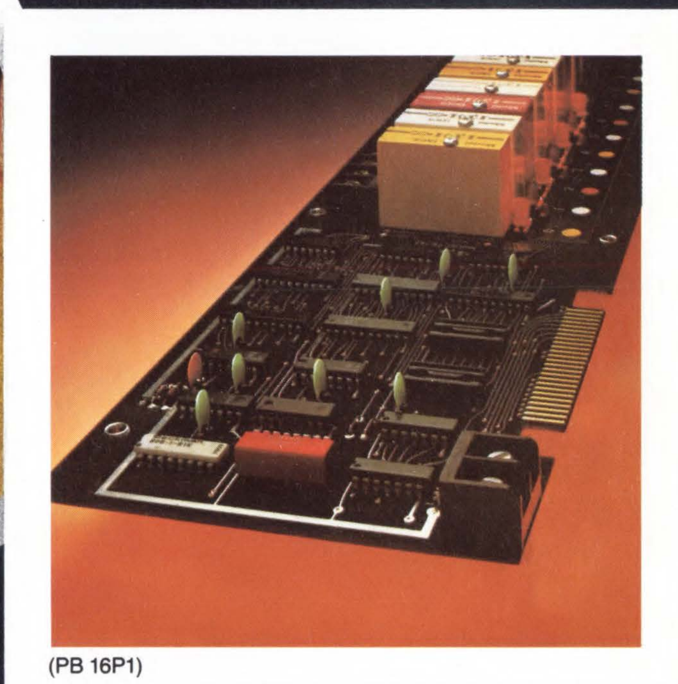
Rate this design: circle 9L, 9M or 9H on Reader Inquiry Card.



Pseudorandom sequence length calculator.

ADDRESSABLE I/O SYSTEMS FROM OPTO 22

(PB 16S1)



(PB 16P1)

Huntington Beach, California . . . Opto 22, originators of the industry standard I/O system, announces the second generation in I/O Systems in both serial and parallel configurations.

SERIAL ADDRESSABLE RACK (PB 16S1)

Communication with multiple input/output stations.
32 station address capability per serial loop.
Up to 16 power I/O modules per station.
Switch selectable baud rate.
Opto 22 provided firmware includes message protocol, event counter, self test, watch dog timer and more.
Plug in modules provide choice of:

1. 20 Ma Current Loop.
2. RS 422 Balanced Differential Drivers and Receivers.
3. Optically Coupled Drivers and Receivers.
4. RS 232

PARALLEL ADDRESSABLE RACK (PB 16P1)

Bidirectional Communication with input or output modules.
64 station address capability.
Up to 16 Power Input/Output modules per station.
50 Conductor Daisy-Chain cable connects all racks to host controller.
On-board station address select switch.

15272 Relay Circle, Huntington Beach, CA 92649
(714) 892-3313

opto 22

Another Opto 22 product available for immediate shipment.

Circle 80 on Reader Inquiry Card

Plotting System CPS-11

Digital plotter and microprocessor based controller

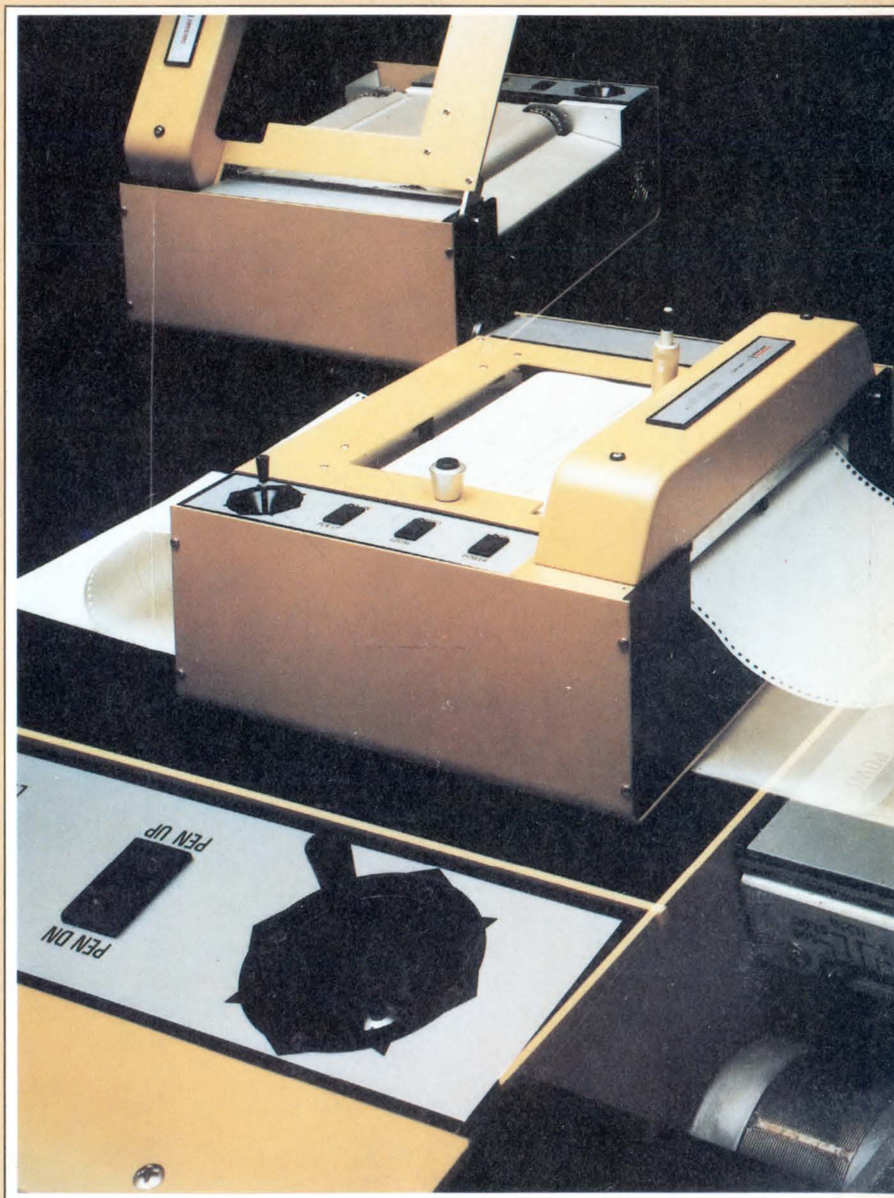
combine to provide high performance plotting

The CØMPLØT® CPS-11 is a plotter and plotter controller designed to meet your plotting applications... whether on line or remote.

The field proven plotter incorporated in the CPS-11 gives you the highest resolution of any 11'' digital plotter on the market today—4 switch selectable step sizes (in English or Metric) ranging from 200 to 1000 increments/inch. The pen moves at a remarkable rate of 4000 steps per second (240,000 steps per minute). The flat plotting surface and Z fold paper let you see what you're plotting while it's being plotted.

The plotter controller utilizes a microprocessor to provide automatic detection and correction of transmission errors, local generation of alphanumeric characters, circular buffer memory, and greatly simplified host computer software. The controller can either operate the plotter remotely from a host computer or serve as a sophisticated computer interface - whichever fits your specific application.

For complete information on how the CPS-11 can upgrade your plotting capabilities for only $5,390,* call or write Houston Instrument, One Houston Square, Austin, Texas 78753. (512) 837-2820. For rush literature requests or sales office information, persons outside Texas call toll free 1-800-531-5205. In Europe contact Houston Instrument, Rochesterlaan 6 8240 Gistel Belgium, phone (059) 27 74 45.



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