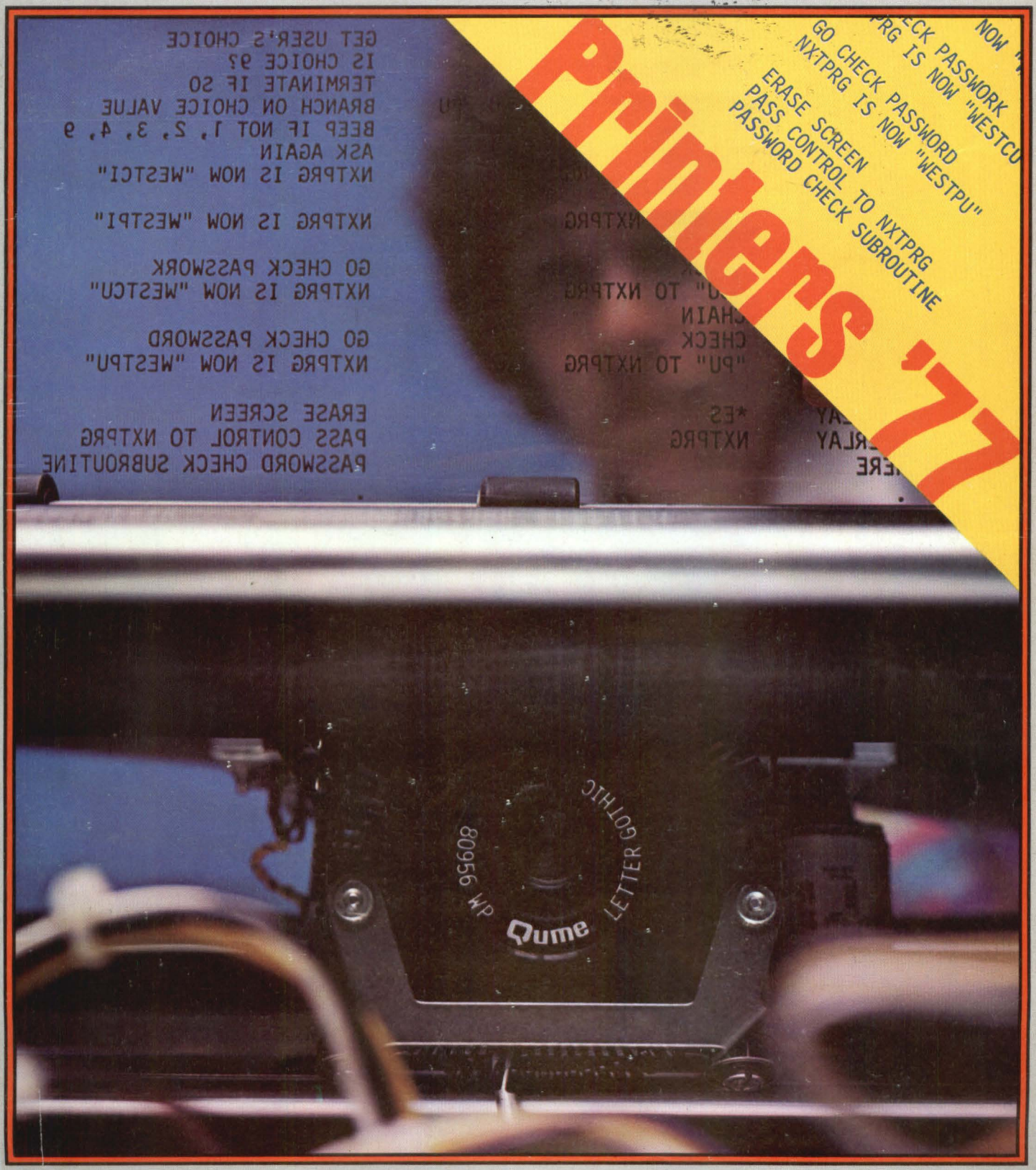
October, 1977

# Digital Design

The Magazine of Digital Systems

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CIRCLE 1

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# Why Toggle?

## (when you can turnkey)

Power-on-start means automatic program execution when computing with the Altair™ Turnkey Models from MITS. Both highly acclaimed Altair mainframes, the 8800b and 680b, are obtainable in easy-to-implement turnkey versions—offering the same capabilities as their full front panel counterparts—and then some.

Our 8800b Turnkey Model incorporates a Module Board complete with serial I/O channel, 1K of RAM, and provisions for 1K of PROM. All 8800 hardware and software are compatible with the 8800b Turnkey Model.

In addition to the 8800b Turnkey, we are introducing these new 8800 system peripherals. The Altair 88-AD/DA converter is our eight channel analog I/O system for applications where analog to digital and digital to analog conversion is necessary. For economical mass storage, the Altair Minidisk System (88-MDS) provides a fast access storage capacity of over 71K bytes per minidiskette.

A big computer in a small package—the Altair 680b Turnkey Model—is a low cost mainframe capable of home, business and process control applications. The 680b CPU module contains all the logic circuitry needed for immediate computing plus 1K of RAM, serial I/O port and provisions for 1K of PROM.

You may expand your 680b Turnkey with these new additions to the 680b line. Load and save programs on audio cassette with the 680b-KCACR. This inexpensive mass storage device is highly reliable under widely varying conditions and requires no circuitry adjustments. Interface your 680b Turnkey to the practical world of process control with the 680b-PCI. Monitor and compensate for changes in any operation, from tracking the sun to watering the lawn.


CIRCLE 3

mits

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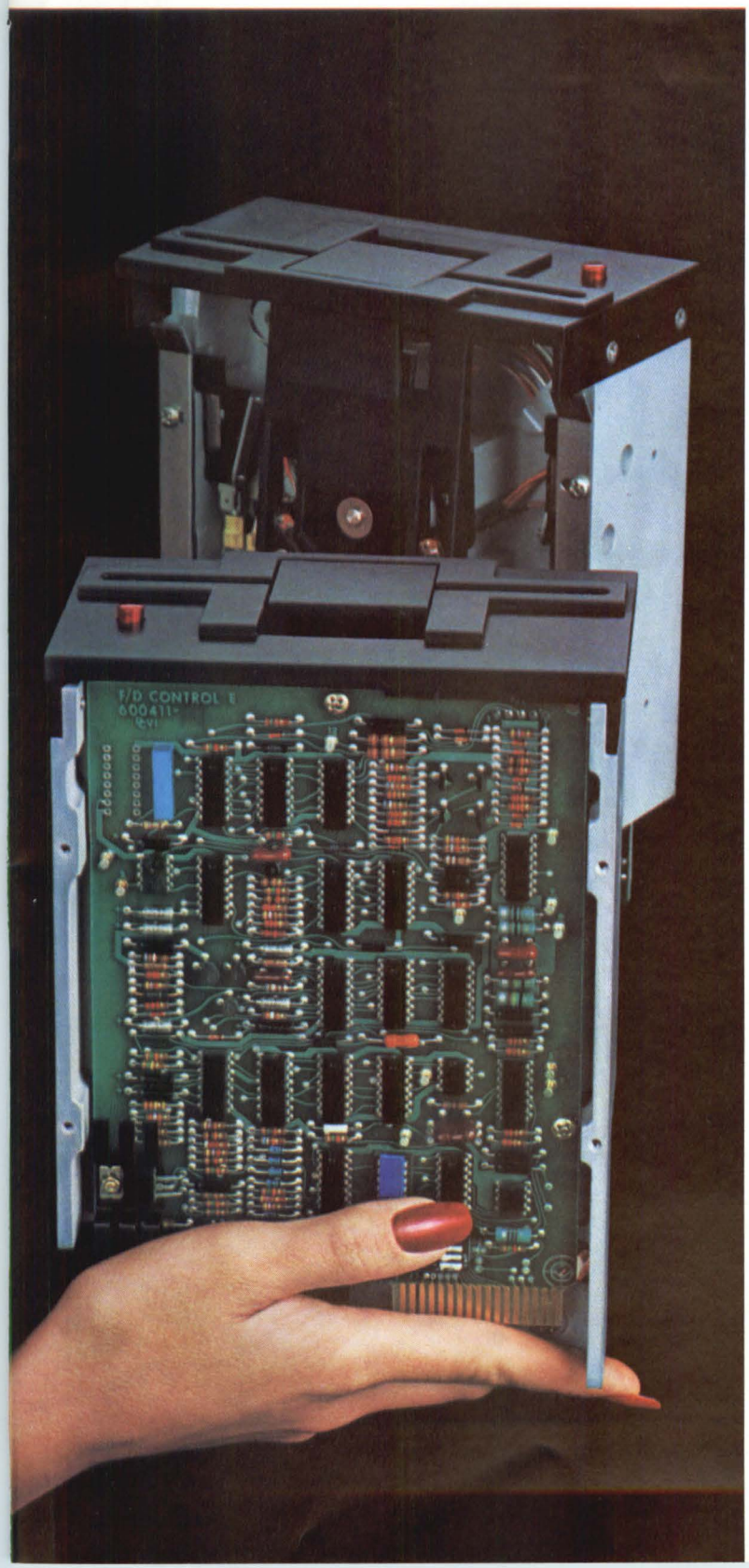
# WORTH FLIPPING OVER:




**Pertec's 40-track double density Microfloppy®—compatible with Shugart's 35-track; comparable to no other μC disk drive.**

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**FD200: Fully compatible with Shugart SA400.** Same dimensions, same mounting holes, same interface signals, same power connector. But unplug their 35-track drive, plug in FD200...and suddenly you're into the only double density, 40-track recording available to date for μC applications.

**Plus flip-side storage.** Up to 500,000 bytes per diskette, recording double density both sides. Up to 250 KB on one side—flip it over and store another 250 KB.

**Compatible to IBM standard.** Through our inventive electronics, it's the same proven read/write head that's built a solid track record for Pertec, in thousands of minicomputer flexible disk drives worldwide.

**Easier to use and maintain.** Options are switch selectable; power supplies are internationally-standard 5- and 12-volt DC.

And Pertec cuts the number of PCBs in half. Not two, but only one quick-disconnect board—to simplify field maintenance, boost system reliability, reduce spares stocking.

The cost-efficiencies of our FD200 Microfloppy are so indisputable, we expect fast turnovers with microcomputer OEMs. Jump in.

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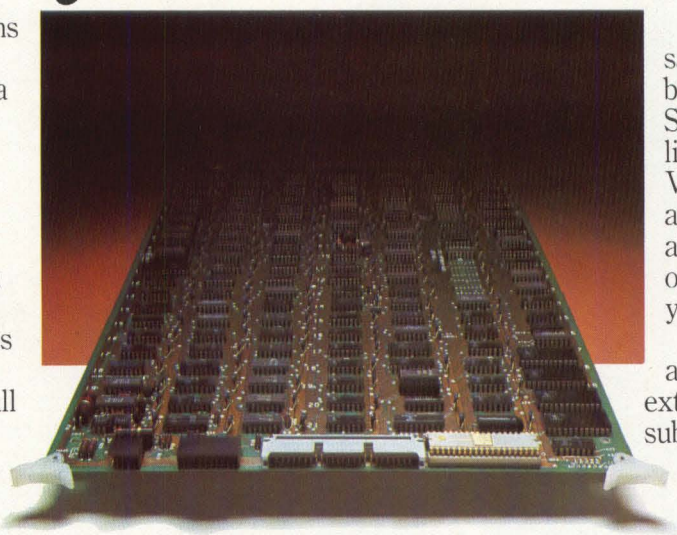
CIRCLE 2

# Sperry Univac's new mainframe-on-a-board: What you do with it is your business.

Whether your systems business is scientific, instrument control, or data communications, know this:

Our new V77-200 delivers more computing power than any other computer-on-a-board you can buy. Handling up to 32K/16-bit words of 660ns MOS memory.

Reason enough to call it the world's first mainframe-on-a-board. But there's more.



Because our new V77-200 comes loaded with "big machine" features. Like 8 programmable registers with byte, word and double word manipulation. Up to 32-bits of arithmetic precision. A powerful set of 187 instructions. Hardware multiply/divide. Direct memory access. Programed I/O. Multi-device automatic program loaders. A real-time clock. And a teletype/CRT controller. All standard. And all on a single 10.8" x 17" board.

There's even Virtual Console Logic that eliminates the need for a programmer's console by allowing you to control the V77-200 from a teletype or CRT keyboard.

You get "big machine" performance, too. Example: a microinstruction cycle time of 165ns that allows multiplication functions to be handled in just 4.9 microseconds—divide in just 8.

Plus your choice of OEM-tailored options. Like a variety of connector planes and general purpose interface boards for custom I/O designs. Three different 660ns memory boards (in 8K, 16K, and 32K-word modules). An operator's console. Power-fail detect and data save. Memory parity. Hardware for up to 64 priority vectored interrupts. An integral or modular power supply. And a system chassis. All the "unbundled" pieces you need for quick and easy system integrations.

The new V77-200 also saves you time and money by allowing you to use Sperry Univac's well-established floppy or disk-based VORTEX real-time operating system. In effect, allowing you to concentrate on the development of your application software.

And giving you access to Sperry Univac's extensive library of software subsystems, language processors, and system utilities.

Best of all, the world's first mainframe-on-a-board has a base price of just $1200. Plus a discount plan designed to give even modest-volume OEM buyers a big break. And you can take delivery in a matter of days—not months.

No matter how you configure it, the new V77-200 is the most economical Sperry Univac yet. Delivering the kind of price/performance value that just makes good sense. No matter what business your systems are in.

For more information on the world's first mainframe-on-a-board, please contact: Sperry Univac Mini-Computer Operations, 2722 Michelson Drive, P.O. Box C-19504, Irvine, California 92713, Telephone (714) 833-2400.

SPERRY UNIVAC

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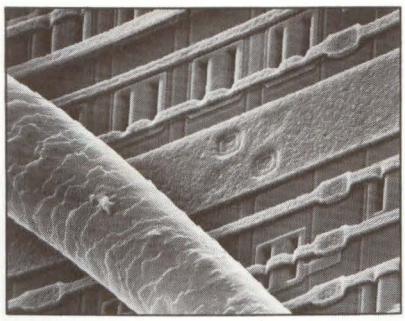
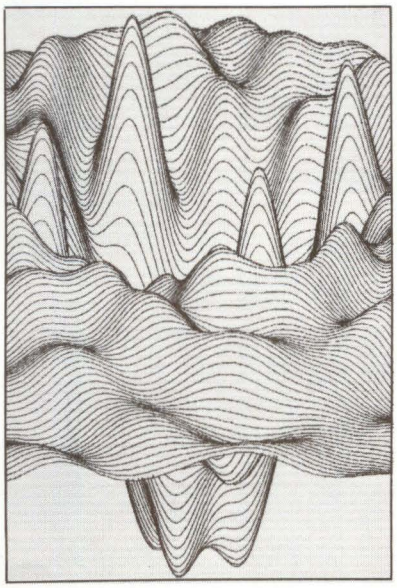
CIRCLE 5

# THIS MONTH

## Features





## Departments




**Published monthly by Benwill Publishing Corp., 167 Corey Rd., Brookline, MA 02146. Application to mail at controlled circulation rates is pending at Waseca, MN 56093.**

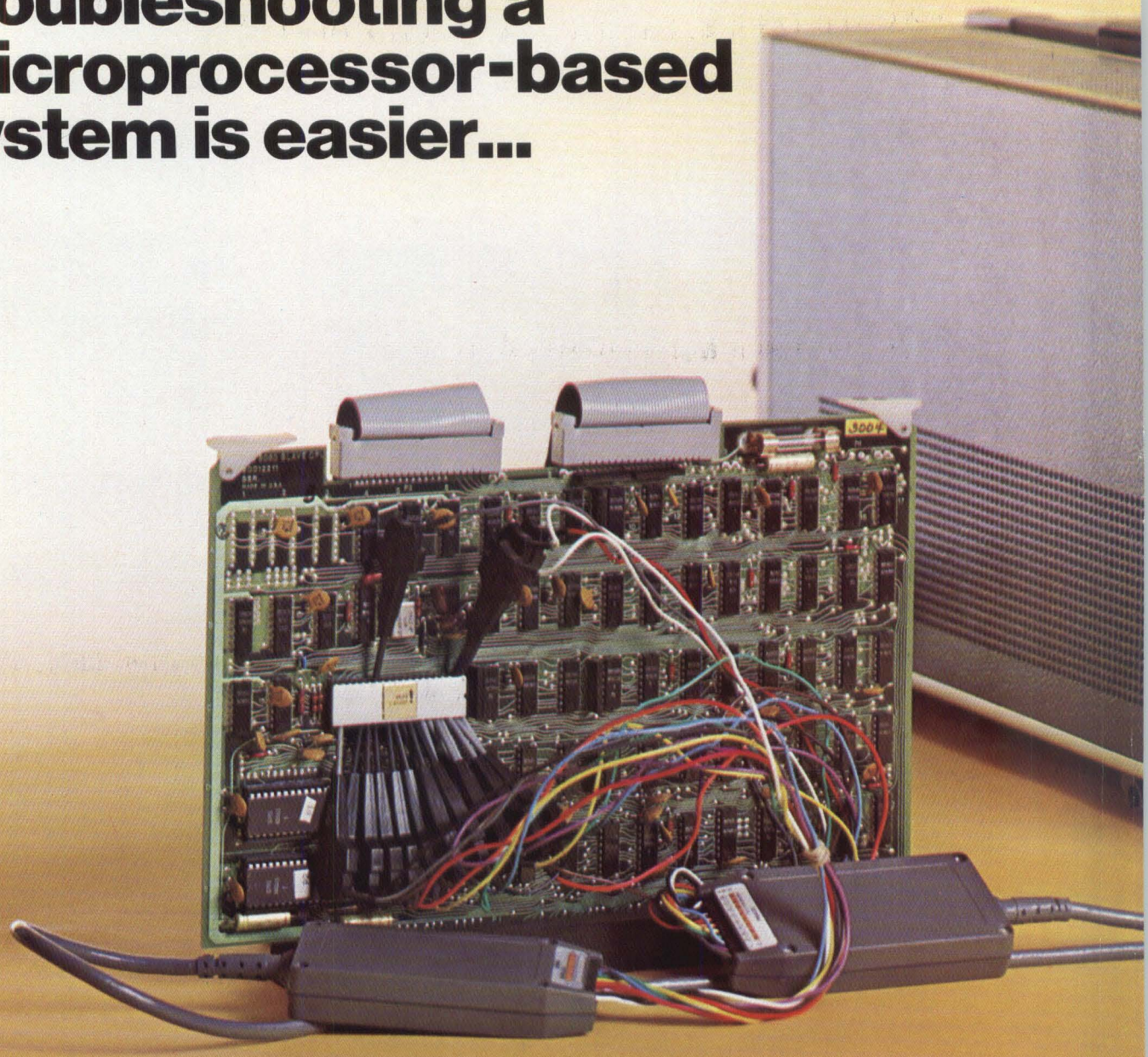
You've designed, debugged, and loaded your system software. Now you need several powerful capabilities to ensure trouble-free execution on the prototype: the ability to look at data in different ways . . . to compare known good data with new data quickly and easily . . . to analyze both system and peripheral-interface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

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

**Look at data in different ways.**

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

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



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

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

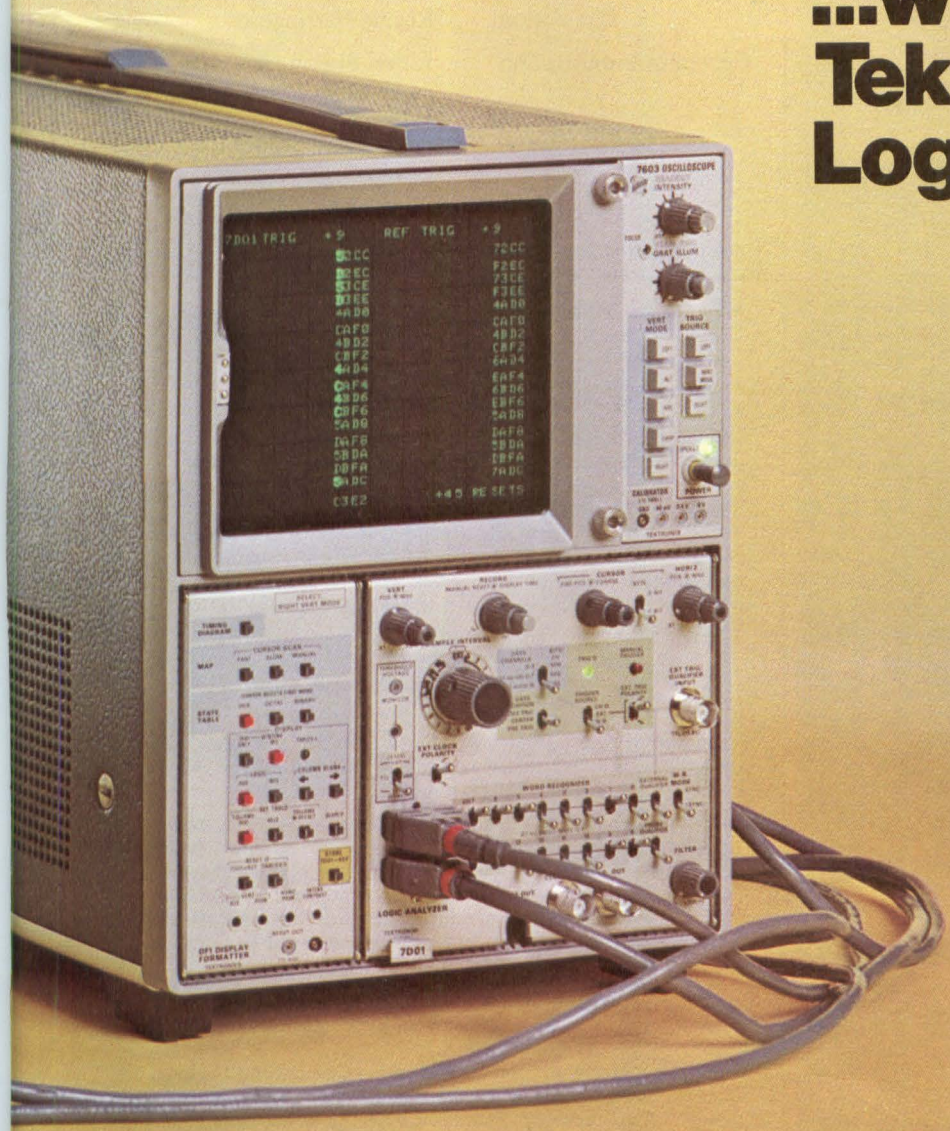
For an EXCLUSIVE-OR comparison, simply verify known good data, store it in reference memory; acquire new data, and select a table comparison mode. The reference table and the compared table (which may be in hex, octal, or binary) will be displayed side by side, and the differences between the two will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

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

**Analyze system and interface timing.**

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

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




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

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

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The Magazine of Digital Systems

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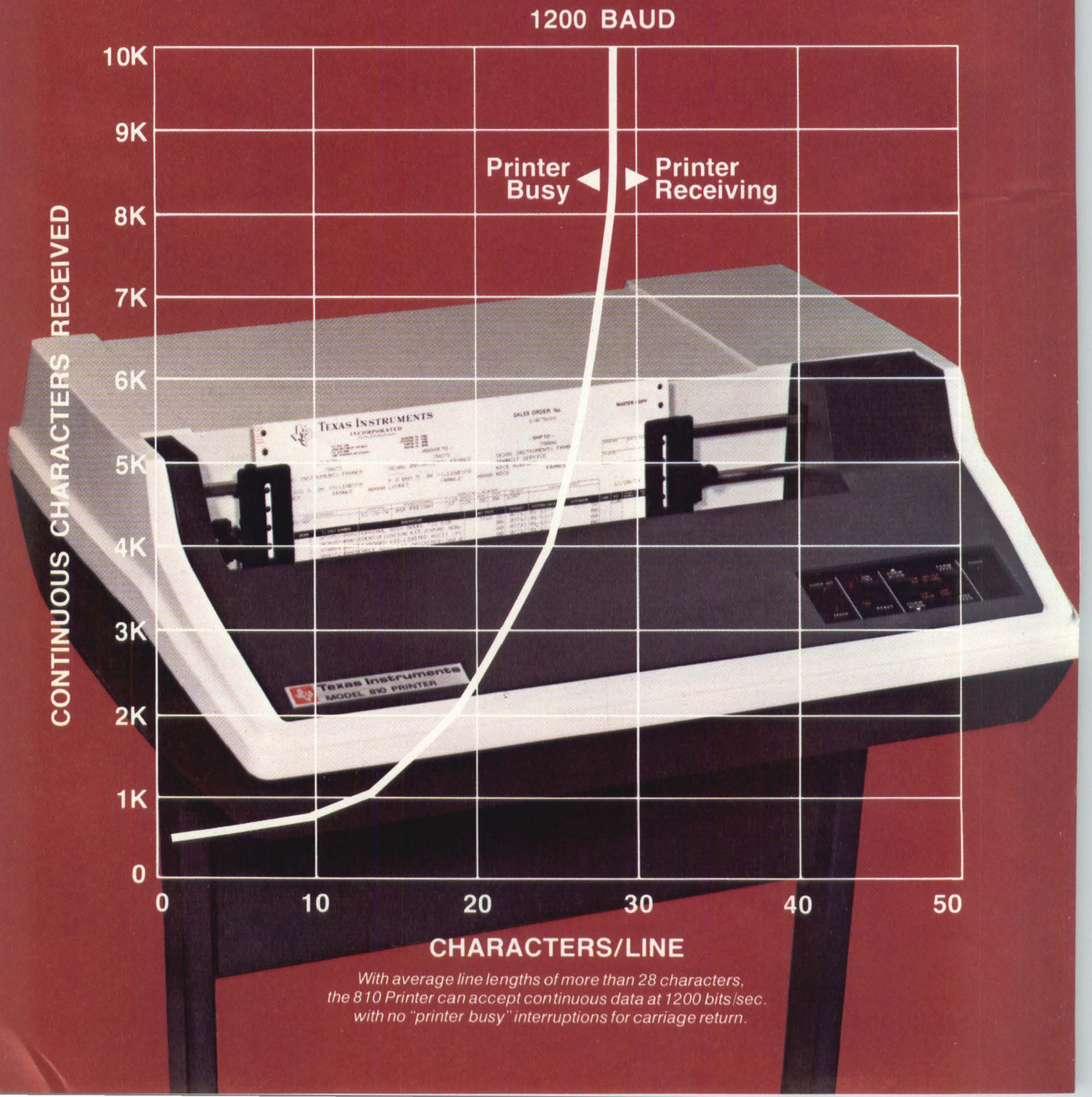
CIRCLE 8

# New from TI.

# Plot the performance of the Model 810 Printer against any other printer on the market.




*With average line lengths of more than 28 characters, the 810 Printer can accept continuous data at 1200 bits/sec. with no "printer busy" interruptions for carriage return.*

# And you'll find our impact is exceptional.

# TEXAS INSTRUMENTS.

Compare the new Model 810 Printer with any other printer you are using or considering. We believe you'll find that the 810's reliable, microprocessor-controlled printing results in the highest throughput per dollar and lowest cost of ownership.

The 810 is ideal not only for OEM's but as a peripheral printer for the TI model 770 Intelligent Terminal and the 990 Mini/Micro Computer Family.

**Plot our standard features.**
The 810 printer has exceptional standard features, too. Like bi-directional printing at 150 cps. No paper tape programming. Adjustable tractors for a variety of form widths. A 9 X 7 wire matrix character font for high-quality printing of an original and 5 copies. Bottom and rear paper loading. Speeds from 110 to 9600 baud. And 6 or 8 vertical lines per inch. Add to these the 810's tested reliability and the result is *performance*.

**Add a full line of options.**
With Vertical Forms Control, you get non-volatile storage of up to 8 different vertical forms. And with Forms Length Control, you can have 11 switch-selectable stored form lengths, from 3 to 14 inches plus 1 programmable form. The compressed printing option lets you print 132 columns in 8½-inch width. And foreign character sets are available as well as interfaces for most applications.

**A company you can rely on.**
A valuable feature of any Texas Instruments product is after-sale support. When you purchase your 810 Printer, you're getting support from a world-wide network of factory-trained personnel. And maintenance contracts are available.

With the Model 810, you can be sure your total cost of ownership is the lowest possible. And printer performance the highest. For a demonstration of the Model 810, or more information, just mail the coupon. Or call your nearest TI sales office, or (713) 494-5115, ext. 2124.

You'll like the 810's impact.

9-10-DD

Yes! I am interested in the new Model 810 Printer.
☐ Please send me more information.
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TEXAS INSTRUMENTS
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# LETTERS

## LCD's work too

Dear Editor:

As manufacturers only of liquid crystal displays we wish to complement Mr. Ross on his technical knowledge of the theory of an LCD (July, 1977) – but we know that the state of the art has developed beyond the area in which he confines this product.

Going over Mr. Ross' summary point-by-point:

1) The backlighting which an LCD uses for reading in darkness gives power savings over any other type of display. How many times is a DPM read in total darkness?

2) LCDs can have viewing angles up to 120°, well within the normal viewing area exposed to DPM viewers.

3) Readability is the criterion for a display. LCDs now come in color as well as white numerals on black background.

4) The temperature range is currently from -20°C to +80°C. What DPM is used in environments beyond this range? Because there is no heat in an LCD, it can be used at a higher ambient temperature than LED's.

5) LCDs can track a 10Hz change rate at room temperature with response time as low as 50mS. How much faster do we need?

6) LCDs mount directly on P.C. boards or with zebra strips. They use DIP and have the same mounting criteria as LEDs.

7) Chips now available incorporate the whole process circuit plus the drive circuit. With the low power dissipation, the whole circuit for an LCD can be put on one chip.

8) The estimated life of an LCD is 50,000 hours, and the warranty longer than the warranty on the average DPM.

9) Multiplexing is coming.

I.T. White
Crystaloid Electronics Co.
Hudson, OH 44236

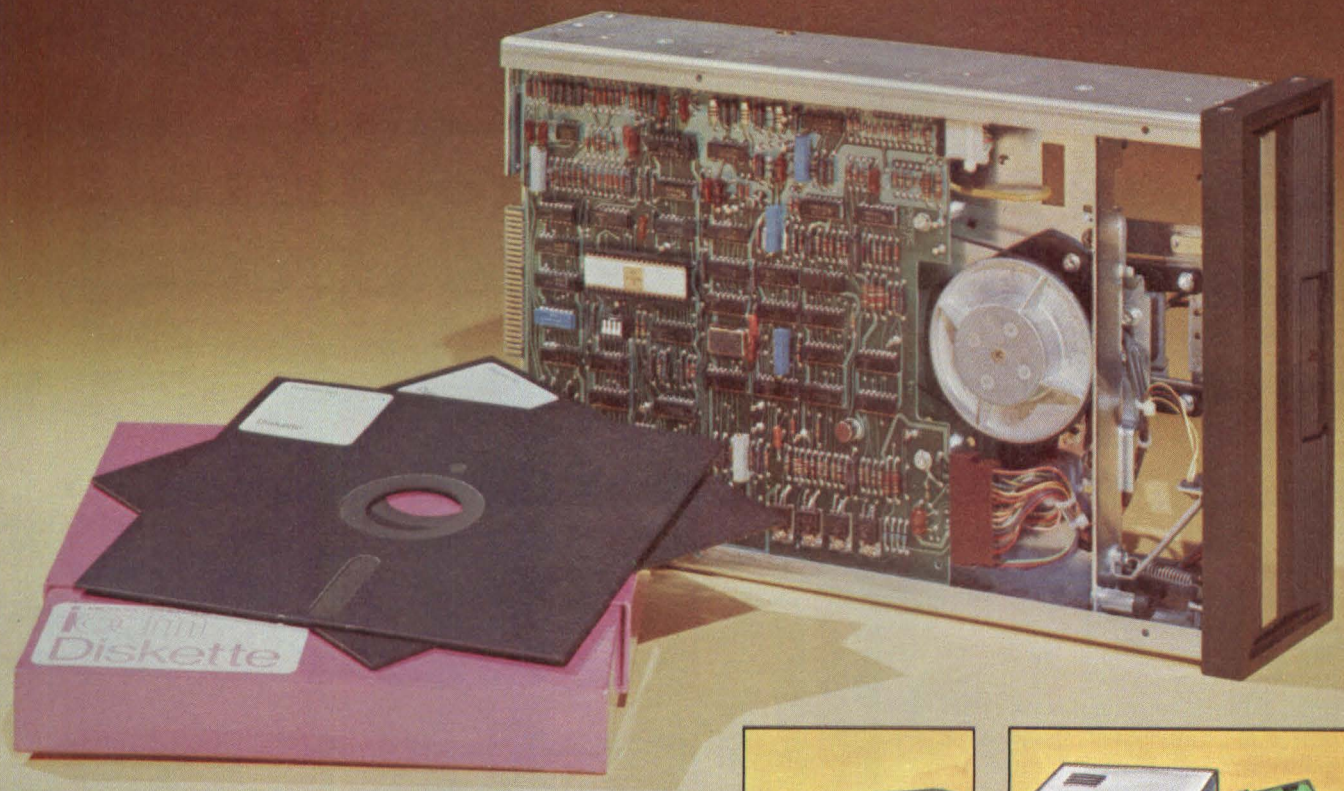
## What's his name?

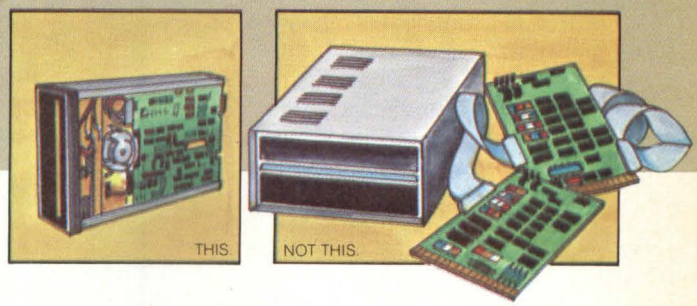
In last month's story on Logic Analyzers (**Digital Design,** August 1977, p. 55), we inadvertently misspelled Ken Pine's name and forgot to mention that he is with BP Instruments.



CIRCLE 11▶

# iCOM's Intelligent Floppy.™




## Controller/Formatter built-in. Packaging problems designed out.

When designing a floppy disk into a compact microcomputer-based system, engineers have been plagued with the problem of where to mount the controller/formatter cards and associated cables.

Our new FD5200 Intelligent Floppy™ solves this packaging dilemma by mounting all circuitry, including the single chip LSI controller/formatter, as an integral part of the disk drive chassis. A neat idea!

The 8 bit bi-directional bus makes it simple to integrate the iCOM® FD5200 into any system. Accrued benefits include: reduced hardware costs, smaller size, shorter assembly time, easier software development, improved reliability and lower maintenance. A mighty impressive list!

### Compatibility to IBM 3740 Format... and Others

The special LSI controller/formatter chip provides the complex logic needed to write data on the diskette in IBM 3740 format — or other user selected formats as well. Another big plus is a phase-locked-loop for data and clock bit separation, and address word detection, which maximizes data reliability.

### Pertec Makes the Driving Easy...

Since a floppy disk drive system is only as good as the mechanics, we use our field proven Pertec drive with three step-per-track head positioning for better accuracy and the unique head retract system for longer media life.

### Why iCOM®?

iCOM®, part of Pertec Computer Corporation, is one of the world's largest manufacturers of Microperipherals®. Thousands of our floppy disk systems are operating reliably in the field. And many major computer manufacturers have incorporated iCOM® floppies into their systems. Which means we deliver — and will be around to give you service whenever and wherever you may need it.

### Speaking of Delivery...and Price

Our new FD5200 Intelligent Floppy™ is available now at a unit price of just $795. Naturally, OEM discounts are available.

So phone us today. Or send for our brochure.

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# TECHNOLOGY TRENDS

## VMOS PROCESS MAKES INTEGRATED CIRCUITS SMALLER AND FASTER

Integrated circuits, introduced less than fifteen years ago, made possible large size reductions of computer parts. Integrated circuits (IC's) represent advantages in lightness, compactness and ability to function from low voltage battery supplies over previously used larger, discrete components.

The operation of both bipolar and standard N-channel MOS circuits depends on their construction. A cross section of an integrated circuit would show a number of layers of different insulating and conduction materials. The manufacturing process starts with a thin layer of crystalline silicon or, in some cases, germanium for the base. An oxide layer goes on top of the initial layer of silicon and UV light shielding photolithographic film protects areas which will later be removed with an acid etch. Further steps add n-type layers, more oxidation, p-type layers, diffusions, contacts, connections, separation of chips, bonding, encapsulation and final testing. The steps build layers on a planar surface, and the chip is essentially two dimensional when finished.

The technologies to develop and manufacture integrated circuits evolved from well known materials processes, and have been refined to the point where the physical size of the IC's probably cannot be reduced further without additional development in the manufacturing technology.

In this regard, American Microsystems Inc. recently announced a patented process which further reduces the size of integrated circuits. Called VMOS (for V-groove MOS), this process produces chips 40%-50% smaller than existing IC's of the same capability. At the same time, VMOS chips have the same 45 ns speed of the existing integrated circuits, yet can handle several times the current of the other chips, according to AMI.

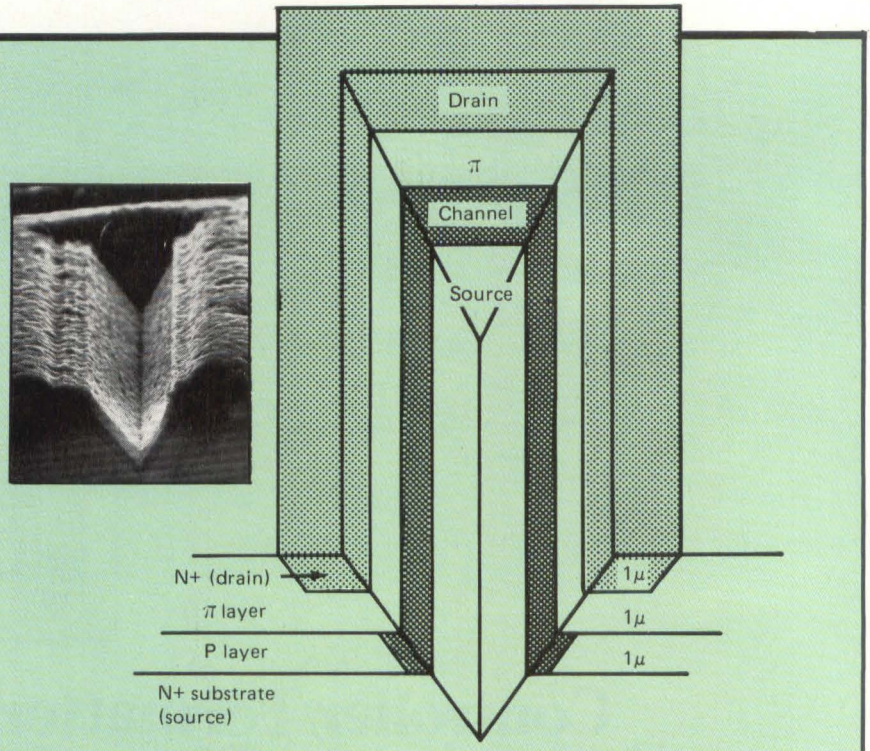


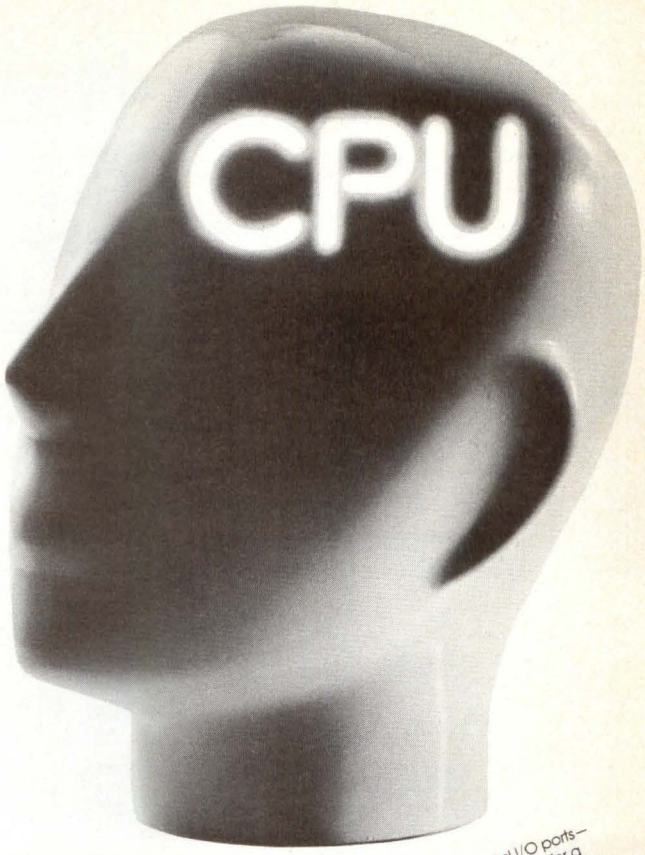

**Fig 1 Channel width is measured around the entire circumference of the V-groove, to give a high power-speed product. The pi-layer is lightly P-doped as a space-charge region to lower capacitance and increase breakdown voltage at the drain-substrate junction. The transistor is formed inside the line connector width and does not require enlargement as in older N-channel integrated circuits.**

**Fig 2 (Insert) Scanning electron microscope photograph shows VMOS transistor.**

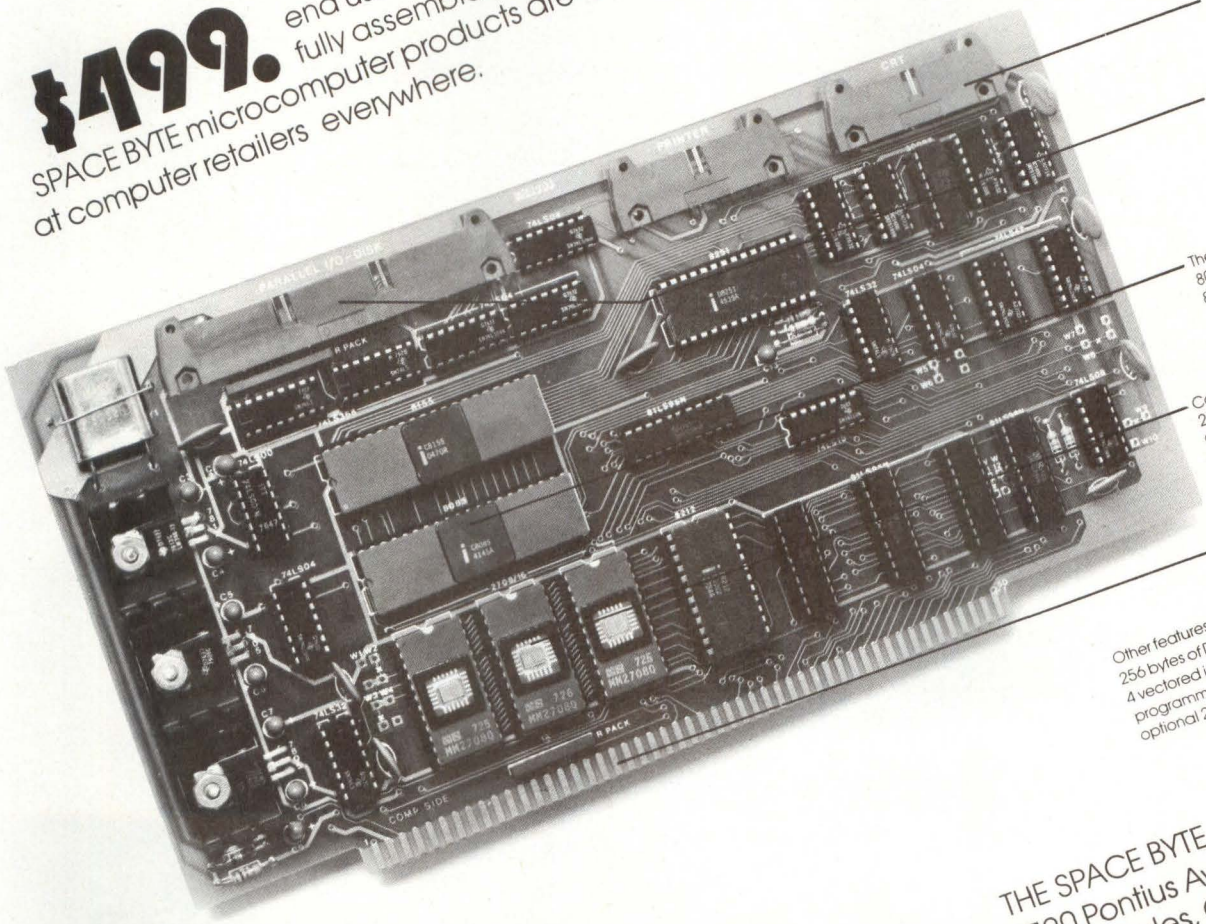
Since the chips are so much smaller than conventional bipolar or standard N-channel MOS, more can be produced from a single wafer of silicon, thus reducing the price. With this low cost and small size, AMI forsees an $8.1 billion share of the semiconductor market in 1980 that VMOS could successfully serve.

The secret of VMOS LSI circuitry rests in the V. According to the designer, Dr. Thurmon J. Rodgers of AMI, VMOS is an N-channel MOS logic structure integrated on a three-dimensional surface rather than in the two dimensions of the older planar NMOS technology. A cutaway view (Fig 1) of a VMOS transistor shows transistor elements arranged vertically up the sides of the V. The heavily doped n+ substrate serves as both a source and the common ground for all transistors on a VMOS chip. Between the source and drain is a p-layer channel, forming the MOS substrate.

# Introducing the SPACE BYTE™ 8085 CPU A self-contained computer




**$499.** end user quantity one. fully assembled, burned in and tested. SPACE BYTE microcomputer products are available now at computer retailers everywhere.



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CIRCLE 12

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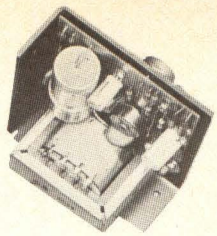


DIMENSIONS: 4"x2.75"x4.87"

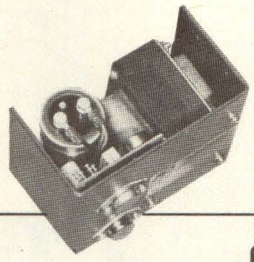
### 15 TO 24 WATT "RED BARON" SERIES. *U.L. Recognized (File No. E58512)

| MODEL NUMBER | RATING | | REGULATION | | RIPPLE (PK/PK) | OVP MODEL SUFFIX | PRICES-ALL MODELS | | |
|---|---|---|---|---|---|---|---|---|---|
| | Vdc | Amps | Line | Load | | | QTY | POWER SUPPLY | OVP UNIT |
| APS 5-3* | 5 | 3 | ±0.05% | ±0.1% | 3mV | OV1-53 | 1-4 | 34.00 | 7.00 |
| APS 6-2.5 | 6 | 2.5 | ±0.05% | ±0.1% | 3mV | OV1-63 | 5-9 | 33.15 | 6.90 |
| APS 12-1.6* | 12 | 1.6 | ±0.05% | ±0.1% | 3mV | OV1-122 | 10-24 | 32.20 | 6.70 |
| APS 15-1.5* | 15 | 1.5 | ±0.05% | ±0.1% | 3mV | OV1-152 | 25-49 | 30.70 | 6.40 |
| APS 20-1 | 20 | 1.0 | ±0.05% | ±0.1% | 5mV | OV1-201 | 50-99 | 29.20 | 6.05 |
| APS 24-1* | 24 | 1.0 | ±0.05% | ±0.1% | 5mV | OV1-241 | 100-249 | 27.00 | 5.70 |
| APS 28-0.8* | 28 | 0.8 | ±0.05% | ±0.1% | 5mV | OV1-281 | 250-499 | 25.20 | 5.25 |

### 30 TO 60 WATT "GREEN HORNET" SERIES. †U.L. Recognized (File No. E58512)

| MODEL NUMBER | RATING | | REGULATION | | OVP MODEL SUFFIX | POWER SUPPLY PRICES | | | OVP PRICES |
|---|---|---|---|---|---|---|---|---|---|
| | Vdc | Amps | Line | Load | | QTY | APS 48-1 | ALL OTHERS | |
| APS 5-6† | 5 | 6.0 | ±0.05% | ±0.1% | OV2-56 | 1-4 | 68.00 | 55.00 | 15.00 |
| APS 6-5 | 6 | 5.0 | ±0.05% | ±0.1% | OV2-65 | 5-9 | 66.70 | 53.65 | 14.85 |
| APS 12-4† | 12 | 4.0 | ±0.05% | ±0.1% | OV2-124 | 10-24 | 64.75 | 52.10 | 14.40 |
| APS 15-3† | 15 | 3.0 | ±0.05% | ±0.1% | OV2-153 | 25-49 | 61.75 | 49.65 | 13.75 |
| APS 20-2.4* | 20 | 2.4 | ±0.05% | ±0.1% | OV2-203 | 50-99 | 58.75 | 47.25 | 13.05 |
| APS 24-2.2*† | 24 | 2.2 | ±0.05% | ±0.1% | OV2-245 | 100-249 | 55.15 | 44.35 | 12.25 |
| APS 28-2*† | 28 | 2.0 | ±0.05% | ±0.1% | OV2-284 | 250-499 | 50.75 | 42.00 | 11.30 |
| APS 48-1* | 48 | 1.0 | ±0.05% | ±0.1% | OV2-481 | 500-999 | 49.60 | 40.00 | 11.05 |

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

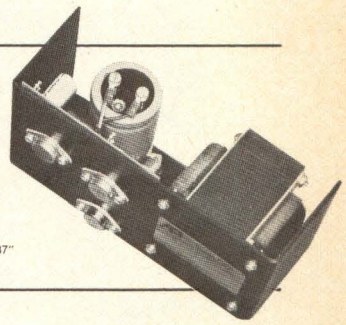


DIMENSIONS: 5.62"x3.40"x4.87"

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

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

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

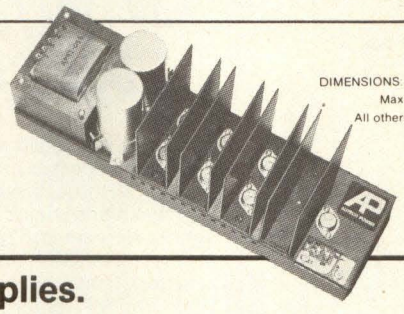


DIMENSIONS: 9"x3.65"x4.87"
APS 5-18 DIMENSIONS: 14"x3.65"x4.87"

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

| MODEL NUMBER | RATING | | REGULATION | | OVP MODEL SUFFIX | POWER SUPPLY PRICES | | | OVP PRICES |
|---|---|---|---|---|---|---|---|---|---|
| | Vdc | Amps | Line | Load | | QTY | APS 5-30 | ALL OTHERS | |
| APS 5-25 | 5 | 25 | ±0.05% | ±0.0.1% | OV3-525 | 1-4 | 163.00 | 158.00 | 25.00 |
| APS 5-30 | 5 | 30 | ±0.05% | ±0.0.1% | OV3-530 | 5-9 | 159.25 | 154.40 | 24.50 |
| APS 6-22 | 6 | 22 | ±0.05% | ±0.0.1% | OV3-622 | 10-24 | 154.65 | 149.95 | 24.25 |
| APS 12-17 | 12 | 17 | ±0.05% | ±0.0.1% | OV3-1217 | 25-49 | 147.45 | 142.95 | 23.15 |
| APS 15-15 | 15 | 15 | ±0.05% | ±0.0.1% | OV3-1515 | 50-99 | 140.20 | 135.90 | 22.00 |
| APS 20-11 | 20 | 11 | ±0.05% | ±0.0.1% | OV3-2011 | 100-249 | 131.65 | 127.60 | 20.65 |
| APS 24-10 | 24 | 10 | ±0.05% | ±0.0.1% | OV3-2410 | 250-499 | 121.10 | 117.40 | 19.00 |
| APS 28-9 | 28 | 9 | ±0.05% | ±0.0.1% | OV3-289 | 500-999 | 118.50 | 114.85 | 18.60 |

RIPPLE (PK/PK): 3mV on 5,6,12,15V models. 5mV on 20,24,28V models.



DIMENSIONS: 16.72"x4.87"x6.60"
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All others 16.72"x4.87"x5.75"

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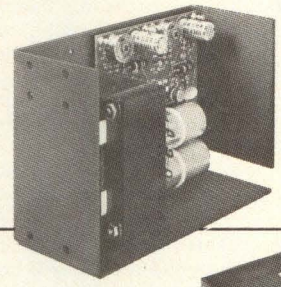
### DUAL OUTPUT MICROPROCESSOR SERIES U.L. Recognized (File No. E58512)

| MODEL NUMBER | RATING | | QUANTITY PRICES | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Vdc | Amps | 1-4 | 5-9 | 10-24 | 25-49 | 50-99 | 100-249 | 250-499 |
| DAPS 5.8 | ±5 | 0.8 | 43.00 | 41.95 | 40.70 | 39.80 | 38.00 | 36.80 | 33.00 |
| DAPS 9-12.5 | ±9-12 | 0.5 | 43.00 | 41.95 | 40.70 | 39.80 | 38.00 | 35.80 | 33.00 |
| DAPS 12-.75 | ±12 | 0.75 | 43.00 | 41.95 | 40.70 | 39.80 | 38.00 | 35.80 | 33.00 |
| DAPS 15-.60 | ±15 | 0.06 | 43.00 | 41.95 | 40.70 | 39.80 | 38.00 | 35.80 | 33.00 |
| DAPS 5112.5 | +5 | 1.0 | 43.00 | 41.95 | 40.70 | 39.80 | 38.00 | 35.80 | 33.00 |
| | -12 | 0.5 | | | | | | | |
| DAPS 12-1.5 | ±12 | 1.5 | 59.00 | 57.60 | 55.90 | 53.30 | 50.65 | 47.60 | 43.80 |
| DAPS 15-1.3 | ±15 | 1.3 | 59.00 | 57.60 | 55.90 | 53.30 | 50.65 | 47.60 | 43.80 |
| DAPS 53121.5 | +5 | 3.0 | 59.00 | 57.60 | 55.90 | 53.30 | 50.65 | 47.60 | 43.80 |
| | -12 | 1.5 | | | | | | | |

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

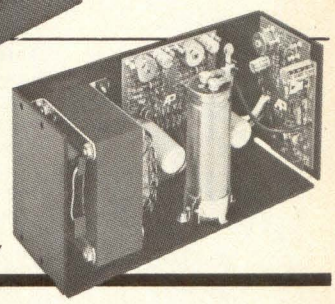


REQUEST BULLETIN DAPS - 976

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

| MODEL NUMBER | RATING | | QUANTITY PRICES | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Vdc | Amps | 1-4 | 5-9 | 10-24 | 25-49 | 50-99 | 100-249 | 250-499 |
| TAPS 1 | 5V | 4.0 | 94.15 | 91.85 | 89.20 | 85.05 | 80.85 | 75.90 | 71.00 |
| | ±9-12* | 0.5 | | | | | | | |
| TAPS 2 | 5V | 6.0 | 107.00 | 104.60 | 101.60 | 96.85 | 92.10 | 89.00 | 87.50 |
| | ±9-12* | 1.0 | | | | | | | |
| TAPS 3 | 5V | 9.0 | 137.00 | 134.00 | 129.80 | 127.80 | 125.00 | 123.75 | 113.85 |
| | ±9-12* | 1.5 | | | | | | | |
| TAPS 4 | 5V | 12.0 | 163.00 | 159.00 | 154.45 | 151.50 | 149.00 | 148.00 | 147.00 |
| | ±9-12* | 3.0 | | | | | | | |

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



DIMENSIONS:
8.62"x3.65"x4.87" to
15"x4.5"x4.87"

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**CIRCLE 13**

The pi ($\pi$) layer is a lightly doped p-type epitaxial layer serving as a space-charge region to lower capacitance and increase breakdown voltage of the drain-substrate junction.

Channel length (the thickness of the p-layer) controls device speed in conjunction with channel width. In VMOS, channel width winds around the entire circumference of the V-groove and each transistor transconducts several times more current per given unit of die surface area than a planar NMOS transistor.

3-dimensionality in the VMOS increases circuit density resulting in large size differences. The Fairchild 93415/25 1K x 1 bipolar RAM is 61% larger and the Intel 2115/25 1K x 1 NMOS RAM is 87% larger than the AMI 1K static RAM VMOS chip. The n+ substrate serves as a common source for all transistors, accounting for the increased VMOS density, by eliminating ground lines required on NMOS circuits.

VMOS cell size can be the same width as the connector lines to it, rather than larger, as in NMOS. The VMOS transistors will fit in the minimum size linewidth connectors needed to join them into an integrated circuit; they do not require large surface areas. In the development stages, a 1K static RAM designed using conservative linewidth rules (the rule specifying the minimum size linewidth connectors needed to ensure that the circuit can be reliably manufactured) of 5.5 microns produced a chip 81 x 125 mils (10,125 mils$^2$), and a 45 ns access time. A later version of the 1K RAM used 4.5 micron rules and produced a chip 69 x 100 mils (6,900 mils$^2$) with a 35 ns access. The latest and smallest design uses 3.5 micron rules and the chip measures 55 x 80 mils (4,400 mils$^2$) with an access time of 28 ns. Delay analysis of the VMOS 1K RAM indicates that access time can be brought down to the 20 ns range, according to AMI, putting MOS technology ahead of second generation bipolar technologies.

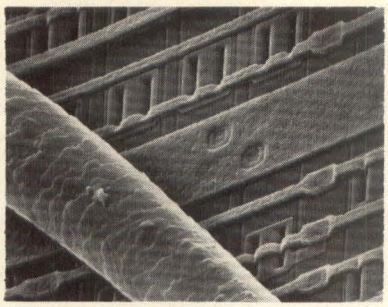

**Fig 3 Using VMOS technology, computer memory transistors are so small that eight of them on an integrated circuit (bottom) will fit in the cross section of a human hair (top).**

A peculiar characteristic of crystalline silicon makes possible the manufacture of the V-grooves in VMOS integrated circuits. Amines will etch silicon only along certain crystal

planes. Wafers sliced from silicon ingots with surfaces in the Miller Index (100) orientation and index flats in the (110) orientation can be amine etched from V-grooves in unmasked areas. The etching stops when the V-grooves have formed, regardless of immersion time. A number of process steps then fabricate the transistors in the V-grooves to create the integrated circuits.

With the memory access speeds achieved in the 1K static RAM, AMI feels that the digital bipolar memory market holds promise for VMOS memory products. Their analysis of the potential markets available shows that VMOS can eventually take the place of P-channel MOS, standard N-channel MOS and a portion of the digital bipolar market in logic and memory applications. AMI feels that the potential market for VMOS could well be larger than the potential markets for standard MOS processes. Thus they see a very good outlook for VMOS.

AMI spokesmen suggest that the greatest immediate opportunity for market penetration by VMOS is in the area of MOS large scale integrated memory products-RAMs, ROMs and EPROMs-for electronic data processing equipment. By 1980 this market will amount to about $902 million annually and most of the memory circuits being made now will be replaced by newer designs, able to store more information and retrieve it faster. AMI expects to design and produce new VMOS memory circuits for this market at prices competitive with or below the prices of those made with other technologies.

VMOS memory products in production or in pre-production stages include a 1,024 bit static RAM, a family of 4,096 bit static RAMs, an 8,192 bit static RAM, a 16, 384 bit ROM, EPROM and dynamic RAM and a 65,536 bit ROM.

## Desktop System Has Graphics Capability

Minicomputers in some applications may find a serious competitor for their jobs with the introduction of a new generation of desktop computers from Hewlett-Packard. The Series 9800 System 45 has the most powerful central processor and the largest built-in mass storage system ever offered in a desktop computer. It incorporates a 12-inch CRT display, BASIC interpretive language conforming to the new ANSI standard, applications software and an optional graphics package with high-speed hard-copy output. According to Frederick Bode, Marketing Manager for HP's Calculator Products Division, System 45 should solve those problems most often encountered by technical users. He points out that solutions can often be found more quickly and conveniently with the System 45

**Fig 1 The Hewlett-Packard System 45 has the most powerful central processor and the largest mass memory ever offered in a desktop computer and incorporates a 12" CRT display, enhanced Basic, applications software and an optional graphics package with high-speed hard-copy printing.**

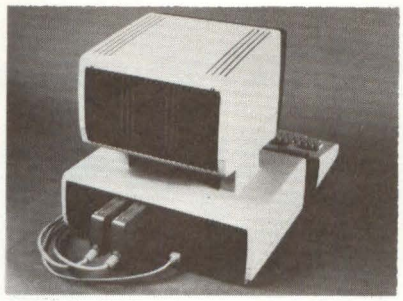

**Fig 2 Four ports on System 45 hold a wide range of interface cards, allowing the user to expand the system and control or acquire data from as many as 20 instruments.**

than with larger computers.

**Software.** System 45 users can select from a growing software library, both from HP and from other sources. You can use programs already available from Hewlett-Packard; these include scientific computation and data analysis, data acquisition and control, management science, business administration and CRT graphics. Other programs in such areas as materials management, medicine and engineering design will become available.

A 98K operating system resides in ROM; the system uses a language based on ANSI BASIC, conforming to the American National Standard for Minimal BASIC; existing software complying with this standard will operate directly with the new computer. In addition to compiling with the new ANSI BASIC standard, the system's enhanced BASIC language makes available to users such features as subprograms, multicharacter identifiers, line labels, powerful array operations and flexible output formatting. The computer's standard keyboard with separate groupings of keys for program control and editing, CRT control and 32 user-definable functions simplifies the use of the enhanced language.

System 45 has two sophisticated system capabilities; one, multiple buffering, allows you to dedicate up to ten buffers for I/O processing. Use of two processors, a language processor and a peripherals processor, provides overlap processing. This feature increases system speed when you have I/O operations and computation that can take place at the same time.

**CRT.** HP's implementation of CRT technology provides both graphics and an alphanumeric display with advanced editing features. The graphics mode uses a 560 x 455 dot matrix with high visual resolution and no perceptible flicker. The alphanumeric mode offers a full 80-character wide, 24-line deep screen. In this mode the screen is split for user convenience, with the top 20 lines dedicated to output in the form of user data, program listings and editing; the bottom four lines provide prompting and diagnostic signals. Other important features of the CRT component include adjustable screen brightness; highlighting functions such as inverse video, blinking and underline; full keyboard-character display; and optional foreign character sets. Software for the graphics mode comes on an optional ROM.

Available as an option, a built-in line printer can produce 80-character lines at 480 lines per minute and transfer graphical images from the CRT in seconds. It uses either continuous blueprinting paper or perforated blackprinting paper that enables top-of-page sensing for page control.

The System 45 allows data and program storage using commands that are device independent. Aside from changing the address of the storage device, available storage devices can be accessed without program modification. These devices include a built-in 210 Kbyte tape cartridge system, an external 460 Kbyte flexible disk drive and a choice of external hard disk drives with capacities of 15 to 50 Mbytes. You can add second built-in 210 Kbyte tape cartridge system for increased storage flexibility and high speed duplication. The basic System 45 has 16 Kbytes of read/write memory, with 13,498 bytes available to the user; this memory can be expanded to 64 Kbytes.

So that system expansion can readily take place, System 45 provides multiple interface ports and the capability to use four standard interface types – bit-serial, BCD, bit-parallel and HP-IB (in accordance with IEEE Specification 488-1975). Equipped with four input/output ports to hold a wide range of optional interface cards, you can add multiple 15 Mbyte or 50 Mbyte disks and control or acquire data from as many as 20 instruments.

The basic system with built-in keyboard, 16 Kbytes of read/write memory, CRT and one tape transport costs about $12000. Can this system replace minis? According to Dennis Procter, Advertising and Sales Promotion Manager for HP's Calculator Products Division, System 45's friendliness (in the form of operator prompts), ease-of-use and integration will make it a tough competitor in many single-user environments.

# Laser to Typewriter: Low Cost Character Recognition

Optical character recognition (OCR) has been around for a relatively long time, but it only recently emerged as a practical alternative to keyed data entry in the office. The chief obstacles to popularity for older OCR units were their expense – $40,000 and up – and their rather particular input requirements in type font, copy format and paper quality. That restricted most OCR installations to businesses where print was the principal commodity – newspapers, book and magazine publishers and advertising typographers.

An OCR unit designed to sell for under $20,000 could become a valuable adjunct to video terminals in word processing situations requiring heavy input of copy. One such unit can handle the output of 40 to 60 typists using Selectric typewriters, which cost a fraction of VDT station prices. Further, only 20 percent of a secretary's work is directed toward a database; the remaining 80 percent presents no requirements for an interactive terminal. In this way, every Selectric typewriter at each location becomes a data entry station. Established office routines are saved from disruption and if the OCR reader will accommodate a font such as Courier 12, no modifica-

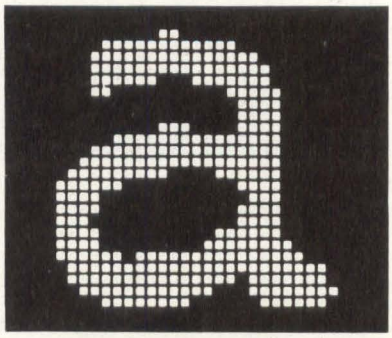

**Fig 1 The OCR changes alphanumerics into a pattern of dots, and sends them to the video buffer, which circumscribes a rectangular box around each element.**

# If you wait until 1978, you'll see some new 150 and 300 lpm band printers.

# If you order a field-proven Printronix impact matrix line printer today, you'll get unbeatable print quality plus full plotting capability for the same price...or less.

# And we'll ship it tomorrow.

Read about the new 150 and 300 lpm band printers scheduled for delivery sometime next year? Supposedly, they'll be in the same low price range as Printronix 150 and 300 lpm impact matrix line printers. But good as they might be, they'll never be able to match the utility and value of Printronix Printer/Plotters.

In the first place, you can't plot with a band printer. A Printronix can plot anything that can be displayed on a CRT. You get this extra capability at no extra cost. Printing and plotting for the same price as a band printer.

What's more, a Printronix gives you a 160 character capacity with no slowdown in print speed. A standard 96 character ASCII set plus your choice of an optional 64 character computer selectable set. No time lost changing bands to print different languages or character styles. And since a Printronix has fewer parts than a band printer, you can count on higher reliability.

Since mid 1975, we have shipped more than 3,000 units. They're field proven. And we are tripling our production capacity. So you won't have to wait 6 to 9 months to get the best buy in printers. Order one today and we'll ship it tomorrow!

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Call us at (714) 549-8272


# PRINTRONIX...

## Your chance to beat the band.

tion of typewriters is necessary.

OCR offers cost advantages in equipment – under $25 for a "golf ball" if a Selectric typewriter is available – and in operator training. OCR can lift extended data entry and rough-drafting tasks from on-line terminals and put them where they belong – off-line. It can cut communication costs for remote timesharing systems and give video terminals back their greatest strength – true interactivity.

or OCR-B alphanumerics (plus special characters for American English, French Canadian or Latin American Spanish) and OCR-A numerics at 500 words per minute, and outputs modified ASCII characters in either duplicate or condensed format. Another model, the 4500, reads 900 wpm.

Passing through a focusing lens, a 2 mW HeNe laser beam in the scan mechanism reflects off a rotating mirror in a horizontal sweep. Powered by a synchronous motor, the dual mirror produces 120 sweeps per second across a line of 7½ inches, leaving half inch margins at either side of an 8½ x 11 inch sheet. A beam splitter deflects approximately 30 percent of the beam onto a grating to produce clock pulses of one-bit value at a rate of 250 per inch. A photodiode strip senses changes in scanning beam intensity as reflected from the paper. Phase-lock loop circuitry compensates for timing variations that follow a parabolic waveform generated by the scanning configuration.

A high-torque, four phase stepping motor moves the paper vertically across the platen in steps of 0.004 inch in response to pulses from the video/grating amplifier. Between lines of copy, the reader slews the paper forward at 1.9 inches per second, sampling every fourth step. When characters are detected, the motor backs up four steps and resumes forward motion one step at a time until it detects no more characters.

The OCR scans characters from top to bottom, a full line at a time, and sends raw data from digitized picture elements to the PDP-8/A's video buffer (Fig 2). A special instruction set stored in the 4K PROM of the PDP-8/A establishes a rectangular box circumscribing each detected character, with north, south, east and west coordinates.

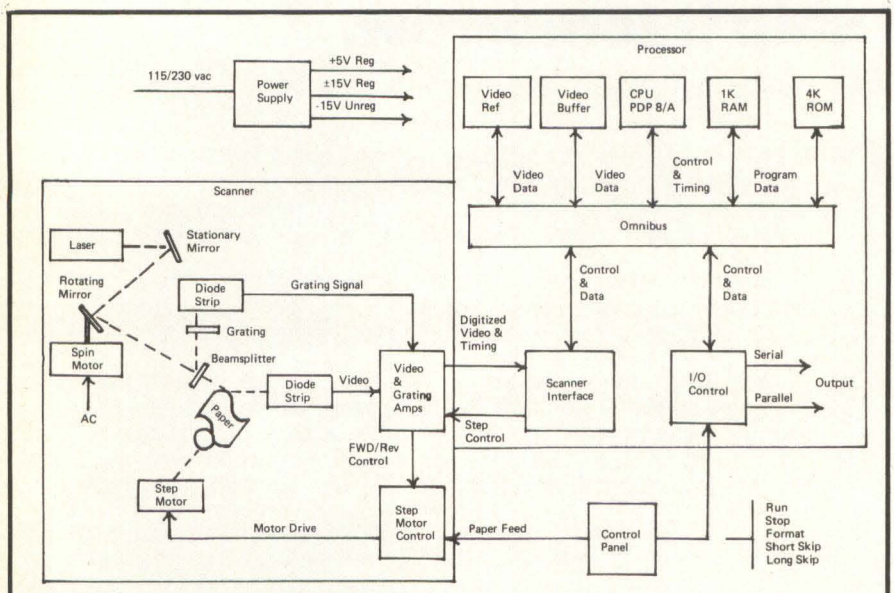


**Fig 2 The block diagram above illustrates the operation of the OCR. The step motor moves the paper in 0.004" increments; after the laser scanner detects characters, it sends the digitized picture elements to the PDP-8/A's video buffer. There, the characters are boxed and identified, or accepted as a best guess.**

**Fig 3 The ECRM Autoreader tabletop unit reads standard Selectric Courier 12 type.**

An OCR for general word processing might be designed with the following goals in mind: compactness, reliability, ease of operation and economy. In other words, it would be affordable, unobtrusive, have no need for constant coddling and would put up with less-than-perfect input copy and standard business letters.

Recognizing the need for a low-cost, office OCR, the ECRM Corp. developed the 4000 series Autoreader tabletop unit, which accepts standard 8½ inch wide sheets from six to 14 inches long, fed through an input hopper in stacks up to 20 pages. The 4000 series uses the laser-scanning mechanism developed for ECRM's larger 5000 series systems, which, says ECRM, has a proven track record. A Digital PDP-8/A minicomputer controls the 4000 series units.

The 4400 model reads Courier 12 Characters are measured for several values including height and width, and results compared with a table of allowances. Exceeding certain minimum requirements, the recognition is accepted as correct; falling short of the minimum, a match is accepted as a "best guess."

After identifying all characters in a typed line, the OCR determines ASCII codes and position data for each and transfers the line to the control of the formatting routine. When switched ON, the formatter converts text to a character stream that maintains word integrity but ignores all line feeds and eliminates extra interword spaces, hand-deleted characters and extra indents. When switched OFF, the formatter retains the original line image with rub-out symbols inserted in place of hand-drawn deletes. Output format appears as in the original with upper and lower case characters and single, double or triple line spacing.

Output can be directed to a hard-copy or video terminal, line printer, paper tape punch or to a host computer system for storage or editing. If

# Tandberg's TDC 3000 Digital Cartridge Recorder.

# WHAT'S IN A NAME?


## Communication. With every computer.

Begin with the industry-proven Tandberg TDC 3000 Digital Cartridge Recorder. Add our new RS-232 I/O controller/interface. And you have a highly cost-effective recording system compatible with *every* computer.

There's a complete family of interfaces for the Tandberg TDC 3000. From the original design conceived by Tandberg of Norway, the $150-million electronics firm that pioneered tape recorders internationally. The company that is to high quality electronic equipment what Rolls Royce is to automobiles. With a tradition of excellence that continues in a wide range of computer peripherals from Tandberg Data in the United States.

With *total* communications compatibility, the microprocessor-based RS-232 controller/interface from Tandberg Data is engineered according to EIA Standard RS-232-C, type D and E, and a "teletype-compatible current loop," recording in ANSI/ECMA/ISO-compatible format.

And from the substantial savings in line charges alone, the TDC 3000 with the RS-232 controller/interface will recoup its modest cost in a matter of months. It's hard to beat that kind of cost-effectiveness.

Conceived in the rugged Norse heritage, the Tandberg TDC 3000 is no wilting lily when it comes to tough environments. Put it to work in subzero snow country or under a desert sun and don't worry about the bad vibes or emissions from nearby equipment. The TDC 3000 is engineered to roll with environmental punches.

Modular construction of the TDC 3000 enables the user to configure a system to individual needs. Applications include minicomputer input/output, minicomputer peripheral storage, terminal peripheral storage, software distribution, data entry via keyboard, local data collection, data transmission, and text editing. And a few other things yet to be dreamed up.

Besides RS-232, Tandberg Data provides TDC 3000 interfaces for HP 21MX, PDP 11, 8080 Microprocessor, AN/UYK-20 and 8-bit parallel general purpose. All give up to 48K bits transfer rate.

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

**TANDBERG**

recognition outpaces transmission and the character buffer becomes full, scanning and recognition processes pause until data is output.

According to ECRM, experience with the 4000 series reveals a scanning error rate of 0.01 percent for normal copy and tolerance of a variety of imperfections in input materials. The reader will handle line skews of 1/6 inch over seven inches and any line density up to six lines per inch. Paper type is specified as any smooth, 16-to-24 pound non-rag-content white bond; plain duplicator paper has been used for most testing, however, and has been found preferable to more expensive bonds, including OCR bond. A video AGC compensates for off-white or tinted paper as long as its reflectivity is at least 90 percent that of white. Moderately smudged or wrinkled paper or cut and pasted sheets up to 14 inches long are also acceptable. Editing marks not intended for detection can be made with red ink reflective at approximately 6330 Angstroms, the laser's wavelength.

# Ireland Uses Microprocessor as Traffic Cop

A microprocessor-controlled traffic system recently put an end to perpetual traffic jams on Ireland's busiest road, O'Connell Street in Dublin. The traffic situation, resulting from 14 intersections on one half-mile stretch, had become a regular topic in the local press. Because the street served as a major shopping area, high pedestrian density aggravated the problem.

The traffic system in existence prior to the new computerized installation used a few fixed-program signals and required the constant presence of police to control both motor vehicles and pedestrians.

The new traffic system uses vehicle actuation, and takes into account the pedestrian crossings. A number of optimal traffic control programs are available at all times; using traffic measurements, the central processor chooses the most suitable program at any given moment.

The equipment came from the Philips Traffic Control Group in The Netherlands, who have many traffic systems currently in use in Ireland, with 65 installations in Dublin alone.





CIRCLE 19▶

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DEC* computers are among the best ever. Everybody knows that. But even with DEC there is room for improvement. We took advantage of that fact and made the best ever even better. In the process, we've given you a chance to supercharge your present PDP-11* instead of upgrading to the next computer. We've given you more time and improved your cash flow with the most complete line of sophisticated computer enhancements on the market today. They are available off the shelf. They are priced competitively. They install in minutes. They provide immediate results. And, in every instance, they outperform the competition. They should. We are the only *computer* people in the business. We are the only people really qualified to help you play out your hand and win.

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# PRINTERS '77

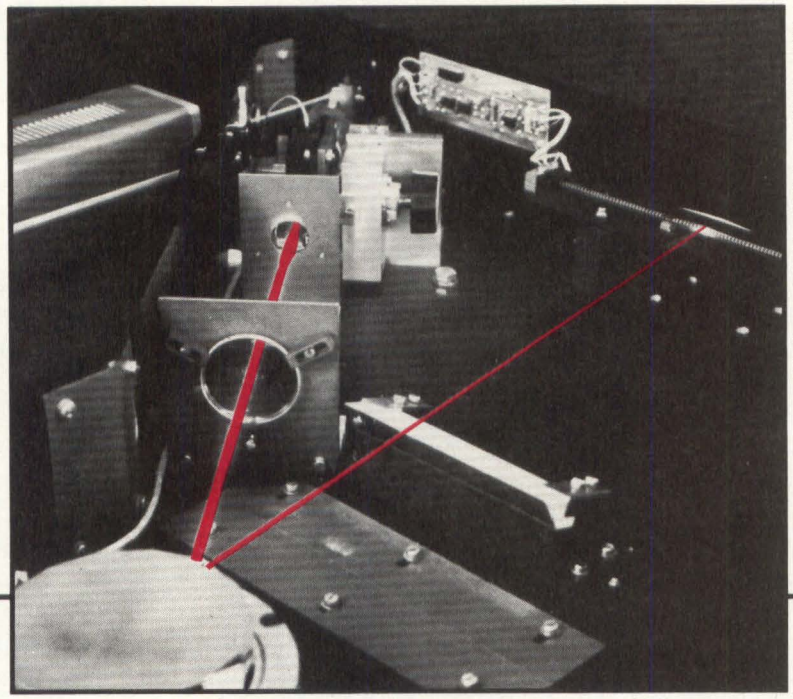

Photo courtesy of Siemens Corporation

by Henry Simpson

Before we start . . . Our survey of printers covers a rather wide range of machines. The least expensive of them sells for well under $100, the most expensive for more than $100,000. Speed, the parameter perhaps most often mentioned when discussing printers, varies in about the same degree – from about 15 characters per second (cps) to over 20,000 lines per minute (lpm). About the only thing that all printers have in common is that they use paper. And we must even hedge this statement a little, because they do not all use the same kind of paper.

**How Printers Are Classified.** Industry classifies printers in several ways. First, it commonly makes a distinction between line (or parallel) and serial printers. In line printers, one print element prints each character position across an entire page. In serial printers, a single print element prints one character at a time. The fastest units are line printers. Although some of the small printers use printing mechanisms that place them in the line printer classification, they are the slowest printers. In the next speedier classification are the serial printers, many of which are capable of very respectable speeds.

Industry also sometimes bases its distinction between line and serial printers on how a line of text is composed, rather than how it is put on paper. If a machine composes a complete line of type prior to printing, we can class it as a line printer, regardless of the nature of its print element. For this reason, some manufacturers classify their single-element printers as line printers. However, industry more commonly makes the distinction between line and serial printers by the way characters are put on paper. We shall employ this convention here.

Industry often makes a third parallel/serial distinction in the way printers receive their input, since some require parallel input, others serial. In summary, then, industry makes the serial/parallel printer distinction in three ways: how the machine composes a line prior to printing; how it prints the line; and how it receives its input.

We can also classify printers by the method of printing – into impact and nonimpact. Impact printers make their mark by bringing an imaging element (which may be a whole character or a portion of a matrix) in contact with paper via a ribbon. A typewriter represents perhaps the simplest example. Nonimpact printers do not use ribbons or hammers, but make their mark in various other ways – for example, thermally or electrostatically.

We may go a step further and note that printers produce solid-line or a matrix-of-dots characters. In matrix printers, the more dots, the better the character is represented. Impact printers may be whole character or matrix printers; nonimpact printers presently on the market are only matrix printers.

From the designer's point of view perhaps the most useful way of classifying printers is by size and application. The printers fall into three size categories: small, medium and large. The smallest print fewer than 21

# The complete $655 line printer.

## It's ready to plug in, has an 80-column format, a remarkable MTBF and is 14 times faster than a teletype!


### Breaking the hardcopy barrier

It's finally happened! The Axiom EX-800 provides full performance hardcopy at a price compatible with today's low cost micros. This little 80-column machine zips along at 160 characters per second (14 times faster than a teletype)—at a breakthrough single quantity price of $655 for a complete printer.

### When we say complete we mean it

The EX-800 is a stand-alone unit with case, power supply, 96 character ASCII generator and interface, paper roll holder, infra-red low paper detector, bell, and multi-line asynchronous input buffer. You won't find these standard features on any other printer, regardless of price!

### Our only option

Our printer is so complete, that we offer only one option. A serial interface (RS 232C or current loop) good for 16 baud rates from 50 to 19,200 and thoughtfully provided with a switch for either Centronics or Tally compatibility. Might we call it a Tally-whacker? At $85.00 it certainly should be!

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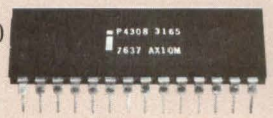

The heart of the EX-800 is a printed circuit card, containing a custom LSI chip made by Intel to Axiom specifications, which controls all printer functions. Microprocessor power means flexibility. Such as the built-in self test routine and variable character size. It also means reliability. Several industry surveys have shown LSI to be many times more reliable than equivalent conventional circuitry.

THIS LIFE-SIZE SAMPLE SHOWS THE 80-COLUMN PRINTOUT FROM AXIOM'S EX-800 PRINTER

There are 3 character sizes (upper and lower case) which can be MIXED.

This can have the same effect as UNDERLINING or changing COLOR.

### The advantages of electrosensitive printing

The EX-800 can print 80, 40, or 20 characters across the five inch wide electrosensitive paper. Under software control, single characters or words may be printed larger for emphasis. The permanence of the hardcopy is archival, because once the aluminum coating has been removed, there is no way to put it back. It's unaffected by sunlight, moisture or heat. Although the printer doesn't provide multiple copies, excellent quality photocopies can be made from the high contrast printout. Also, the paper is inexpensive and readily available, costing about 1¢ for an 8½ x 11" equivalent.

### Light, small, quiet, reliable, and versatile

Our EX-800 weighs in at 12 pounds, is just 9½ inches wide, 4 inches high, and 11 inches deep, and is delightfully quiet which makes it ideal for office and other low noise environments. The simple print mechanism is virtually maintenance free. In fact, tests show an incredible MTBF, many times greater than impact printers. This versatile printer is the ideal mate for micros, minis, CRTs, instruments and systems.

### Just unbox and plug it in

That's all you have to do to the Axiom EX-800 — apart from pay for it, and at $655 that's <u>almost</u> a pleasure.

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columns of data. Generally these printers are used for instrumentation or for remote data readout. Microprocessors can increase their potential considerably, however, and in some applications make them competitive with larger capacity printers. A number of medium sized printers on the market can print up to 48 columns of data. Generally somewhat faster than the smaller machines, these printers perform well in such applications as ticket printing, microcomputer and minicomputer printout, remote data logging, as well as in instrumentation. The majority of printers fall into the large category. Most are capable of printing 132 columns of data, though we have included some 80 column machines in this category as well. The large category is very diverse. Speed ranges from 15 LPM to 21,000 LPM. Applications include printout for microcomputers and minicomputers, teleprinters, terminals and high-speed data printout.

**A Word About Technology.** Printers employ mostly tried and proved technology. Some relatively recent developments, such as the Daisy Wheel (1972), seem to have succeeded and their acceptance is attested to by their availability from a number of manufacturers. The newest technologies (laser and ink jet printing) seem to be on the verge of wide acceptance. They are becoming increasingly available and potential users should seriously consider them for some applications.

## Types of Printers and How They Work

Fig 2-11 and 13 (courtesy of Data Products) depict the working of the majority of printing mechanisms commonly found in today's market. Table 1 lists the 12 types of mechanisms, whether they print by impact or nonimpact and whether they produce whole or matrix characters.

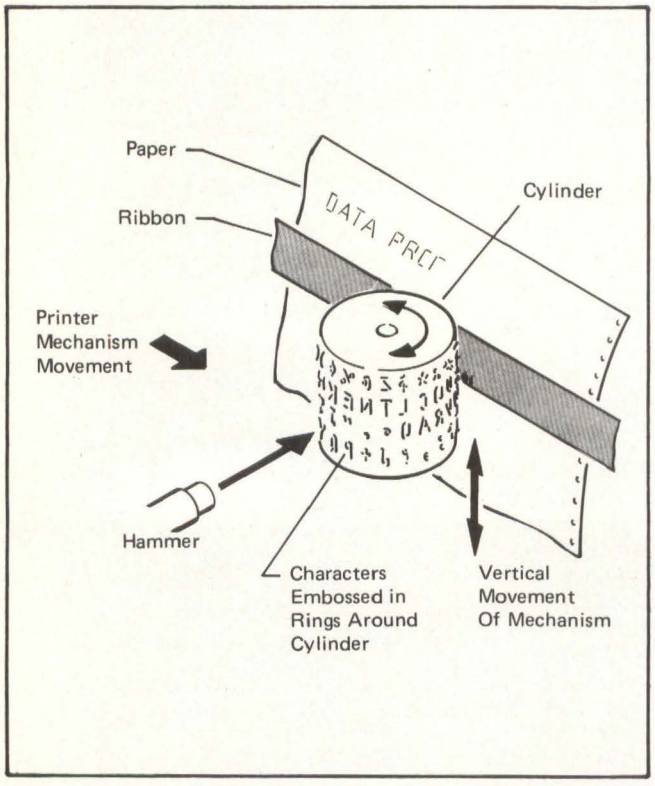


**Fig 2 Part of a cylinder printing mechanism consists of a complete character set embossed in a series of rings around the small cylinder. To print, the mechanism moves the cylinder into position along the paper, rotates it and shifts it vertically, then strikes it with a hammer.**

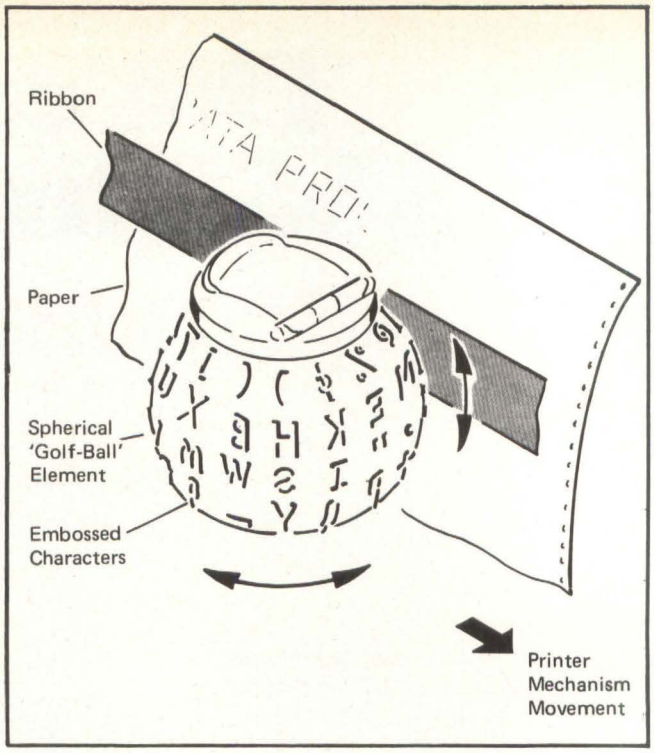


**Fig 3 Golf ball printing mechanism performs its printing functions much as the cylinder mechanism, except that the sphere itself strikes the paper without the aid of a hammer.**

It is difficult to make broad generalizations about the characteristics of each printing mechanism because manufacturers are constantly improving their products, as well as developing new ones, and today's truisms soon become dated. However, we can indentify some general characterteristics of the generic printer types to give you an overview.

**Speed and Cost.** Unsurprisingly, cost increases with required output speed. The faster the printer, the more complex its electromechanical gear, electronics and logic, for which the buyer must pay. Table 2 gives you an idea of typical maximum speeds of various printer types. Printers of these types operate both slower and faster than the speeds shown. But these figures may give you a general feeling of what's available.

**Print Quality.** Whole character rather than matrix printers generally produce better print quality. Matrix printers use an essentially universal font to form characters with dot patterns. Typical matrix printers use a 7 x 5 matrix (7 vertical, 5 horizontal). Other common matrix sizes include 9 x 7, 8 x 5, and 12 x 9. The new Siemens laser printer uses a 24 x 18 matrix. As you would expect, coarser dot patterns do not represent characters as well as whole-character printing. However, the Siemens small dot matrix appears to produce quality roughly equivalent to whole-character printing, according to the manufacturer.

For multi-copy applications, you can argue in favor of the print quality obtainable with matrix printers. Ray Melissa of Printronix, a manufacturer of matrix comb impact printers, points out that all printer manufacturers must make a tradeoff when determining the impact force of their printing hammers, so that print quality will be acceptable for single as well as multiple-copy applications.

However, many printers do not contain an adjustable hammer impact. Manufacturers of whole-character printers must make an additional tradeoff in selecting an impact force which can produce acceptable quality for small and large characters (for the period versus the W, for example). Since matrix printers form characters from a dot pattern rather than whole character, each dot is always the same size in area. Thus, the argument goes, the print quality of the lower carbon copies may be better, and less variable, with matrix than with whole-character printers.

**Multiple Copy Capability.** Only impact printers can generate multiple (carbon) copies. Nonimpact printers generate only one copy at a time. Manufacturers of the fastest nonimpact printers argue that single-copy printing is not a serious disadvantage, because the printer can produce additional copies by running the whole print cycle over again.

**Type of Paper.** Nonimpact printers may require special, more expensive paper than impact printers. In applications that produce printouts on forms (billings, for example), this paper cannot be printed with the required boxes. However, it is possible to employ software to generate the forms during the actual printing process. The user must decide if this makes sense to him.

**Color Printing.** Impact printers can print in more than one color. For example, cylinder, golf ball and daisy wheel machines can, when equipped with two-color ribbons, change color anywhere in the printed text. On the other hand, nonimpact printers can print only one color. A number of instrumentation printers have a two-color capability.

**Graphics.** When a user is interested in generating graphics on his printer, he should use a matrix printer, because it creates the output with a relatively fine dot pattern. Some character printers are also capable of graphics, but the matrix printer by its nature seems more suited to graphics. It should be recognized, however, that printers are machines primarily designed to produce alphanumerics. If a potential user is mainly concerned with generating graphics, he may be better advised to consider one of the many plotters on the market.

**Noise Level.** Impact printers are much noisier than nonimpact machines. The many moving and clattering parts in impact printers generate noise in the process of printing. Nonimpact printers can perform almost silently, because the manner in which they generate characters requires far less mechanical movement. However, manufacturers of impact printers are sensitive to the noise problem and in many cases offer sound-deadening cabinets that reduce the decibel level significantly. The user must first of all determine whether or not silent operation is important in his application. If it is, he may want to consider seriously nonimpact printers. If they are unsuitable for his application for other reasons, then he should look carefully at the sound-reducing options available from the manufacturer.

**Character Registration.** For line-type printing applications, character registration (where each character falls with respect to the line) may be important. The human eye perceives vertical misregistration (the character above and below the line) better than horizontal misregistration. Drum type printers are subject to vertical misregistration. Belt and train type printers are subject to horizontal misregistration. If neatness of copy is important, then belt or train-type printers may be preferable to drum printers.

**Changing Fonts.** Typeface (font) changing is possible in all but the most simple printers. In some impact printers, this operation involves changing the printing element. In other impact printers and in all nonimpact printers, it involves changing the character-generating software. It is becoming increasingly common for manufacturers of matrix printers to offer interchangeable plug-in ICs to change fonts. Among the impact printers, the user can change individual type elements in the train-type printing elements without changing the entire set of characters. You may also replace individual elements, because of wear or to offer another character set.

**Printing Speed and Character Set.** While we are talking about drum, belt and train printing mechanisms, we should note that the size of the character set affects printing speed. The larger the set, the slower the printing speed, because the printing speed in all of these printer types is a function of how rapidly the mechanism can locate accurately the required character for printing on each line. A printer with 96 character locations and 96 characters must run through its full cycle before bringing the same character again into place. A machine with the same 96 character locations but with two identical 48-character sets can locate each character twice as fast.

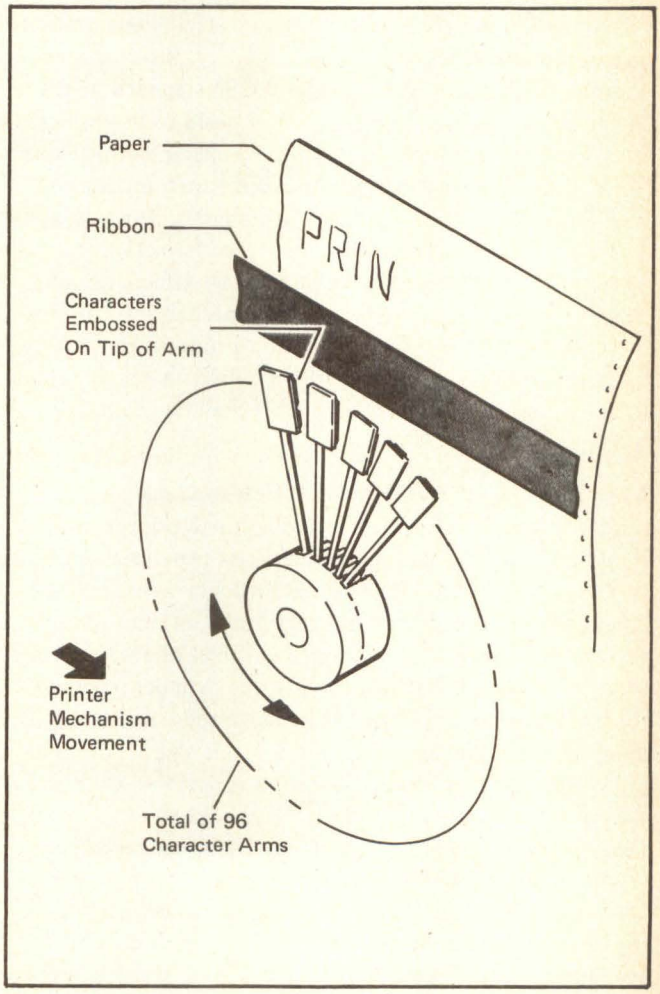


**Fig 4 Daisy wheel printing element consists of a series of "petals" with a single character at each tip. After the wheel moves into position along the paper and rotates to locate the appropriate character, a hammer strikes the petal tip. A variant (not shown), the cup wheel, is shaped like a tulip. It operates on the same principle, but rotates about a vertical rather than horizontal axis.**

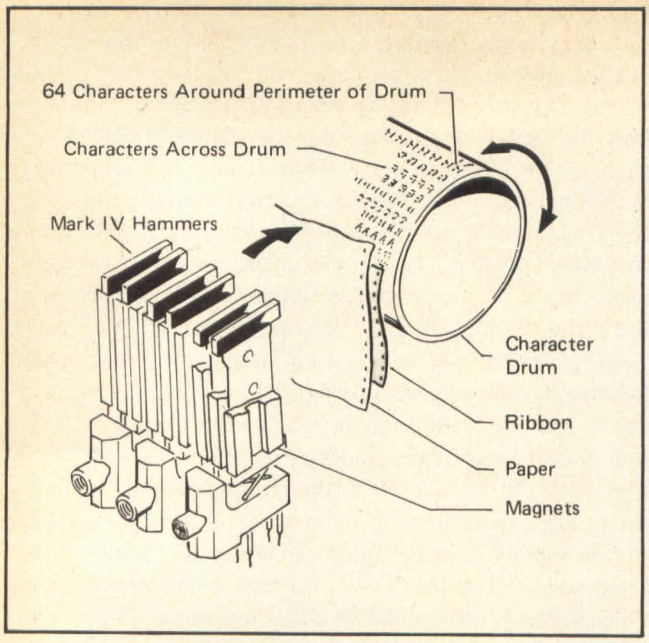


**Fig 5 Embossed with a complete character set for each column to be printed, the drum rotates at constant speed. A hammer for each column fires at the precise time to catch the appropriate character beneath it when it strikes.**

**Character Sets Available.** The number of characters available in printers varies somewhat. Generally, the larger medium-sized printers make available the 96 standard ASCII characters or a subset consisting of 64 or 48 of these characters. Some printers make more than 96 characters available for printing. The smallest printers, of the instrumentation type, typically make available only numerics, symbols, and in some cases, a limited number of alpha characters. As previously noted, the size of the character set affects printing speed in drum, belt and train printing mechanisms. In contrast, the size of the set affects matrix printers very little, be because these machines access the required character formation instructions electronically rather than mechanically.

## Applications

**Cylinder and Golf Ball Printers.** Widely available and relatively low in cost, cylinder and golf ball printers use somewhat older technologies. Teletype Corp. has manufactured more than 500,000 Model 33 machines that contain cylinder print mechanism. Industry still continues to buy and use them. The IBM-developed golf ball printer may be thought of as an updated version of the cylinder machine, for it can operate at somewhat higher speeds. Although many systems use golf ball printers as teletypewriters and in low-speed terminals, the IBM unit is best known as a part of the ubiquitous Selectric™ typewriter.

**Daisy Wheel.** Introduced in 1972 by Diablo, a Xerox subsidiary, and somewhat uncharitably characterized as Xerox's answer to the IBM golf ball printer, daisy wheel printers are used in many of the same applications as cylinder and golf ball printers and a number of others as well. Daisy wheel manufacturers claim higher speed and greater reliability for their machines than for cylinder and golf ball mechanisms. The higher speed of daisy wheel printers cannot be questioned. The first Diablo printer ran at about 30 cps. Improvements (including a metal composite instead of a plastic print wheel) led to higher speeds (55 cps), though Diablo suggests for word processing applications reducing the speed to 40 cps to improve print quality. Qume Corp. began manufacturing daisy wheel printers in 1973 and has just introduced its new "Twintrack" with two printwheels. The new Qume printer's two printing mechanisms operate independently or concurrently. The wheels print in both directions – right to left, left to right – and each is driven by its own microprocessor that accesses a line buffer to determine which printwheel needs to be used for a particular character. The printer operates in two modes, independent or concurrent. During independent operation, the machine may use the two different character sets on the two printwheels and prints at 45 cps. During concurrent operation, the machine uses identical printwheels and operates at 75 cps. Qume has designed this printer for high-speed word processing and for applications requiring large character sets. The company suggests such possible applications as the simultaneous presentation of two different languages on the same sheet of paper with different character sets. The printer can change color in mid-line and two print heads make up to four colors possible.

Diablo claims greater reliability for daisy wheel printers because they contain fewer moving mechanical parts. One estimate lists fewer than eight moving parts, with golf ball printers containing more than 600. The difference exists because daisy wheel printers are electronically controlled, whereas golf ball printers are basically electromechanical machines.

Daisy wheel printer manufacturers also offer graphics capabilities. For example, Zentec Corp. markets a daisy wheel printer that operates in a graphic mode in which its carriage is free and prints outputs with a resolution of 1/48" vertically and 1/120" horizontally.

In summary, 132-column daisy wheel machines operate at relatively slow speeds and can produce multiple copies, multiple colors, high-quality copy and graphics. Possible applications include terminals, word processing, miniperipherals, computer-aided forms filing and processing, and small accounting systems.

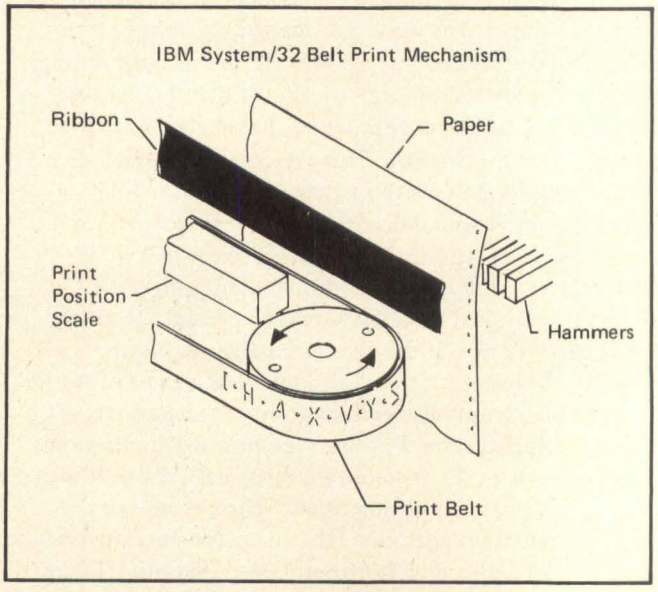


**Fig 6 This printing character belt moves at constant speed. Precisely timed hammers make the impressions. The hammer may strike the belt or the paper.**

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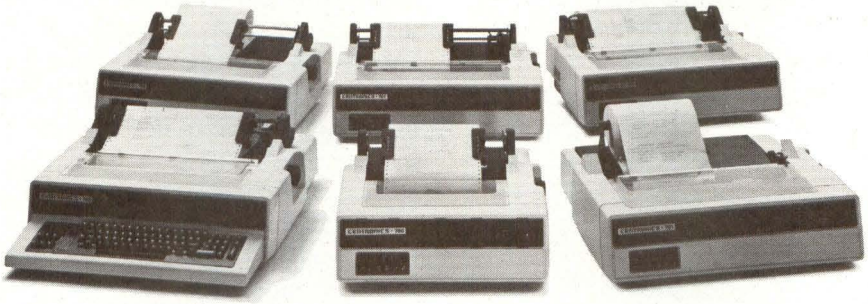

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CIRCLE 21

**Thermal Matrix.** The slowest and least expensive of the non-impact machines, thermal printers require special heat-sensitive paper, which is more expensive than regular paper, and cannot produce multiple copies or color. Users may choose thermal printers for their primary asset, silent operation, which may be overriding in some applications, such as hospitals. They are also widely used in small hand-held calculators where the compactness of their mechanisms and their silent operations are advantageous. In recent years, manufacturers have increased the speed of these printers considerably – from about 30 cps up to 100 cps. They have also modified the printing heads by changing from a single moving head that starts and stops to multiple fixed print wires and continuously moving heads.

The Perkin-Elmer Corp. recently introduced a 100-cps page printer for off-line printing of full 1920 character screens from CRTs, a device they dub the "Pussycat." This fully-buffered, microprocessor-controlled unit interrupts terminal operation for only two seconds while it transfers data to its buffer. Since the printer then produces hard copy off-line, the operator can continue using the terminal. Using only one moving part, the printer makes its copy sideways and offers improved resolution for the 24-line, 80-column page obtained from the CRT. The 9 x 12 character matrices print upper and lower-case characters. The printing mechanism consists of 288 fixed print elements, similar in appearance to some direct electrostatic printing mechanisms.

Dataproducts produces the T-80 thermal printer that operates in a fashion somewhat similar to an impact matrix printer. Rather than lifting the head off the paper after each character impression, the T-80 print head remains in constant contact with the paper. The head heats and cools quickly enough to affect the sensitized paper without stopping its motion, yet the machine prints at 80 cps. Using a 5 x 7 character matrix, the printer is capable of presenting 80 columns of data.

In the small printer category, another printing head variant found in the Facid 5406 thermo matrix printer prints 14 columns and is suitable for such applications as office calculators. Its printing mechanism places dots in selected positions in each matrix line at the same time before the paper advances to the next matrix line; the process continues until complete characters are formed at about a 120-lpm speed.

The Gulton Corp. offers a number of thermal printers and printing mechanisms which are somewhat different. All use a fixed print head, and the only moving part is the paper drive mechanism. The GAP-101M is a 10-column recorder whose print head consists of 101 dual print elements. Either graphics or alphanumerics can be printed in any column, depending upon software. Speed is 150 lpm. The resolution is exceptional for a 2" paper width. The GAP-200M, which uses a Texas Instruments 200-element printing mechanism, provides an even higher resolution and prints on the same paper width at the same speed. Possible applications for these printers include simultaneous alphanumeric-graphic recording from instrumentation, according to the manufacturer. The Gulton AP-20, an alphanumeric printer which uses 5 x 7 characters, prints at 150 lpm, a speed that makes it suitable as a low-cost terminal

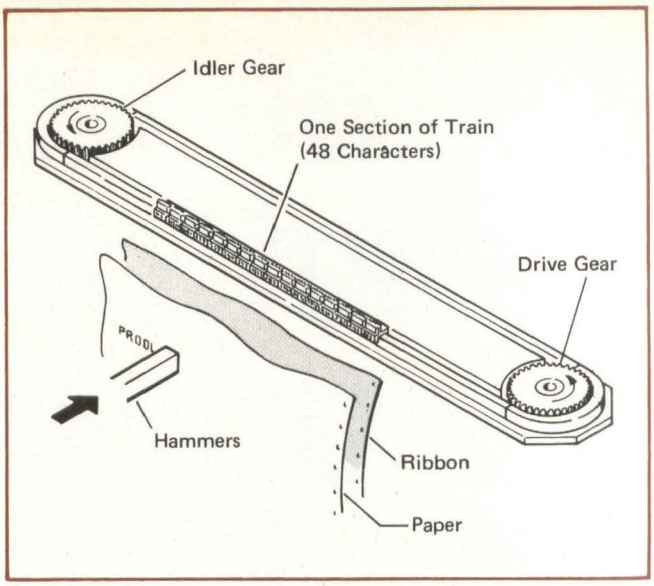


**Fig 7 Similar to a belt machine, the train printer consists of a series of linked character "slugs" moving at constant speed. Precisely timed hammers make the impression striking from behind the paper.**

printer. The Gulton NP-7 and NP-9 machines print 7 columns and form characters in print "segments" instead of dot patterns (like an LED display), which according to the manufacturer results in very clear character representation. Applications include instrumentation and data acquisition.

**Serial Matrix and Matrix Combination.** Almost the fastest single-element printers available, serial matrix machines operate over a slightly lower speed range than matrix comb printers. Manufacturers of matrix comb printers claim that their printing elements move and wear less than serial matrix elements. On the other hand, serial matrix heads are easily replaceable at relatively low cost, even though their individual pins operate over a higher duty cycle and may be expected to wear more quickly. An examination of these two printer types underlines the difficulty in labeling a printer as a serial or line machine. Many serial matrix and matrix comb printers use similar software that enables them to compose whole lines of type prior to printing. In serial matrix printers, this capability drives the printing head "intelligently" – that is, to select the best path for printing forward or backward and to anticipate the best location for the next line of type. Yet, unquestionably a single printing element generates the printed page. Parlance in the industry typically classifies single-element printers as serial printers, though some manufacturers rightly class their single-element matrix printers as line printers. Industry considers matrix comb printers as multi-element machines and classes them as line printers. Yet both types of printers typically operate within a similar speed range and are capable of the same printing functions. This paradox shows the difficulty you can get into when classifying a printer as serial or line and the greater importance of printer performance, rather than labelling. We generally believe line printers to be faster than serial printers and perhaps to posess greater capability. Such prejudice can be misleading.

Although serial and matrix comb printers typically print at about 200 lpm (assuming a 132-column line), the range of

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CIRCLE 22

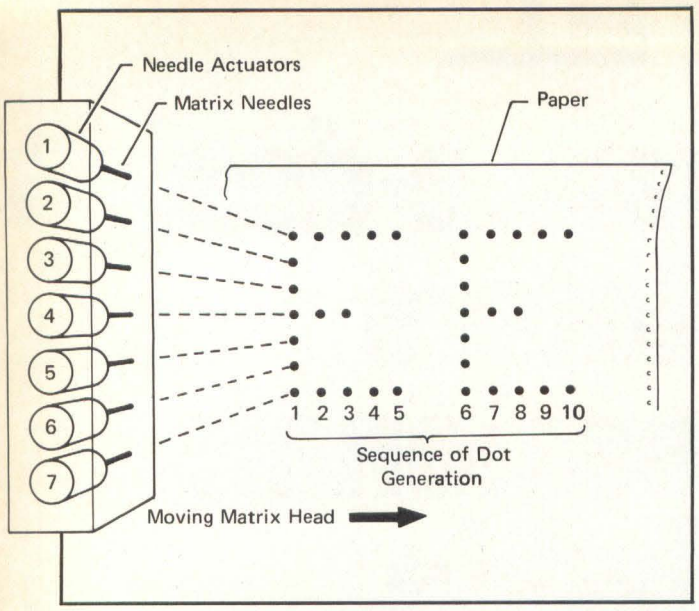


**Fig 8 Serial matrix printers employ a single head that moves across the page. Electromagnetically driven pins in the head form the characters from dot patterns. Each scan of the print head across the page produces one line of print. The number of pins varies, but 7 is most common.**

speeds in machines offered is large – around 60 to 300 lpm. Their wide speed range and type font versatility make these printers useful for many applications.

As previously noted, in some mechanical printers speed is inversely proportional to the size of the character set. This limitation does not hold for matrix machines, because character set formation instructions generally come from random-access memory and speed of access is independent of the size of the character set. So, at least in theory, it is possible to make available for printing as many characters (Arabic, Hebrew, Chinese, Greek or any other alphabet) as there is space in the electronics cabinets for circuit cards containing character formation instructions. Thus, designers usually favor matrix printers for applications that require multiple or extremely large character sets, or which require the capability to change character sets by plugging in cards. However, not all matrix printers can change fonts to the same degree.

Matrix printers can produce multiple copies in one color, with fairly good definition, at medium speed. Character registration is good, in comparison with faster whole-character printers; type fonts are interchangeable, and many use these machines to print graphics. In fact, many users employ them as ideal "general-purpose" printers in the sense that they offer a strong capability for presenting alphanumerics and graphics. They are generally less expensive than faster whole-character printers, though more expensive than slower whole-character printers. They are also, as a class, less noisy than faster whole-character printers. They produce sound at a higher frequency (they generate a character by fast multiple impacts instead of a single impact.) Insulation can dampen this high-frequency sound more readily than the lower frequencies produced by whole-character printers. Again, however, the noise output of particular printers varies widely, regardless of class, and the designer must examine specific products to determine whether or not the noise level can be a problem.

Printronix presently markets a 300-lpm matrix comb printer with 44 printing elements. Because of the design of the printing mechanism and the way it applies dots to the paper, the manufacturer refers to its printing method as "raster matrix." Up to 160 characters are available for printing with a 7 x 9 matrix pattern. Additional fonts are available via plug-in microcards. Printronix has also come out with a smaller 150-lpm printer which the manufacturer classes as a printer-plotter. Because Model 150 can place dots anywhere on the paper, it can generate drawings, graphs, bar codes, large block characters (and pinups, carefully placed behind a door in one of the offices). Since the dots in the Printronix matrix overlap slightly, the character edges look smooth and give the appearance of whole characters.

Okidata markets a 125-lpm matrix comb printer which uses 22 printing elements, with 96 standard characters formed by a 5 x 9 matrix. Emphasizing the flexibility of its fonts, this manufacturer offers 12 different types available for printing on command. This availability demonstrates the point made earlier about the inherent flexibility of matrix printing for changing typefaces. This printer is designed primarily for heavy-duty printing and for applications requiring multiple copies. Okidata also markets for CRT hard-copy applications an 80-column serial matrix printer that prints at 110 cps.

While the matrix comb machine generally prints up to 132 columns, serial matrix printers come in this size and in smaller sizes. The fairly typical full-size Dataproducts M-200 printer operates at 125 lpm and uses a single sweeping head to produce a 7 x 7 dot matrix for generating a 128 character set. The head contains twice the number of printing elements normally used (14), to reduce the duty cycle of each element and thereby, the manufacturer claims, increase head life. In many serial matrix printers, speed depends upon the number of columns printed per line. The M-200, for example, has a rated speed of 125 lpm for a 132-column line, which increases to 200 lpm for 80-character lines and to 300 lpm for 40-character lines. Possible applications for the M-200 include printing for small business computers, distributed data processing and dedicated termi-

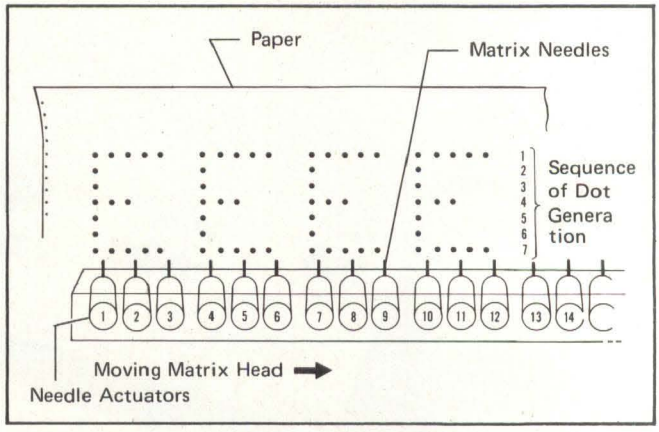


**Fig 9 Matrix comb printers contain several single-element heads housing pins driven by electromagnets. The comb moves back and forth. Each oscillating motion produces a portion of every character in every column. The number of movements required to produce a complete line depends upon character vertical resolution.**

nal systems. Some of these printers can print on preprinted forms.

Another 132-column machine, of somewhat slower speed (60 lpm), is Texas Instruments' Model 810 , which was introduced early this year. The printer uses a 9 x 7 matrix for generating a 64-character set. The manufacturer emphasizes its thick forms printing capability and claims it capable of producing up to six high-quality copies. Operators can feed preprinted forms into the printer from the rear to enter information on such preprinted forms as invoices, checks and purchase orders.

Centronics recently introduced two serial matrix printers, the 306SC and the 306TP. The 306SC generates alphanumerics as well as symbols and horizontal/vertical bars and can print characters ranging in height from 1/10" to newspaper headline size. Paper width is 8", and the operator can select the number of characters to be printed within this width up to the most condensed printing mode, 16.5 characters per line. The similar-appearing 306TP was designed for printing thick tickets with five or more high-quality copies. Applications of this printer include airline or other ticket printing, invoicing, inventory control and traffic management, for which thick forms and/or high quantity are required.

Other small, specialized serial matrix printers, the AH Series produced by Extel Corp., are compact, 30-cps units that use a 5 x 7 matrix head to print on 8.5" paper lines of selectable length, ranging between 50 and 80 characters. Up to 128 characters are available for printing. The printer manufacturer has aimed his product primarily at the teleprinter market.

Teletype has just introduced its Model 43 teleprinter, which is compatible with Model 33 interfaces, and which uses a 9-wire serial matrix printing mechanism to produce 7 x 4 matrix characters across 132 columns. Speed is selectable at 10 or 30 cps, with the higher speed considerably faster than that of the older Model 33, which used a cylinder printing mechanism. Model 43 is priced comparably to the Model 33 and the manufacturer sees it being used in terminal and hobby applications as well as in teleprinting.

Several manufacturers produce serial matrix printers in smaller sizes than the 132 or 80-line machines already discussed. Printers in this size range are many in number and vary considerably in configuration, particularly in terms of interface requirements. We shall give a few examples, but if you are interested in this size, you should examine the list of manufacturers elsewhere in this article and write away for more information.

Amperex offers several small serial matrix printers for such uses as desktop computers, instrumentation, inventory control, and label and ticket printing. Model 60SA prints 20 columns, uses 2¼" wide paper, contains a 5 x 7 matrix head, and operates at about 60 lpm. The company also produces a 40-column printer, the DX486 , which operates on 12 volts and which is useful in similar applications to the 20-column models. Both printers are compact and portable and possess many of the capabilities of larger machines.

A number of smaller printers for the microcomputer user are coming onto the market. Datel offers a 40-column serial matrix printer, the AIP-40 , which is low enough in price and high enough in capabilities to interest many computer hobbyists. The printer uses a 5 x 7 matrix, operates at 50 cps, and can print standard ASCII characters in normal and double width.

**Drum, Belt and Train Printers.** All of the printers of the drum, belt and train type are considered line printers. These are the fastest whole-character printers, considerably faster than matrix printers, but slower than the electrostatic and inkjet printers. The basic technology has been around for many years. Actually, line printers of this type fall into

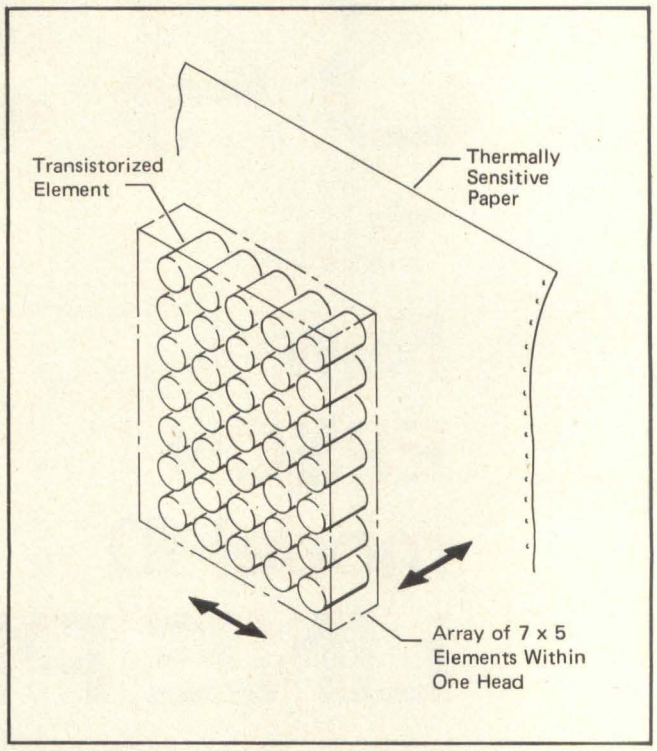


**Fig 10 A single thermal matrix head moves across the paper and stops momentarily at each character position. The matrix head elements are transistors that when switched on produce heat. The hot spots force a heat sensitive dye in the paper to change color and create a series of dots.**

two classes, those that use a metal drum, and those that use a moving belt or train.

Although belt and train-type printers come in many shapes they all operate on the same basic principle – they provide a continuously-moving set of characters which is presented before the paper during the moment the stepping motor in the paper drive mechanism stops paper movement, and during this moment a set of hammers impacts the appropriate character for each print column. As noted earlier, drum printers may produce imperfect vertical character registration; belt and train printers, imperfect horizontal registration.

Belt printers differ from train printers in one important aspect, which may matter to a potential user. Belts contain one complete set of characters, none of which can be changed. Trains are made up of linked character elements (sort of like the individual treads of a tank track) and individual elements can be changed, because of wear or to alter a character set.

The primary application for line printers is high-speed data output on multiple copies, when necessary. Speeds range from under 75 lpm to over 2000 lpm. Almost all of

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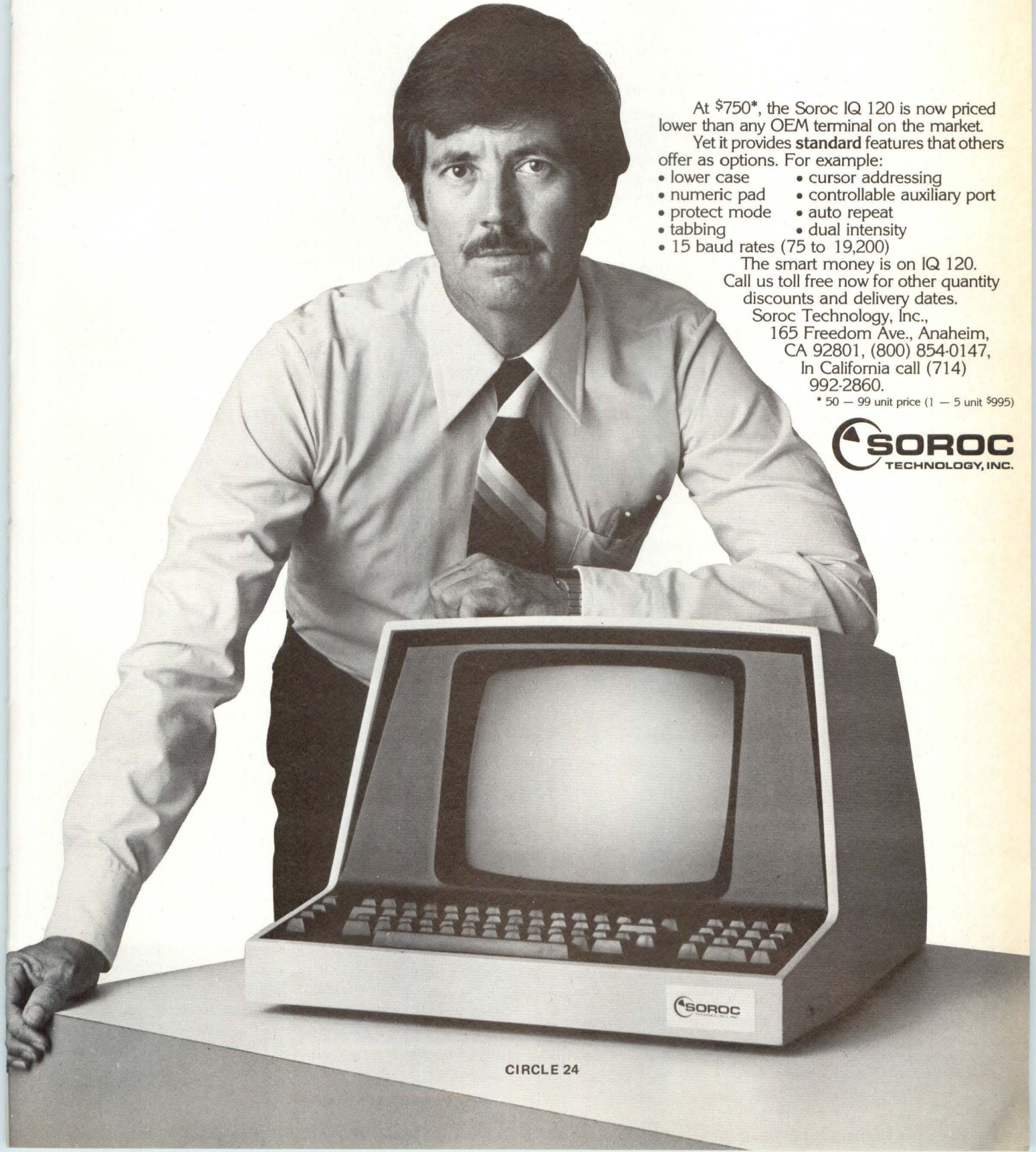


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CIRCLE 24

the printers intended for this application can produce 132-column copy.

Drum technology has not changed much in recent years. Manufacturers have made most of their innovations in train printers. We probably can expect further innovations and higher speeds in the years to come.

Burroughs markets a number of drum-type line printers in their B-9246 and B-9243 series. Speeds range from 925 to 1800 lpm with a 64-character set.

Dataproducts offers its 2200 series of drum line printers, with speeds ranging from 300 to 1800 lpm for a 132 or 136-character set, depending upon model.

Data 100 markets a line of belt printers with printing speeds of 62.5 to 600 lpm for a 48-character set. The smaller printers are for desk-top use; units in the speed range above 250 lpm are mounted in floor cabinets. All print 132 columns. The 600 lpm unit, with replaceable character cartridges, a variation of the usual belt mechanism, enables the user to change character sets quickly. The slower printers find applications in communications and minicomputer systems.

Burroughs offers several printers with train type printing mechanisms. These print between 160 and 1100 lpm, with a 48-character set.

Control Data's 9380 Series band printers, probably fairly typical of the type, use a 64-character set, print at between 300 and 900 lpm.

One unusually small-size line printer, Epson Model 10, uses a 64-character set belt to print 80 columns at 150 lpm. It's a low-priced machine intended primarily for terminals, minicomputers and microcomputers.

The number of belt and train printers is so large that we cannot treat them fully here. We advise the reader to examine the listings of manufacturers at the end of this article and ask for further information.

**Electrostatic Printers.** Several manufacturers are producing electrostatic printers, in sizes ranging from small 12-column models which are typically used in small calculators, to full, 132-column models, which are used in line printing and printing/plotting. As noted earlier, electrostatic printers come in two types, direct and indirect. Most electrostatic printers are of the direct type. Indirect electrostatic printers use a laser and are, as a class, large in size, very fast, and expensive.

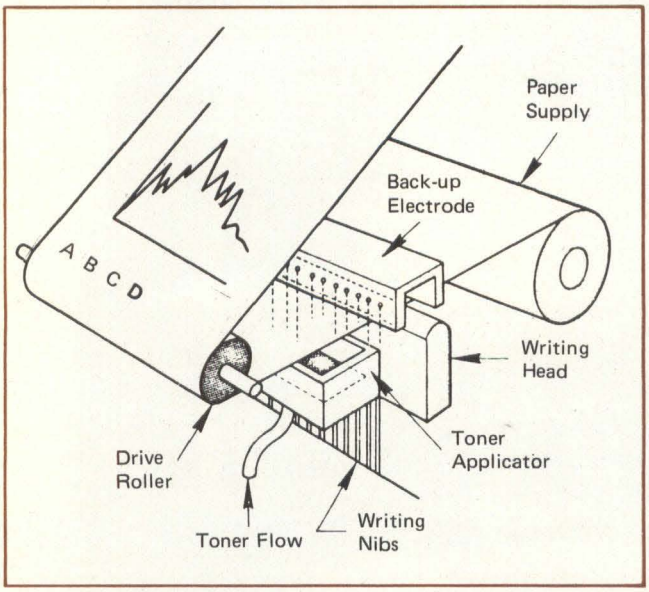


**Fig 11 Direct electrostatic printers use a specially-coated paper passing over an array of styli or nibs. Each stylus is charged to produce the required output. The paper then passes through a toner bath from which the charged areas attract ink particles.**

High speed gives electrostatic printers an edge for alphanumeric and graphic applications. The cost of special papers may make them impractical for many line printing applications. They cannot produce multiple copies; that inability automatically rules them out of many line printing applications. Unusual applications that require special fonts and/or plotting make their use very attractive. Very small printers of this type are relatively cheap and may find application for small calculators and minicomputers/microcomputers.

Versatec, Varian and Gould manufacture direct electrostatic machines. Honeywell manufactures an 18,000 lpm printer, which is considerably faster than the typical direct electrostatic printer. Direct electrostatic processing is fairly straightforward and the technology has been around for several years. Because the indirect electrostatic (laser) printers are still relatively new and have suffered some maintainability problems, many people in the industry believe that the direct electrostatic process will continue to dominate the high-speed printer market.

Let's examine some medium size direct electrostatic printers to discover how technology is being employed in some special applications.

For example, Houston Instrument manufactures the 8200 Series of printers, which it classes as line printers. They are available in a 132- or 80-column format, with printing speeds of 1400 or 2400 lpm, respectively. The maker says that the printers are best suited to software development and high-speed data logging, where speedy and quiet operation provide the benefits that more than balance the lack of a multiple-copy capability. These printers use a 7 x 9 overlapped matrix and can print up to 96 characters.

In another example, a low-priced, direct electrostatic printer, Micro-1, was jointly developed by Centronics and Sharp of Japan, and is aimed mainly at home, hobby and microprocessor markets. The manufacturer also states that other possible applications include producing hard copy from CRT terminals, message printing, industrial instrumentation, microcomputer development printouts, and data logging in emergency vehicles, call boxes and taxicabs. It prints 20, 40 or 80 software-selectable columns at 180 lpm with a 5 x 8 matrix for a 64- or 96-character set.

The Axiom Corp. recently introduced another small machine, EX-800, an 80-column printer which operates at 160 cps and is aimed at a similar market to the Centronics Micro-1.

In still another example, but in the small printer area, Hycom Corp. manufactures a series of 12, 16, 21, 34 or 48 columns which print by electrostatic discharge from a moving head (like many thermal printers). The moving head, the manufacturer states, allows these machines to plot analog graphical data for sequence-of-events recording. The head uses a 5 x 7 printing matrix; when equipped with 8 or more electrodes, the head can print upper and lower case characters or plot analog data on eight separate chan-

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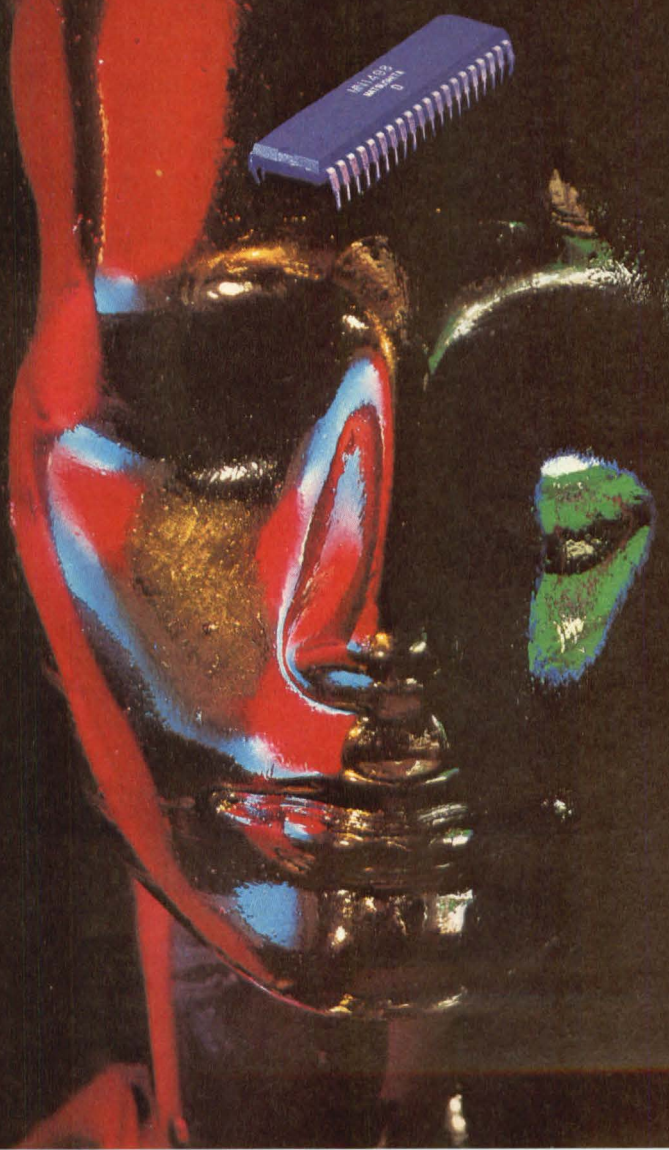
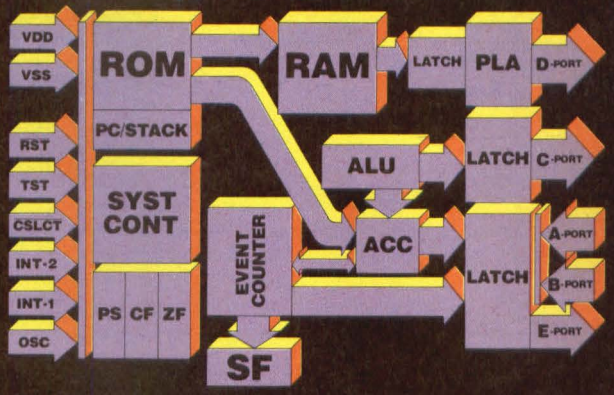


**Block diagram of MN1400 with on-chip, 1024x8-bit ROM.**

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| Instruction Cycle Time | | 10μs | 10μs | 10μs | 10μs |
| Instruction Set | | 75 | 57 | 68 | 75 |
| Instruction Memory | Instruction ROM | Internal 1024 x 8 bits (8192 bits) | Internal 768 x 8 bits (6144 bits) | External 1024 x 8 bits (8192 bits) | External 2048 x 8 bits (16384 bits) |
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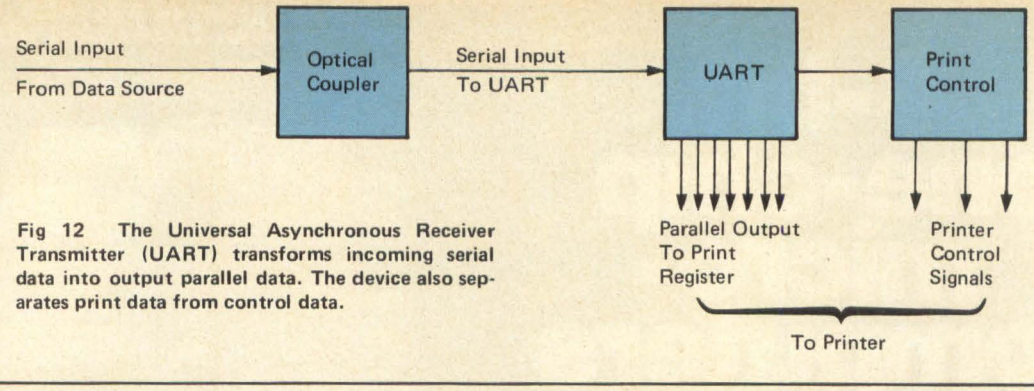



**Fig 12 The Universal Asynchronous Receiver Transmitter (UART) transforms incoming serial data into output parallel data. The device also separates print data from control data.**

nels. These printers find applications in calculators and other similar devices.

Xerox and IBM have been selling indirect electrostatic printers for the last few years. Xerox already markets its 4000-lpm 1200 system, and has installed several systems in industrial plants. IBM is in the process of developing a series of high-speed laser printers. According to some industry spokesmen, maintenance problems have plagued laser printers, but the technology is fairly new and it is to be expected. Siemens Corp. has jsut entered the field with its ND 2 printer, which operates at a maximum printing rate of 21,000 lpm and a non-stop printing rate of 8800 lpm. It employs a very large matrix (18 x 24) and generates characters that closely resemble whole characters, according to the manufacturer. The maker makes 128 standard characters available, with an additional 127 as an option. The manufacturer considers this printer to be applicable to the need for large volumes of hard copy in a short period of time – for example, monthly billings that do not require multiple copies. Another possible application is in the production of individual copies of classified or sensitive reports.

**Ink Jet.** Although ink jet printers have gone through ups and downs in popularity, they now seem to be rising again. A. B. Dick and Teletype began manufacturing them a few years ago and then stopped. Electro-Print developed an 8000-lpm model which was never produced in the United States, but a Japanese licensee manufactured several machines for use in Japan. A.B. Dick modified its technology, for marking containers, and has built a strong business in this field. IBM is currently doing considerable work in the area and is expected to market a product line in the next few years. Some of these printers are capable of operation at speeds up to 20,000 lpm, but industry has not begun to use them widely, according to one spokesman.

Siemens recently offered its PT-80 printer terminal with an ink jet printing capability. (The terminal is also available with an impact serial matrix printing head.) The ink jet head increases printing speed from a maximum of 90 cps to 300 cps. There are no moving parts in the head. The ink is indelible, waterproof and instant drying. The printer stores enough ink for $5 \times 10^6$ characters (the equivalent of five thick novels).

## Interfacing

**Terms, Standards, Connectors.** Printers are interfaced with their signal sources in serial or parallel fashion. Serial interfacing requires two data lines, and parallel interfacing requires seven or, in some cases, eight data lines. Both data and control information are sent across these lines in predetermined formats, according to standardized codes, the most common being the ASCII (American Standard Code for Information Interchange). IBM has developed its own code, referred to as EBCDIC, which is an 8-bit code. ASCII is a 7-bit code. The printer requires additional wires if it must communicate with the CPU, as in terminal installations.

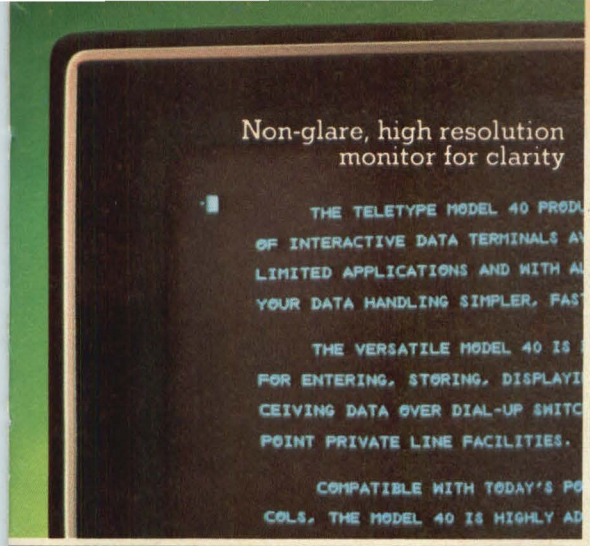
Parallel interfacing allows much more rapid data transfer. It is most commonly used where the distance between the CPU and printer is fairly short and a high data transfer rate is required. Larger printers typically use parallel interfacing.

Serial interfacing, for reasons that we will soon explain, is common when the distance between the data source and the printer is large, or when the data must be received in serial format via modem. Serial data transfer which occurs at speeds generally below 9600 baud permits a maximum printing rate of about 1000 cps. Parallel data transfer can occur at rates up to $5 \times 10^8$ cps – a considerable difference, to say the least.

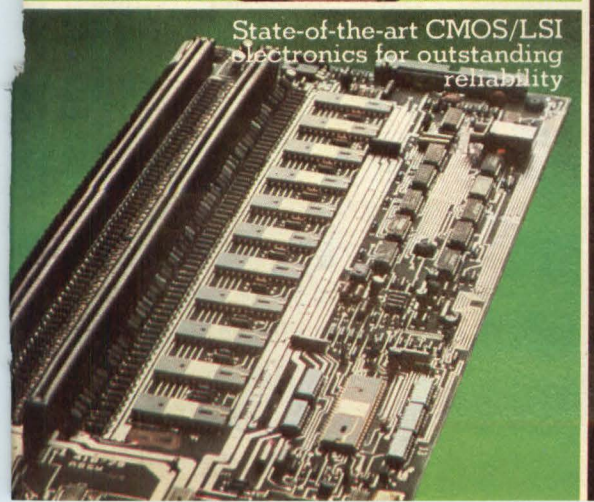
Parallel interafcing almost always uses TTL voltage levels (0 to + 5V). Serial interfacing commonly uses voltage levels (according to the RS-232 code) of +3 to +12V and -3 to -12V; or uses a so-called current loop, in which the current typically varies between 0 and 20mA. Current loop connection finds its widest application when the distance between the printer and its data source is fairly great and a voltage drop is expected across the line. Variations in current level are accurately transferred to the printer, regardless of voltage. Current loops often connect printers to remote instruments. In addition to the 20mA standard, current loop levels such as 60mA can be used.

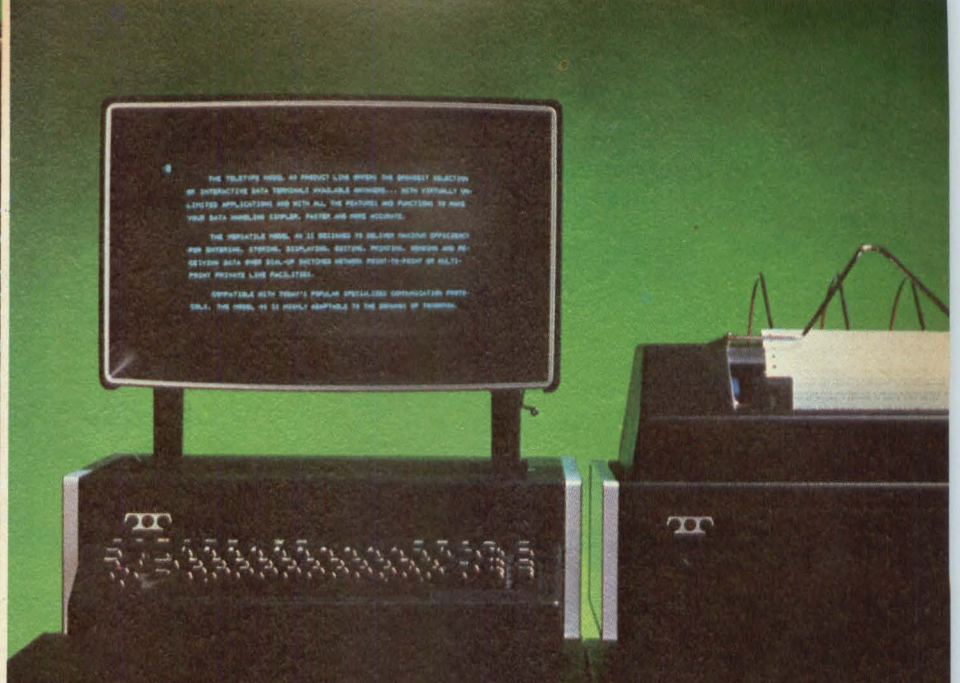
Regardless of whether the system uses parallel or serial interfacing, industry employs fairly standardized connector, particularly for medium and larger printers. A common serial connector is the 25-pin Amphenol unit. Industry has widely adopted Centronics or Dataproducts connectors for parallel interfacing, because of their wide use. No industry-wide standard actually exists. Hence, the user can find other types of parallel connectors.

After the printer receives the incoming signals, the electronics must transform them into usable information. With serial data, an IC chip called a UART (Universal Asynchronous Receiver Transmitter) most commonly performs these functions. The UART takes incoming serial data, separates print data from control data, and performs a serial-parallel





# THE MODEL 40 IS SO GOOD, NOTHING EVEN COMES CLOSE. AND WE CAN PROVE IT, COMPONENT BY COMPONENT.

We're convinced the Teletype® model 40 product line matches—if not exceeds—any data terminal system on the market today. Because on a cost/performance basis, nothing even comes close.

The 40 printer, using a unique design, is incredibly dependable. And its CMOS/LSI drive electronics are so advanced and compact, they fit inside the printer itself on a single circuit card.

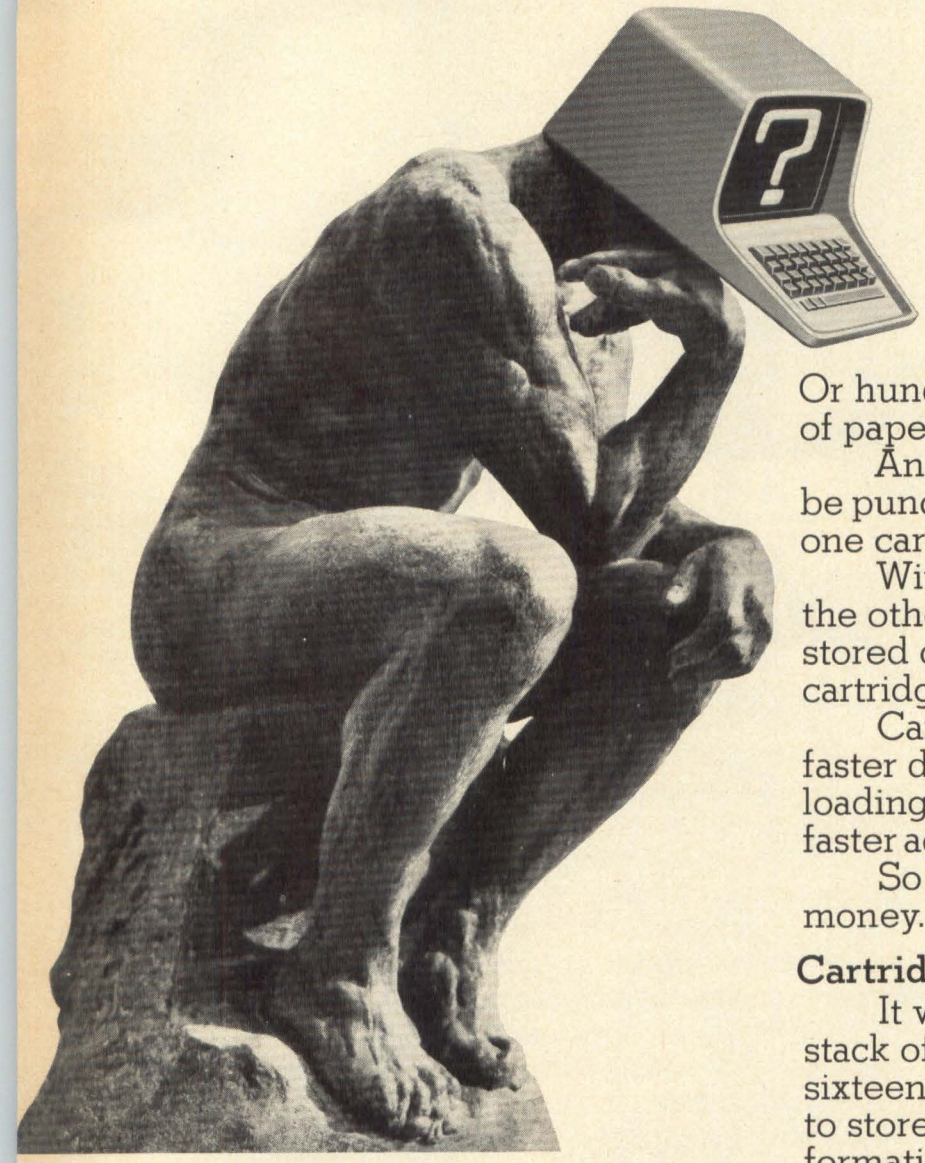
Our keyboard is anything but ordinary, too. Naturally, all controls are grouped according to function. But more importantly, the entire unit is human engineered to provide the most in throughput. Not only do the keys impart a typewriter feel, they're also contoured to the shape of the operators' fingers.

We admit we could have cut corners when we designed and built our display tube. But good enough wouldn't have been good enough. So we used a glare reducing screen. Even the display type is specially designed for legibility, with a flicker-free refresh rate of 60 times/second. Character separation and clarity are insured by a large 7 x 9 dot matrix. And the whole unit tilts through 20° for the best viewing angle.

As good as the individual components are, added together they put the model 40 product line in a class by itself. For more information, write or call: Teletype, 5555 Touhy Ave., Skokie, IL 60076. Phone 312/982-2000.

TELETYPE

# Is your computer smart enough



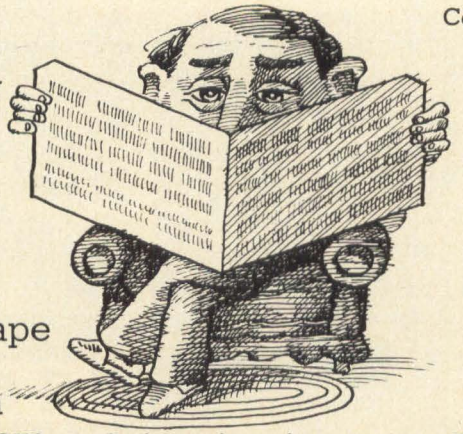

A 3M peripheral drive which uses 3M data cartridges is better than any drive which uses punched cards or paper tape.

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

It's simple logic.

**Cartridges are faster than cards.**

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



*Cards must be read one at a time.*

Or hundreds of feet of paper tape.

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

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

Cartridges offer much faster data storage, program loading, data transfer and faster access to the computer.

So you save time and money.

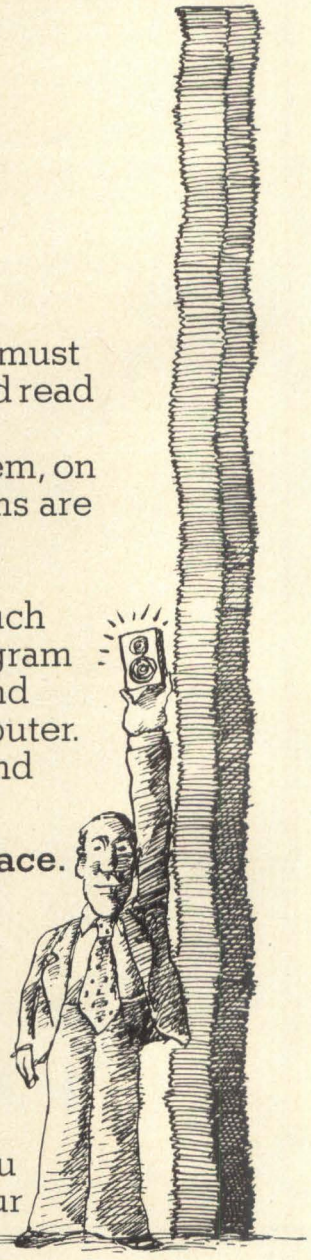
**Cartridges take less space.**

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

With cartridges, you can store all of your programs in a fraction of the space you'd need for cards or paper tape.

Your filing system is simplified and overhead is greatly reduced.

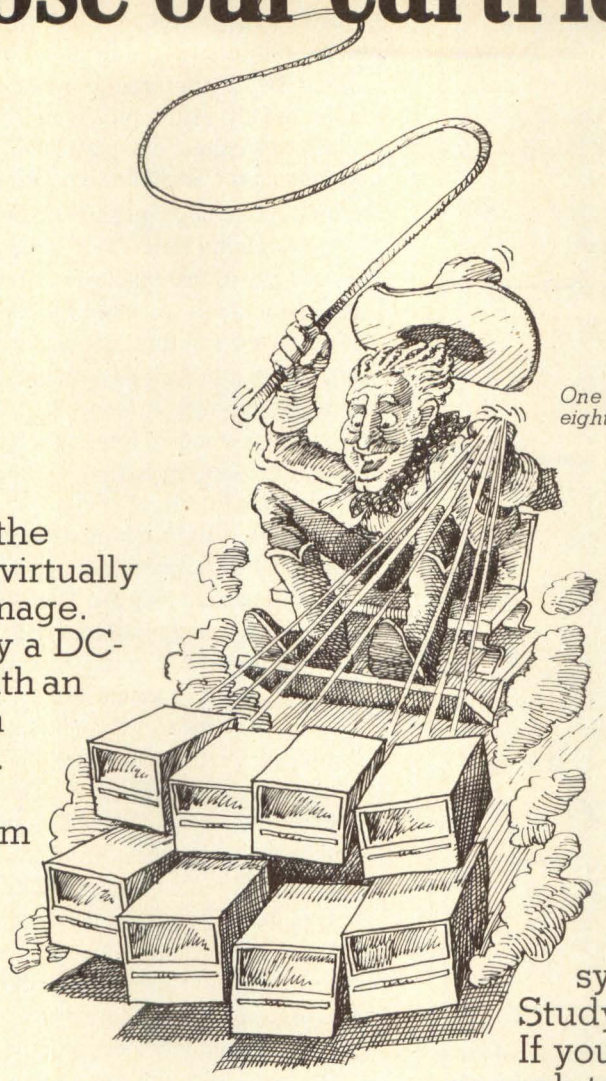
*One DC-300A cartridge equals almost 16 feet of cards.*



**Cartridges won't fold, spindle or mutilate.**

Unlike paper cards, you need never touch the media. It's well

# to choose our cartridge drive?



*One formatter can control eight drives at once.*

protected inside the cartridges, so it's virtually impossible to damage.

You can carry a DC-100A cartridge with an entire program in your shirt pocket.

Even if you drop it, the program will survive unscathed.

Remember that the next time you drop a stack of cards.

**Don't take our word for it. Ask your computer.**

If you'll send us the coupon, we'll send you the specifications for all three of our drive systems.

Ask your computer to compare them with any other type of drive system.

We'll bet your computer will prefer ours.

Maybe it'll choose our famous DCD-3 drive. It's people-proof, jam-proof and wear-resistant.

Or maybe your computer will decide upon our DCS-3000 series, an ANSI-formatted system that allows one formatter to control up to eight drives.

The DCS-3000 is extremely easy to integrate into your system. Only one cable to the user's logic is required.

But if you require compact size, your computer will probably choose our unique DCD-1. It offers many of the features of our bigger systems, yet it will fit inside a five-inch cube.

The cartridge alone measures just 2.4 x 3.2 x .5 inches.

**See for yourself.**

Send us the coupon. There's much more we can tell you about our drive systems.

Study the information carefully. If your computer isn't smart enough to choose our drive systems, we'll bet you will be.

Send me more information.

Name _____ Title _____

Firm _____ Address _____

City _____ State _____

Zip _____

Phone _____

3M COMPANY

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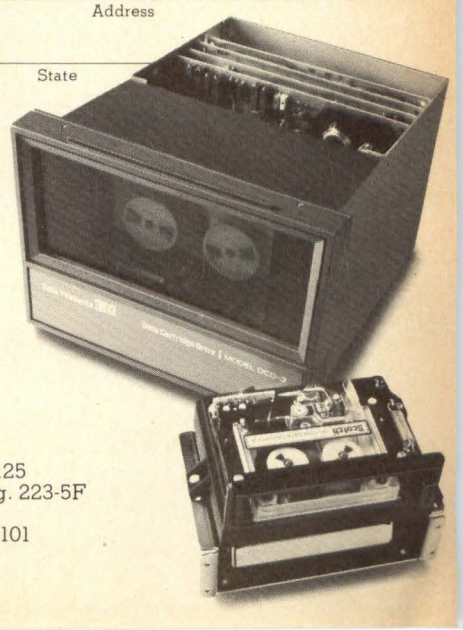


CIRCLE 16

conversion. It then feeds parallel data and control information to the printer. The UART also performs the reverse function – transforming parallel data to serial – for transmission, if the data source requires information from the printer. If a current loop is used, optical coupling is often employed to convert the current or no-current condition to a TTL level, prior to entry into the UART. The diagram below shows the optical coupling and UART functions in a serial interface in very simplified form.

Serial data may be transmitted synchronously or asynchronously. Asynchronous transmission is most common,

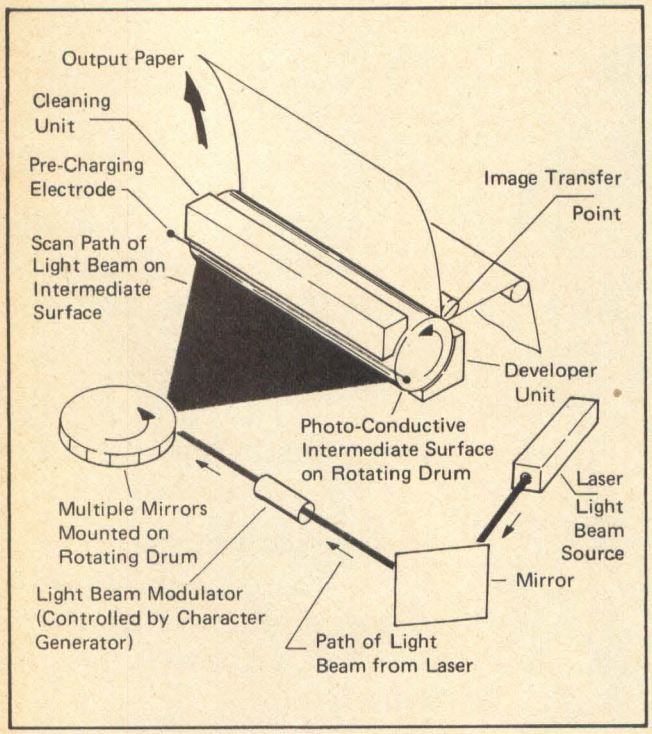



**Fig 13 Indirect electrostatic (laser) printers need no special paper. A modulated laser light beam, aimed at an intermediate surface (drum), forms dot matrix characters photoelectrically. The drum is then toned with ink powder and transfers the ink to the paper. Heat fuses the ink to the paper.**

because the data flow can start and stop without any special fillers or control codes. Synchronous transmission requires a continuous flow of data. If the data flow stops momentarily, special filler data must be supplied to keep the receiver from becoming confused. Synchronous transmission is most common for the prearranged transfer of data from a transmitter to a receiver – for example, when two computers are talking to each other. For the most part, as stated earlier, printers operate in the asynchronous mode.

**Interfacing the Large Printer.** Let's define large printers as 80- and 132-column machines, the type most commonly used in commercial applictions. Standardized connectors usually interface these printers to the signal sources, though in the majority of cases the customer exercises certain options about how the connection is made. A few examples: The Printronix 300 line printer comes standard with ASCII parallel input, TTL logic levels, compatible with Dataproducts or Centronics plug. Optional is an RS-232 serial interface, supplied by the manufacturer. The Texas Instruments Model 810 printer comes standard with a serial EIA RS-232-C 25-pin connector. Alternatively, it can be supplied with 20 mA current loop interface using a 9-pin Cannon type DEC-9S connector, or with a Centronics compatible parallel interface. The Digital Equipment DECprinter™ comes standard with a parallel interface and uses its own 40-pin Berg connector. Serial interface is available as an option. Other printers in this size class are similarly interfaced, usually with standard connectors, sometimes with connectors unique to a particular manufacturer.

**Interfacing the Small Printer.** Often more difficult to interface than larger printers, many smaller printers (the 7- to 48-column variety) are designed for the OEM market, for sale to manufacturers who provide their own electronics for use in special-purpose instrumentation. A great diversity exists in this class of printers and with it a wide variation in interfacing requirements. Some examples: Datadyne supplies its Model 722-247G high-speed serial printer with standard interfaces for either RS-232-C or 20 mA current loop operation. Optional are other voltage or current loop interface, available from the manufacturer. These printers use a 6-bit data input and the data input code varies with model number. Thus connection is not made with simple plug-ins. The user must take into account the data codes and input requirements of the printer. To potential users the manufacturer supplies specifications, describing input requirements.

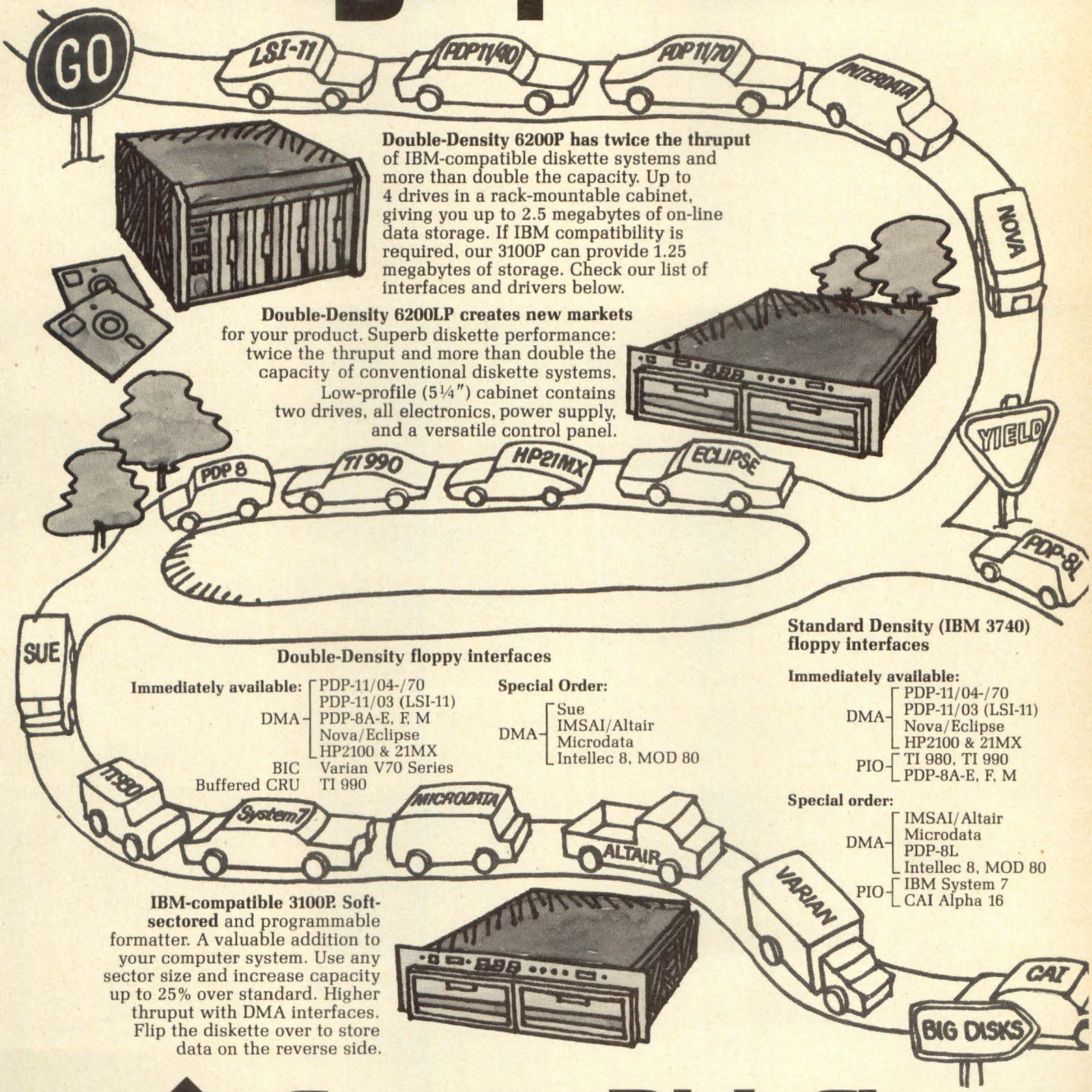
In the May issue of this magazine, Peter Engstrom dealt in part with interfacing of what could be called the "stripped-down" small printer (see "Cheap Hardcopy For μP-Based Systems," **Digital Design**, May, 1977). Sodeco (Landis & Gyr) markets a line of 15- and 21-column small printers designed for sale to OEMs for use in such applications as instrumentation, data logging, weighing systems and automated bank terminals. They are fairly characteristic of a class of small printers that Engstrom refers to as low-cost impact line printers and which are generally shipped without any electronics. They are equipped with the required solenoids, but without control circuitry, and so the user must provide his own. According to Engstrom, typically such printers are equipped with a connector for attaching external logic to the solenoids. The manufacturer provides specifications that tell the user what inputs are required to drive the printer, and suggested circuits for accomplishing the required functions. But it is up to the user to provide the printer with "smarts." According to the manufacturer, interfacing is accomplished, via any number of readily available microprocessors. The manufacturer has considerable experience in providing interfacing information to the user, and so you are not on your own; the manufacturer can provide suggested circuits and even recommend microprocessor chips.

Perhaps at the other extreme of interfacing complexity are such small printers as the 40-column Datel machine, designed essentially as a scaled-down version of a larger machine, for use as a teleprinter. The manufacturer provides standard parallel or serial interfaces which are of the plug-in variety.

## How Printers Are Likely to Change

We asked people in the industry who manufacture printers what they saw in the future, as we approach 1980. We noted some agreement among the respondents. They agreed

# AED floppies solve heavy traffic storage problems




**Double-Density 6200P has twice the thruput** of IBM-compatible diskette systems and more than double the capacity. Up to 4 drives in a rack-mountable cabinet, giving you up to 2.5 megabytes of on-line data storage. If IBM compatibility is required, our 3100P can provide 1.25 megabytes of storage. Check our list of interfaces and drivers below.

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**Double-Density floppy interfaces**

**Immediately available:**
- DMA: PDP-11/04-/70; PDP-11/03 (LSI-11); PDP-8A-E, F, M; Nova/Eclipse; HP2100 & 21MX
- BIC: Varian V70 Series
- Buffered CRU: TI 990

**Special Order:**
- DMA: Sue; IMSAI/Altair; Microdata; Intellec 8, MOD 80

**Standard Density (IBM 3740) floppy interfaces**

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CIRCLE 28

# THE WORLD'S A SOMEWHAT LESS

In the spring of 1962, Dataproducts began building printers.

And a reputation.

Today, we design and build printers (in the United States and Europe) for OEM's and their end-users the world over.

We are dedicated to producing the finest printers money can buy.

We will never copy.

We will never offer you a printer whose only virtue is low price.

We will never compromise with quality. And neither should you.

## Everything from 80 CPS to 2000 LPM

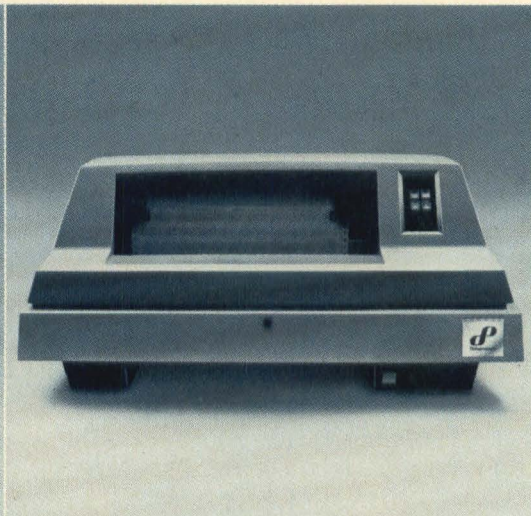
We have a printer for every purpose.

We make fast printers and slow ones; big printers and little ones.

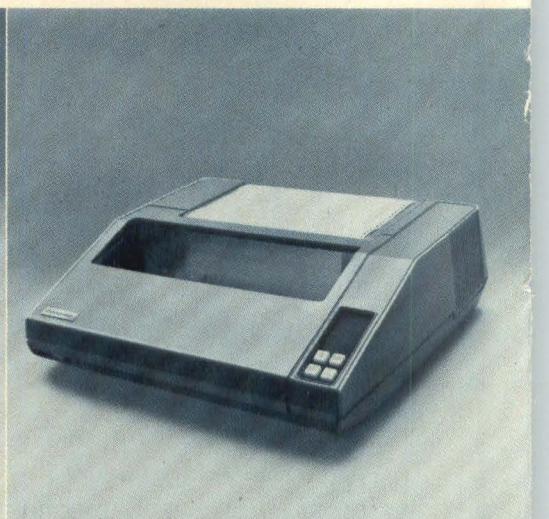
We make printers for high-volume EDP, for small business systems, for message terminals, and machine readable applications.

We make impact and nonimpact printers;

T-80 THERMAL PRINTER—80 CPS



B-180 BAND PRINTER—180 LPM



M-200 MATRIX PRINTER—200 LPM

2290 LINE PRINTER—900 LPM

2470 LINE PRINTER—1250-2000 LPM

2550 CHARABAND PRINTER—1500-2000 LPM

# FINEST PRINTERS: THAN HUMBLE AD.

we make matrix and full character printers; and we make them for commercial as well as military systems.

We have what you need.

**Our printers work and work and work**

The computer industry is crowded with printer companies.

But only one dotes on dependability.

Only one consistently comes up with innovations like the Mark IV and Mark V friction-free hammers, the 14-wire dual-column matrix head, the unique self-cooling thermal print head, the Charaband horizontal font carrier, and many more.

And only one is the largest independent printer company in the world.

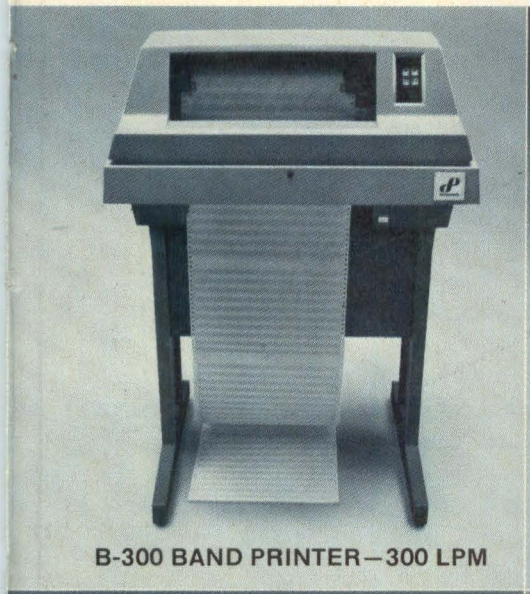
Dataproducts is the one.

We're not just a printer company.

We're *the* printer company.

And we're setting the stage for a whole New Era in printers.

CIRCLE 29



B-300 BAND PRINTER—300 LPM

2230 LINE PRINTER—300 LPM

2260 LINE PRINTER—600 LPM

TEMPEST LINE PRINTERS—
300, 600, & 900 LPM

2910 MILITARIZED PRINTER—
356-1110 LPM

**A NEW ERA**

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that printers will get cheaper, faster and that the market will continue to expand, especially printers designed primarily for the micro-minicomputer market, specifically those models aimed at the hobby applications. Many of the comments we received from specific manufacturers tend to look toward the future in their own specialized marketplace, rather than to the field in general – which is understandable.

In the small printer area, John Plump, product manager of Amperex, sees a need for more specialized printers, similar to those used in the keyboard market. He believes that manufacturers will have to be able to produce a variety of printers for each specific application by assembling standard hardware for different configurations. He also sees a need for faster printing, while retaining versatility.

Low cost will become the significant design criteria, according to Larry Copeland, product marketing manager of printers for Datel Systems. Prices for the low-cost printer market (microprocessor-based data loggers, computers for small business, the hobbyist) will drop approximately 25-35% by 1980.

No substantial changes will occur in printing technology in the next three years, said Fred Simonds, assistant sales manager of Practical Automation. He believes that matrix printing technology will continue to be important for several years to come because of its simplicity and versatility.

Daphne Campo, vice president of Master Digital, believes that small printers should make more effective use of microprocessors. Ms. Campo also presents some interesting ideas on the use of small printers in applications heretofore pretty much restricted to larger printers, such as teletypewriters or matrix printers. She describes the efforts of her company in expanding the use of its small 21-column instrumentation printer through the use of microprocessors humorously. (See nearby item in a box.)

In the medium to large printer area, Ron Wells of Intertec predicts that teleprinters will get faster. James Raska of Houston Instrument believes that the trend is towards very high-speed, single-copy machines, and that it will affect printers throughout the size range, from the largest line machines down to mini-microcomputer printers. Richard Mizrahi, marketing manager of Siemens, which, like Houston Instrument also manufactures nonimpact printers, sees a similar growth in the non-impact printer area. He believes that nonimpact printing for computer output will grow considerably.

According to Irving Weiselman of Dataproducts, a manufacturer of a wide range of machines using different printing technologies, microelectronics will continue to change printers, as they have in the past, by providing more flexibility and enabling electronic control of many functions that have previously been performed mechanically or electromechanically. Dot matrix machines will print with a larger number of smaller dot matrixes to give the appearance of whole-character copy. He sees further growth in the nonimpact printer field, particularly laser and ink jet printing, as the technology is perfected and more accepted by industry. Impact printers will still dominate the general marketplace, but nonimpact printing usage will expand, particularly in very high-speed applications.

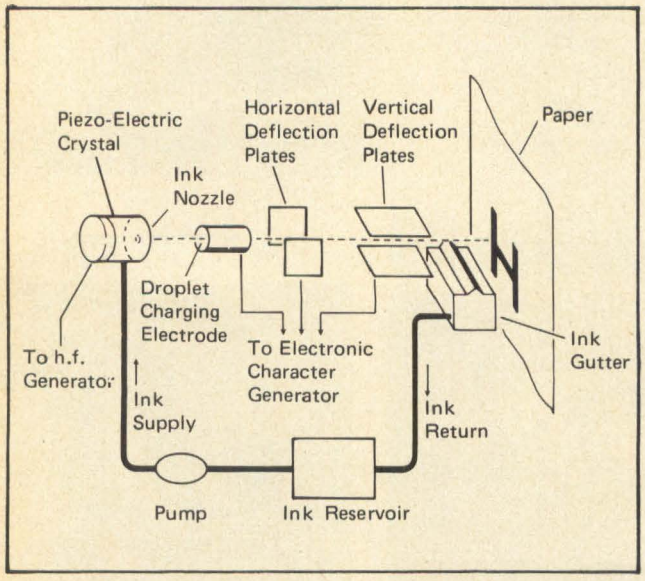



**Fig 14 Ink jet printers use a special ink which is charged and directed against plain paper. Electric fields direct the ink against the paper to specific points to form matrix characters. At those points that require no mark, the ink is deflected down into the gutter.**

**Table 1 Type of Printing and Character Formation for Various Printing Mechanisms**

| Printing Mechanism Type | Impact | Non-Impact | Whole Character | Matrix Character |
|---|---|---|---|---|
| Cylinder | X | | X | |
| Golf Ball | X | | X | |
| Daisy Wheel | X | | X | |
| Drum | X | | X | |
| Belt | X | | X | |
| Train | X | | X | |
| Serial Matrix | X | | | X |
| Matrix Comb | X | | | X |
| Thermal | | X | | X |
| Direct Electrostatic | | X | | X |
| Indirect Electrostatic (Laser) | | X | | X |
| Ink Jet | | X | | X |

**Table 2 Typical Maximum Speeds of Various Printer Types**

| Printer Types | Typical Maximum Speed |
|---|---|
| Cylinder, Golf Ball | 15 CPS |
| Daisy Wheel | 55 CPS |
| Thermal Matrix | 100 CPS |
| Serial Matrix, Matrix Comb. | 200 LPM |
| Drum, Belt, Train | 2000 LPM |
| Direct Electrostatic | 8000 LPM |
| Indirect Electrostatic (Laser), Ink Jet | 20000 LPM |

Want to know how to choose a printer and who sells them?
Turn to page 52 and find out.

# GE puts it on the line with a new family of TermiNet® line printers

## Four value-packed true line printers with real 90-340 lines per minute throughput at practical, low prices

Small size. Compact design. Modern styling. Quiet operation. Low prices.

At the same time this new space-saving family of GE TermiNet line printers is big on throughput. Gives you a range of speeds from 90 lpm to 340 lpm, depending on the number of printable characters per line and the size (64 or 96) of the ASCII subset. And that's *real* throughput.

They're big on reliability backed by years of proven electronics and rotating belt technology. (Over 75,000 GE belt printers installed worldwide.)

Big on quiteness. They're a welcomed addition to any office or computer room. Big on value-packed features. 132 columns. Original and 5 copies. A unique ribbon cartridge. With a life span of 50 million print characters.

The only thing you'll find small about this new family of true line printers is their size and price. In these days of spiraling costs, GE is putting it on the line with practical, low prices. From $3900 for the TermiNet 310 printer to $5130 for the TermiNet 340 printer (user quantity 1).

Let us prove it. Write General Electric Company, TermiNet 794-17A, Waynesboro, VA 22980.

## For your special kind of needs- a special kind of printer

GENERAL ELECTRIC

# BUYING A PRINTER

Although the printers available may not be quite as varied as the fish and fowl of the sea and air, they do show considerable variety. They are different enough to make it mandatory to be systematic in the selection process. Even though some of the subsequent discussion is obvious and some is less so, we have included all factors except size, because you probably know that you need a small, medium or large printer.

**Number of Columns.** Larger printers normally print 132 columns, occasionally more. Some 80-column machines are available and so are smaller printers with as few as 7 columns.

**Speed.** Speed varies considerably and generally increases with cost. For this reason, you should generally buy a printer that is no faster than you actually need.

**Color Capability.** Nonimpact machines print in only one color. Only single-element impact printers (cylinder, golf ball, daisy wheel) can change color within a single line. You can change color on faster impact printers only by swapping ribbons. Some instrumentation machines print in two colors.

**Graphics Capability.** Some printers are equipped to do graphics, others not. Some printing mechanisms intrinsically produce better graphics than others. If graphics are important, choose an electrostatic or a matrix machine.

**Reliability and Maintainability.** Since reliability and maintainability significantly affect cost, you should consider costs in the overall cost equation. Although we have been unable to gather sufficient data to provide guidelines here, many manufacturers make various MTBF and MTTR claims for their printing mechanisms.

**Cost.** Remember that initial purchase price is only part of what a printer (or any piece of equipment, for that matter) will cost you. In particular, printer consumables – paper and ribbons – add considerably to the original cost. For nonimpact printers, some of which require special papers, this cost can be high. If you intend to purchase a printer which requires custom interfacing, then you must take into account the costs of labor and material for this work. Reliability and maintainability costs are also important.

**Character Size/Interchangeability.** Some applications require large character sets. In other applications, the ability to change the size of the characters is important. These capabilities are available in many of the medium and large printers, but not in all.

**Noise.** In applications where quietness is important, nonimpact printers have certain advantages. But many impact

## BUYER'S GUIDE

### Small Printers

Printer manufacturers listed here offer mainly small printers of the instrumentation and data-logging variety. Interface requirements vary widely. In some cases the maker offers only printing mechanisms; in others, a complete printer with all electronics.

**Addmaster Corp.**
416 Junipero Serra Dr.
San Gabriel, CA 91776
(213) 285-1121
**Circle 226**

**Amperex Electronics Corp.**
230 Duffy Ave.
Hicksville, NY 11802
(516) 931-6200
**Circle 227**

**Axiom Corp.**
5932 San Fernando Rd.
Glendale, CA 91202
(213) 245-9244
**Circle 228**

**Datadyne Corp.**
Box 247
King of Prussia, PA 19406
(215) 265-1793
**Circle 229**

**Datel Systems, Inc.**
1020 Turnpike St.
Canton, MA 02021
(617) 828-8000
**Circle 230**

**Data 100**
25 Graystone St.
Warwick, RI 02886
(401) 738-9500
**Circle 245**

**Dataproducts**
6219 De Soto Ave.
Woodland Hills, CA 91365
(213) 887-8451
**Circle 246**

**Diablo Systems, Inc.**
24500 Industrial Blvd.
Hayward, CA 94545
(425) 786-5126
**Circle 247**

**Digital Equipment Corp**
1 Iron Way
Marlboro, MA 01752
(617) 481-7400
**Circle 248**

**Documation, Inc.**
P.O. Box 1240
Melbourne, FL 32901
(305) 724-1111
**Circle 249**

**Epson**
23844 Hawthorne Blvd.
Torrance, CA 90505
(213) 530-6553
**Circle 250**

**Extel Corp.**
310 Anthony Corp.
Northbrook, IL 60062
(312) 564-2600
**Circle 251**

**General Electric Data**
GE Drive
Waynesboro, VA 22980
(703) 942-8161 X-1188
**Circle 252**

**Houston Instrument**
8500 Cameron Road
Austin, TX 78753
(512) 837-2820
**Circle 253**

**Intertec Data Systems**
1851 Interstate 85 South
Charlotte, NC 28208
(704) 377-0300
**Circle 254**

**Microdata Corp.**
17481 Red Hill Ave.
Irvine, CA 92714
(714) 540-6730
**Circle 255**

**Milltype Corp.**
151 Sunnyside Blvd.
Plainview, NY 11803
(516) 938-9521
**Circle 256**

**Okidata Corp.**
111 Gaither Dr.
Moorestown, NJ 08057
(609) 235-2600
**Circle 257**

**Perkin-Elmer Data Systems**
Route 10 and Emery Ave.
Randolph, NJ 07801
(201) 366-5550
**Circle 258**

**Printronix Corp.**
17421 Derian Ave.
Irvine, CA 92714
(714) 549-8272
**Circle 259**

**Qume Corp.**
2323 Industrial Parkway West
Hayward, CA 94545
(415) 783-6100
**Circle 260**

**Siemens Corp.**
P.O. Box 5006
Cherry Hill, NJ 08034
(609) 424-2400 X312
**Circle 261**

**Teletype Corp.**
5555 Touchy Ave.
Skokie, IL 60076
(312) 982-3134
**Circle 262**

**Texas Instruments, Inc.**
P.O. Box 1444
Houston, TX 77071
(713) 494-5515 X3365
**Circle 263**

**Wang Laboratories**
836 North St.
Tewksbury, MA 01876
(617) 851-4111
**Circle 264**

**Zentec Corp.**
2390 Walsh Ave.
Santa Clara, CA 95050
(408) 246-7662
**Circle 265**

printer manufacturers can supply sound-deadened cabinets that reduce the noise level significantly.

**Multiple-Copy Capability.** In many applications, the ability to produce multiple copies is absolutely essential. Nonimpact printers do not provide this capability. Some impact printers possess a limited multiple-copy capability, while others are expressly designed to provide high-quality multiple copies.

**Print Legibility.** The user must decide whether a matrix or whole-character printer best suits his requirements. Although no consensus regarding print quality of the original and carbons exists, many in the industry believe that the slower whole-character printers (cylinder, golf ball, daisy wheel) produce the best originals, followed in order by whole-character line printers and then by matrix printers.

**Interfacing.** Interfacing generally poses the greatest difficulties in the smaller printers. If you are considering one of these printers, check with all of the manufacturers who can provide machines suitable for your application.

### Medium to Large Printers

Printer manufacturers listed here offer machines ranging from basic teletypewriters to large and very high-speed line printers.

**Anderson Jacobson, Inc.**
1065 Morse Ave.
Sunnyvale, CA 94086
(408) 734-4030
**Circle 241**

**Burroughs Corp.**
Burroughs Place
Detroit, MI 48232
(313) 972-7000
**Circle 242**

**Centronics Data Comp. Corp.**
Hudson, NH 03051
(603) 883-0111
**Circle 243**

**Control Data Corp.**
1480 N. Rochester Rd.
Rochester, NY 48063
(313) 651-8810
**Circle 244**

**Digitec (United Systems)**
P.O. Box 458
Dayton, OH 45401
(513) 254-6251
**Circle 231**

**Facit-Addo, Inc.**
66 Field Point Road
Greenwich, CT 06830
(203) 622-9150
**Circle 232**

**Gulton Industries, Inc. (M.C.S. Division)**
Gulton Industrial Park
Ea. Greenwich, RI 02818
(401) 884-6800
**Circle 233**

**Hycom, Inc.**
16841 Armstrong Ave.
Irvine, CA 92714
(714) 557-5252
**Circle 234**

**C. Itoh Electronics, Inc.**
5301 Beethoven St.
Los Angeles, CA 90066
(213) 390-7778
**Circle 235**

**Master Digital Corp.**
1308-F Logan Ave.
Costa Mesa, CA 92626
(714) 751-8271
**Circle 236**

**MFE Corp.**
Keewaydin Dr.
Salem, NH 03079
(603) 893-1921
**Circle 237**

**Practical Automation Inc.**
Trap Falls Rd.
Shelton, CT 06484
(203) 929-5381
**Circle 238**

**Sodeco (Landis & Gyr)**
4 Westchester Plaza
Elmsford, NY 10529
(914) 592-4400
**Circle 239**

**Victor Comptometer Corp.**
3900 North Rockwell St.
Chicago, IL 60618
(312) 539-8200
**Circle 240**

# COMPUTER PLOTTING Comes of Age

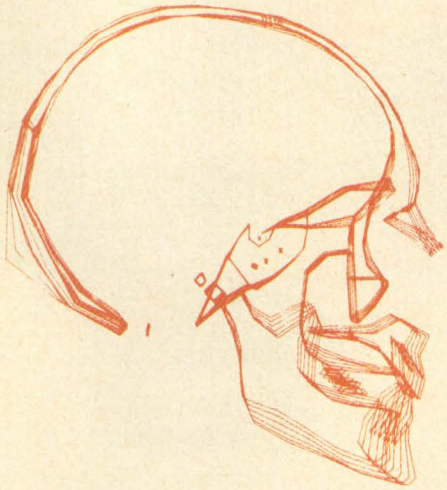


**Fig 1 Plot shows the results of surgical resectioning in patient with mandibular prognathism (jaws projecting beyond the upper part of the face).**

New developments in computer technology provide the capability to translate data into more useful, meaningful graphic forms. Although the term 'computer graphics' usually refers to numerous pieces of equipment and their application, (ranging from large-scale interactive CRT terminals to modified hard-copy terminals that provide visual representations) computer plotting *directly* generates line drawings from computer-processed data.

Two basic types of plotters are available in the marketplace: absolute and vector. In absolute plotting, endpoint data is transmitted as a series of X and Y coordinates referenced to a constant point of origin. Analog plotters and CRT displays use this technique. In vector plotting, the information source transmits data points as a series of X and Y coordinates referenced to the previous X-Y location. Vector plotters employ this digital incremental technique.

Analog plotters employ an absolute code, typically consisting of 11 characters, to generate a straight line segment in any direction. This code allows rapid plotting of long straight lines. These plotters generate short straight lines, such as those used to draw alphanumerics at a slower rate, although some manufacturers have increased lettering speed by using special character-generator codes.

In spite of their ability to generate straight lines in any direction at very high speed, analog plotters suffer from a number of limitations: they do not start drawing instantaneously, because the 11-character code transmittal time is fairly long; they change direction slowly, because they must stop to change direction and must again await 11-character transmittal before taking off again; they cannot draw a very long straight line continuously without stopping for reference points; and they tend to deviate slightly from the commanded direction and do not always stop exactly at each endpoint.

Standard vector plotters use a form of vector code that requires only one character to generate a straight line segment in any of 8 directions 45° apart. This code allows rapid generation of these 45° angle segments but the plotter draws odd-angle lines and curves very slowly. The advantages of standard vector (incremental) plotting include fast start, high accuracy and repeatability, fast direction change and good speed in the eight directions. Standard vector plotters suffer from several limitations: their maximum speed is limited to eight plotting directions; they plot curves and odd angles progressively slower as the direction deviates from the eight prime directions; and they generate wiggly lines as they attempt to maintain accuracy at odd angles by incremental stepping and correcting of the course.

Differential vector plotters employ a form of vector code that requires only one character to generate a straight line in any direction. This code allows plotters to rapidly generate long line segments and curves regardless of direction, but they slowly generate any short straight line segments that have abrupt direction changes, such as those used to draw alphanumerics. Manufacturers overcome this problem by providing hardware/software modes for symbol and axis generation.

Differential vector plotters provide fast drawing starts, highly accurate and repeatable generation, true curves and high speed drawing of straight lines. They suffer from two limitations: short straight line segments require abrupt changes in direction and slow plotting speed, and as the

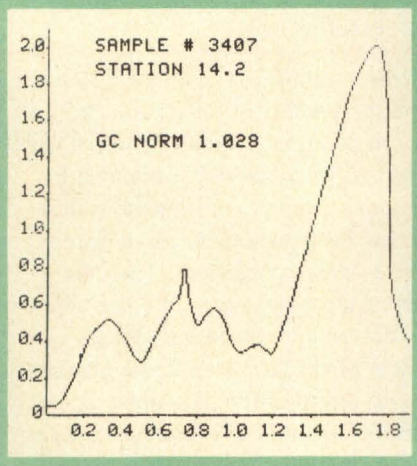
# The complete $795 graphics plotter.

## It's self contained, plots 8,192 dots per second, and is priced thousands of dollars less than others.


### They said it couldn't be done!

Recently, we introduced the EX-800, a complete 80 character line printer for just $655. Now meet the Axiom EX-810 graphics plotter, our printer's younger and smarter brother, incredibly priced at $795!

"You can't build a plotter for $795," we were told. But we have. Using the same simple, reliable marriage of mechanics and electronics that made our printer an instant success.




### Plots fast — and prints, too

The EX-810 is a compact, self-contained unit, designed to work with microcomputer systems. It can print 8,192 dots per second with up to 512 dots per row. Under software control, the EX-810 can also function as an 80 column alphanumeric line printer with speeds up to 160 cps.

The plotter has been designed to be driven by an 8-bit microprocessor with a minimum of software overhead. The built-in TTL compatible controller takes care of all of the timing functions required to drive the printhead and advance the printer.

### The advantage of electrosensitive plotting

Electrosensitive plotting is the key to the high performance and low cost of the EX-810, because this technique is the simplest possible way to place a visible mark on paper.

The advantages are many. The permanence of the hardcopy, unaffected by sunlight, moisture, heat or age. The shelf-life is indefinite, and the high contrast makes excellent photocopies. Also, the paper is inexpensive, and readily available, costing less than 1¢ per plot.

### Lightweight and rugged

Designed for the OEM, the EX-810, which can print forms, tickets, maps, pictures, charts, logos or anything you want, is completely self-contained including case, power supply, and paper roll holder. Weighing in at 12 lbs., the plotter is only 9⅝" wide, 3⅞" high and 10⅞" deep.

The EX-810 is virtually maintenance free, too. The simple, non-impact print mechanism has an amazing MTBF of 11.6 million lines, and the print-head is self-adjusting. Also, there are no inky ribbons to change.

The EX-810 graphics plotter ushers in a new era. Phone or write for OEM prices today.

Send to AXIOM
5932 San Fernando Rd.
Glendale, CA 91202

- ☐ Urgent. Please phone me at ext ____
- ☐ Have rep contact me
- ☐ I'd like a demonstration
- ☐ Send lit including sample plot
- ☐ Send EX-800 printer info

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Dept _____

Address _____

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plotter constantly corrects its course, it draws lines that visibly wiggle at odd angles.

## Applications

A multitude of potential applications for computer plotting exist and descriptions of a number of actual installations should stimulate you to use these instruments in the systems you design. We wish to thank Houston Instrument for the applications that follow.

**Oral Surgery.** In a computer-based project involving the simulation of certain surgical procedures and growth patterns, researchers at the School of Dentistry, Univ. of Michigan, Ann Arbor, seek to compare the relative efficiencies of several approaches to jaw rotation, surgical resection and bone displacement. They hope to identify the procedure that can produce the desired effects with minimum surgery. They also intend to record long-term biologic changes in craniofacial morphology.

The procedure for following the history of a patient via computer plotting consists of several steps. First, a lateral cephalogram – a silhouette of the craniofacial bones in profile – is produced on x-ray film. Digitizing the cephalogram produces 177 coordinate points that an Amdahl 470 computer stores. The plotter also generates a frontal skull model showing 138 points. The typical plots are often replotted or over-plotted (Fig 1) to show deviations due to corrective surgery, age or other changes. This research represents the beginnings of the use of computer-based technology by dentistry.

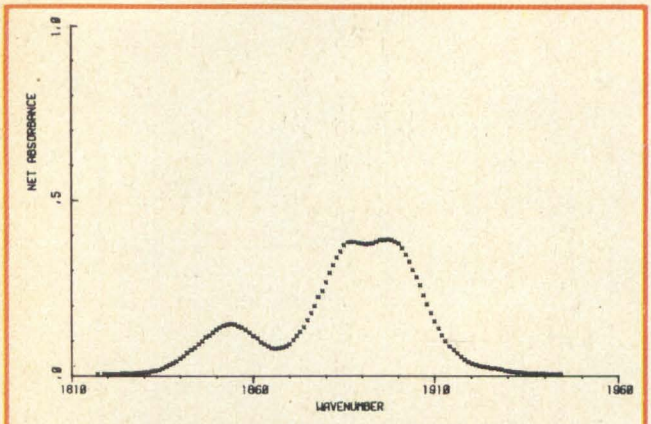


**Fig 2 High-resolution infrared spectrum of 0.02 M $NaCo(Co)_4$ dissolved in tetrahydrofuran.**

**Spectroscopy.** To study the microscopic nature of nonaqueous electrolytic solutions, a member of the chemistry department at Purdue Univ. is particularly interested in solution structure at ion sites. He is also trying to determine why vibrational selection rules for Raman and infrared spectroscopy often do not produce a good representation of what you see in the spectrum.

Major pieces of laboratory equipment consist of a number of spectrometers, a minicomputer and a plotter. The computer converts the complex spectral curve information received from the spectrometers into component bands. It also separates out the spectrum for a salt in solution; this spectrum contains contributions from the vibration of solvent molecules as well as the vibration of ions. The computer subtracts one vibration from the other to prepare a table of scattering intensities at equally spaced spectral chart wavenumbers from the solution spectrum and a second table from the solvent spectrum. A plotter generates the spectral curves (Fig 2), component bands and calculated spectral curves with experimental points.

**N/C Programming.** Errors in N/C tapes are difficult to detect and can cause disasters. A wrong instruction can wreck the cutting tool, a machine component or the part being made; such a wreck on an N/C machine can cost $5000 to $10,000 to repair. Since N/C machine motions closely resemble plotter movement, part of the checkout can be performed as a byproduct of the computer programs used to prepare tapes. By allowing programmers to examine the final plot of the tape in detail before running it on an N/C machine, costly errors are detected early and tape production costs are cut.

Most programmers prepare tapes for N/C machines with a computer and generate the finished part drawing with a digital plotter. One company, Houston Grinding and Manufacturing, adds three steps and is preparing a fourth for its tape preparation and checkout. In the first added step the plotter draws the blank part and then the finished part, so that the programmer can determine whether a wreck will occur and whether the part is completely machined. In added step two, the plotter generates cutting paths in relation to the part, so that the programmer can detect minor program errors, as well as wreck conditions. Then the plotter notes tool cutting movement as a solid line and a positioning move as a dotted line. It notes a tool change by recording the number of the new tool. These graphics allow the programmer to interpret the plot and examine only the significant moves. In another proposed step, the plotter will generate the chucking (holding) location on the part and the outline of any machine supports for the part, such as a tailstock; this added step will allow the programmer to see graphically whether the cutting tool is clearing those parts of the cutting machine.

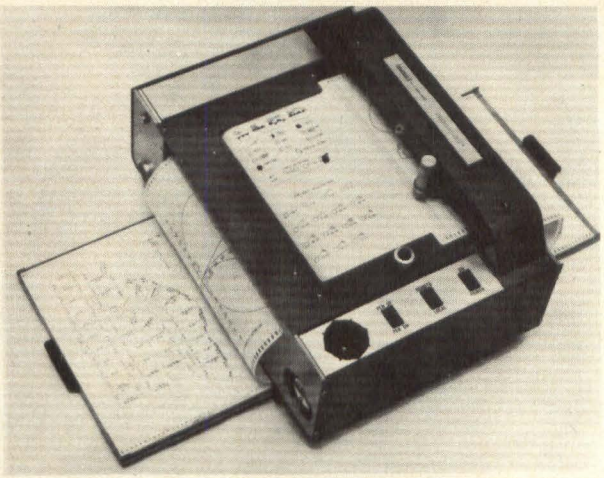

**Fig 3 Model DP-11 COMPLOT digital plotter from Houston Instrument produces an 11" wide Z-fold chart across which the pen moves at about 4 ips in 4000 increments per second of 0.005", 0.0025", 0.002" or 0.001" each.**

**Marine Charts.** A new oceanographic Dutch vessel uses a system to plot the ship's position on charts and to record oceanographic data on these charts.

Let your imagination soar. If you do, you may find novel uses for computer plotting. **DD**

Yes, Art did develop Graphware® I: Specifically to improve the output from your electrostatic plotter.

A typical plot could take several minutes to produce on-line from your computer, because your computer uses a very rigid "compute-bound" method of changing a vector format to a raster format. Add to that the asynchronous nature of computer output — the stopping and starting — while the plotter waits for more data — and you've obviously been getting somewhat less than ideal plots, and wasting valuable CPU time.

Graphware I has changed all that. Vector-end-point data is converted into raster data — outside of the computer — in a nanosecond-speed, control-store microprocessor. Data is passed directly to Graphware where the conversion takes place. The computer moves to other tasks; Graphware I processes the data for high-speed synchronous output to the plotter. The plots look perfect. And the whole process is accomplished two to five times faster.

The blackboard shows the old as well as new methods of plotting. As you can see, data transmission is cut to an absolute minimum with Graphware I. And, because Graphware is a dedicated combination of firmware and hardware, not just another computer with specialized software, it will improve the output of any electrostatic — yours, ours, theirs.

Simple? You bet. Efficient? There's no comparison. Available? Only from Art.

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**Varian Graphics Division**
611 Hansen Way
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# I'm Art Bliss.
# I developed a hardware vector-to-raster converter for electrostatic plotters.
# I call it HVR.
# Marketing wants to call it "Graphware® I".
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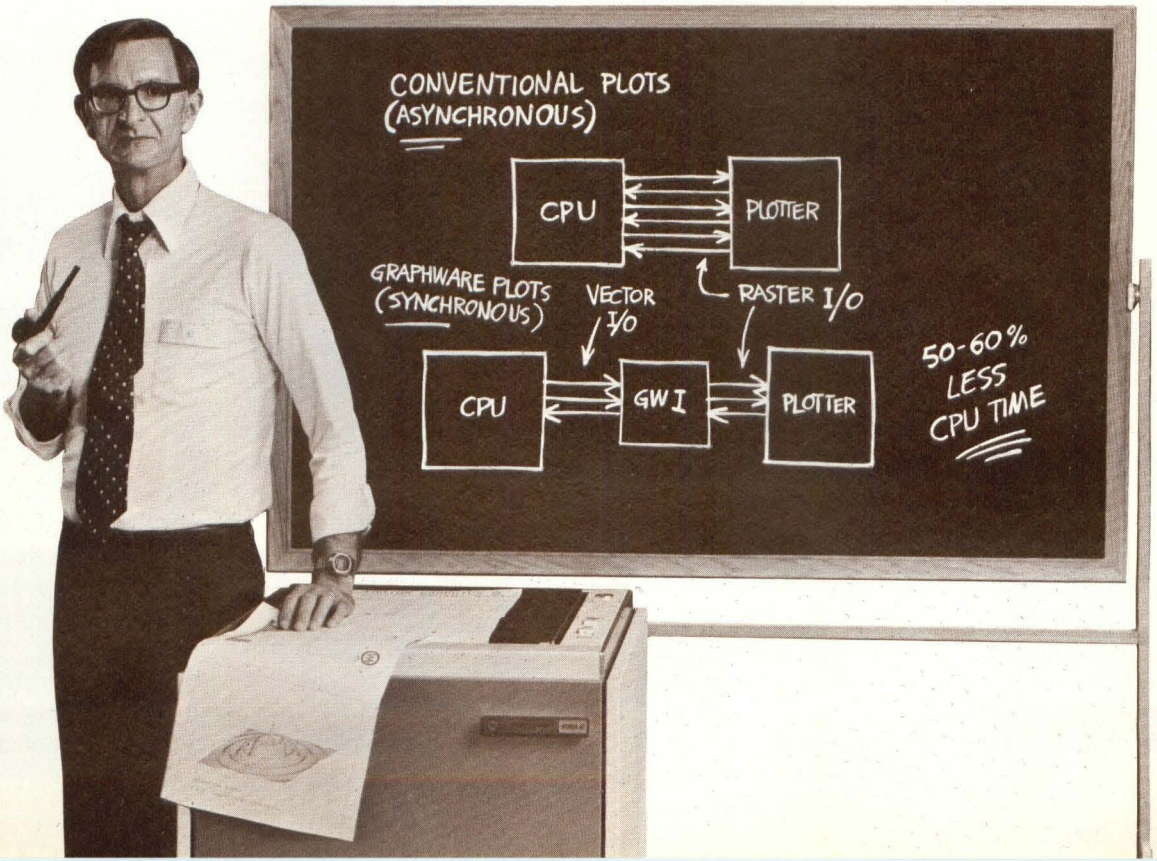
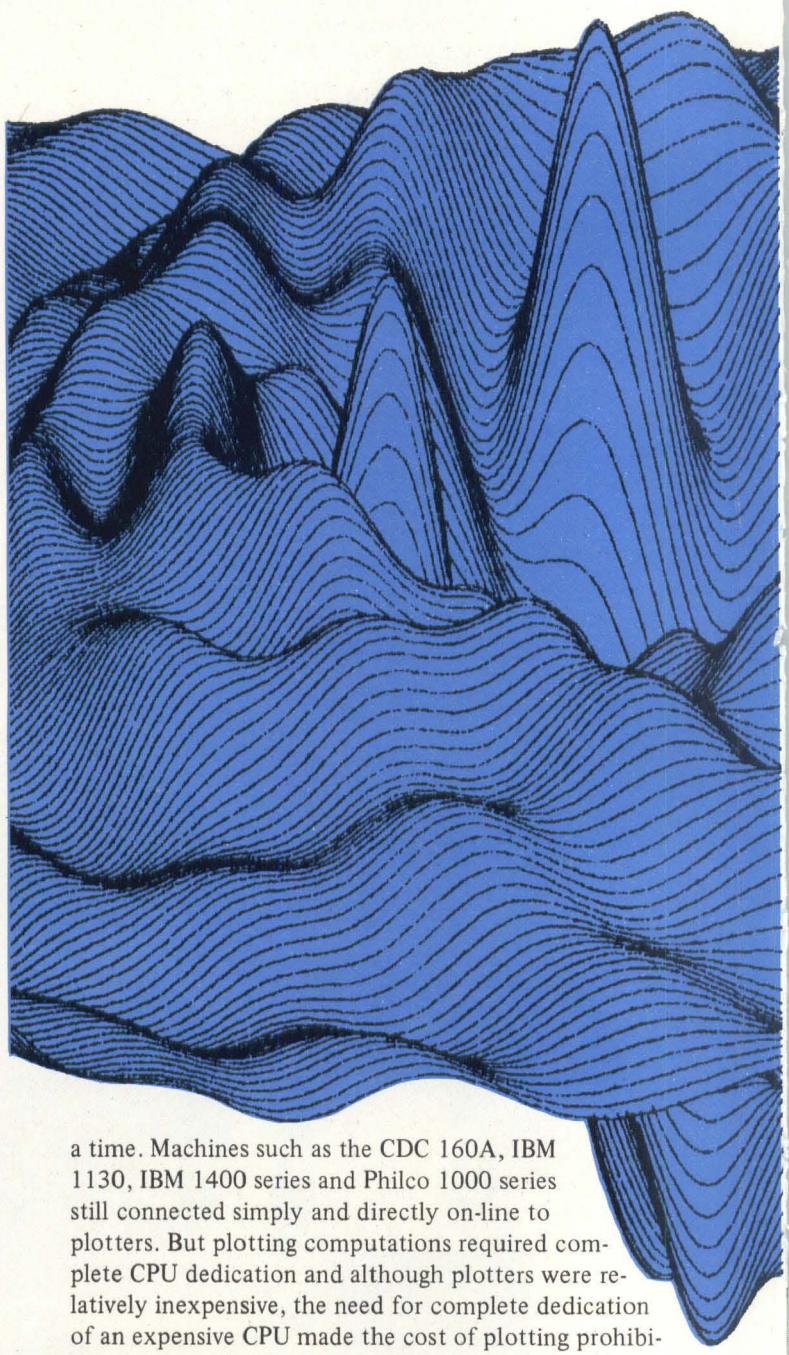


# Plotters Go

by Ronald C. Derby



As computer processing costs decrease, the number of business establishments using computers increases. Along with the increased use of computers has come an ever widening demand for graphical presentation of data. More and more businesses realize the potential benefits of plotting and must now decide how to use a plotter most effectively.

The plotter communicates with the computing system – its source of data – in three modes: on-line – connected directly to the computer system; remote/timesharing – connected to the computing network through communications protocol; and off-line – connected indirectly to the computer system, which feeds commands and data via such storage media as magnetic tape, paper tape, magnetic cards, floppy disks, cassettes, cartridges or hard disks.

A recent study shows that 53% of all plotters now in use connect on-line to computer systems or networks and by remote/timesharing links. By 1980, this number will increase to 83%, a shift caused by two complementary trends. First, such devices as calculators, microcomputers and minicomputers distribute more computing power directly to users. Second, microprocessors operating as powerful controllers make connecting plotters on-line or remotely to computer systems easy. From these trends, you can draw one preliminary conclusion: as you get ready to buy a plotter and its controller, stay flexible.

The past history of these three modes of operation can explain the trend towards direct plotter connection.

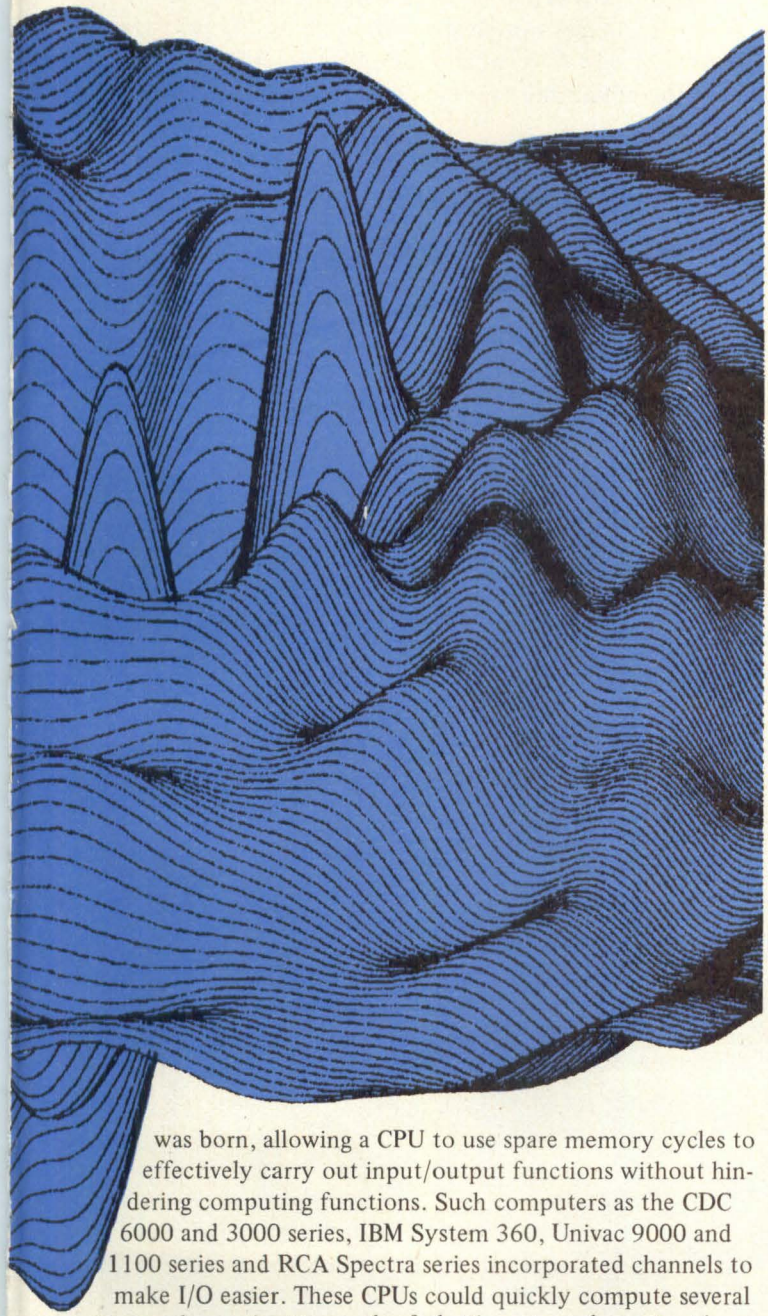
## On-Line

In the late 1950s, computing hardware was expensive and slow. Engineering decision of that day concluded that you should run plotters on-line to the smaller computers then available. Computers such as the Bendix G-15, Packard Bell PB250 and IBM 1620 connected directly to incremental plotters and required virtually complete dedication to controlling them. The fault lay not necessarily with the plotters since these early computers could process only one task at a time. Punching and reading cards also required complete computer dedication.

As computers evolved, especially small and medium-sized ones, they were able to perform the plotting function on-line. Even though these second generation computers operated faster, they were generally still dedicated to one task at a time. Machines such as the CDC 160A, IBM 1130, IBM 1400 series and Philco 1000 series still connected simply and directly on-line to plotters. But plotting computations required complete CPU dedication and although plotters were relatively inexpensive, the need for complete dedication of an expensive CPU made the cost of plotting prohibitive for most applications.

However, new developments in computer architecture allowed computing to go on simultaneously with plotting, especially in larger computers. The concept of channels

# Off-Line



was born, allowing a CPU to use spare memory cycles to effectively carry out input/output functions without hindering computing functions. Such computers as the CDC 6000 and 3000 series, IBM System 360, Univac 9000 and 1100 series and RCA Spectra series incorporated channels to make I/O easier. These CPUs could quickly compute several seconds or minutes worth of plotting, store the output in a buffer, start the channel pumping the output to the plotter and then rush off to perform several other computing functions. This architecture and its attendant operating system software allowed the expensive computer hardware to share services with peripheral equipment such as plotters, printers and punches.

Most early installations centered all peripheral equipment around these computers. At these installations it became obvious that computer operators couldn't do good plotting work, because the plotters required more care than hurried CPU operators could spare. This condition initiated a move to placing plotters off-line or locating them remotely.

The appearance of lower cost minicomputers helped the changeover to remote plotting. By allowing direct connection to the plotter via a direct memory access, the minicomputer could perform other tasks while carrying out the computing function for the plotter. In many installations, the user also operated the plotter and had to take the care needed to get good graphics from the plotter. At the time, in spite of the obvious advantages of using a minicomputer, the relatively high price for minicomputers held back their justification for all tasks that could benefit from their computing power. In addition, little or no software for graphics existed. Therefore, since users had to custom-tailor software packages for their tasks, few users could justify developing sophisticated programs.

Noting this need, a number of companies in the business of preparing software and assembling wish-list hardware began producing systems. These systems provided the capability to perform sophisticated tasks in designing and drafting integrated circuits and printed circuit boards. Some companies also marketed systems capable of handling sophisticated mapping tasks. Although these systems produced a plot at the output, users could look at intermediate design stages by looking at the display on a graphic CRT terminal.

The cost of computing power continues to drop. Putting significant calculating power into the plotter itself provides useful work stations for calculators and process or experiment centers for microprocessors. A plotter with calculating power can compute line algorithms and generate characters, as well as provide all electronic protocol needed to connect it to all types of calculators, microprocessor structures, minicomputers or communication line adapters.

## Remote/Timesharing

Public awareness of timesharing began with the Dartmouth system. Since users of these systems needed graphic and

plotted outputs, they generated graphs on the teletype-writers then in use. However, these inelegant graphic outputs did not satisfy users. Early designs for attaching controllers to electromechanical line drawing plotters suffered from the high cost of computing hardware and from slow data rates available at the timesharing networks. Early controllers provided information for stepping eight basic plotter movement directions; thus, generating curves, off-axis motions and symbols took considerable time.

As the cost of computing hardware dropped, manufacturers could offer plotter controllers with built-in symbol generation and line and curve algorithm packages. These plotters became even more useful as time sharing networks began supporting 300, 1200 and higher baud-rate lines. When fitted with intelligent remote controllers, these plotters produced good quality graphs, charts and drawings.

Microprocessor-based remote/timesharing plotters cost less than other systems yet maintain the flexibility of general-purpose computing equipment. Controllers in these plotters can be used as on-line, remote/batch and remote/timesharing interfaces. They can even control an off-line system by adding only a compatible tape or floppy disk drives.

## Off-Line

Early large computers performed I/O functions with difficulty. Going off-line solved this problem in the days of IBM 709, 7090, 7094 and other 7000 series computers; magnetic tape became the off-line storage medium with these machines because of speed considerations. In particular, magnetic tape storage more than met the speed of plotter operation needs as plotter drives read data at 0.5 ips or slower from tapes written at speeds of up to 150 ips. These tapes held only 1"- 8" of plot information per lineal inch. Even so, off-line plotting systems were low-cost and very practical.

At that time, manufacturers also marketed off-line card-fed and paper tape-fed plotters, especially large precision systems intended for numerical/control tool applications. However, because neither card nor paper tape reader speed could match large computer speeds adequately, plotters, so equipped, eliminated one of the main purposes for going off-line.

Fortunately, a large group of users recognized that plotting demands a special type of operator. These users kept doing their plotting off-line, though computer salesmen

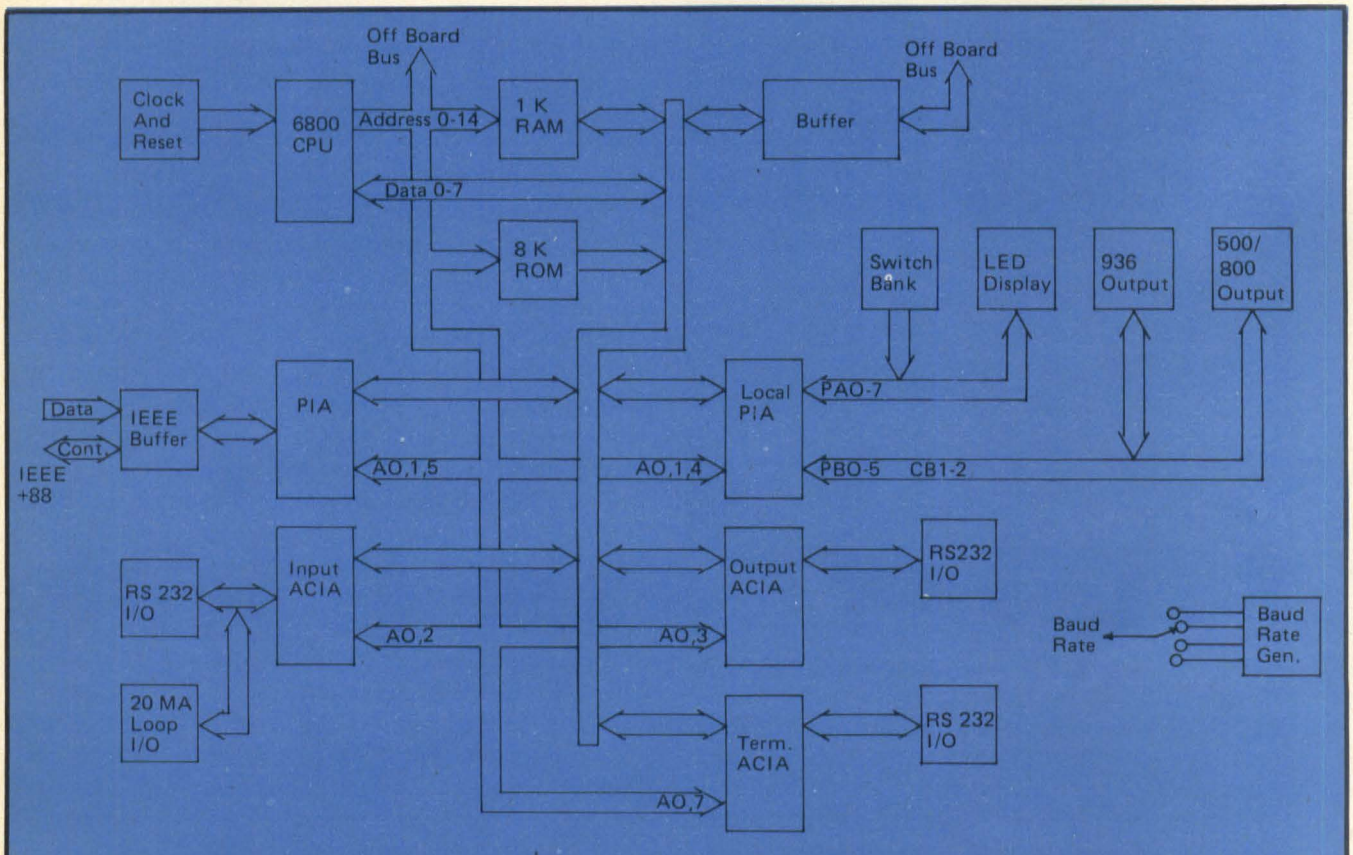



**Fig 1 Simplified block diagram of CalComp Model 906 on-line controller indicates how it can provide significant flexibility for plotters. Off-board buses permit memory expansion, additional I/O circuitry, or greater microprocessing power. The bank of switches provides the operator with a means of setting parameters that define plotter type, information about I/O message headings, parity or other checking code, and a powerful self-analysis and checking capability.**

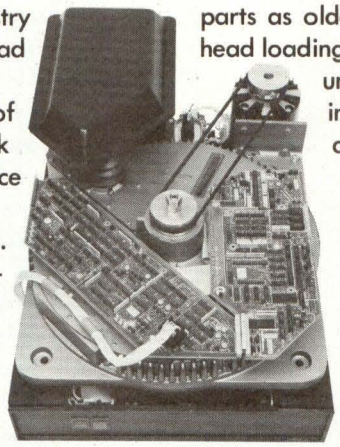
## Another first for ISS

# THE INDUSTRY'S MOST ADVANCED FIXED HEAD DRIVE

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

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

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



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

But even high performance isn't everything. The new 550 is exceptionally reliable. It has only 25% as many parts as older technology fixed head drives. There's no head loading mechanism. DC power supply is built in. The unit is self clocked. And the design incorporates interchangeable modular subassemblies for quick and easy maintenance.

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

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

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CIRCLE 34

kept extolling on-line plotting. Consequently, off-line plotting grew very strongly during the System 360 era.

Several years after the introduction of the IBM 360, simple plotting algorithms still required considerable computing time to generate straight lines. By this time computer hardware prices had dropped low enough to put a minicomputer into an off-line plotter driver. This arrangement relieved the main computer of much of the computing load, gave the system added flexibility and allowed the user to connect it to various types of plotters. These off-line drivers could solve the line-generating algorithm; they could generate, scale and rotate symbols; and they could scale drawings for a wide variety of plotters. In many instances, the drivers

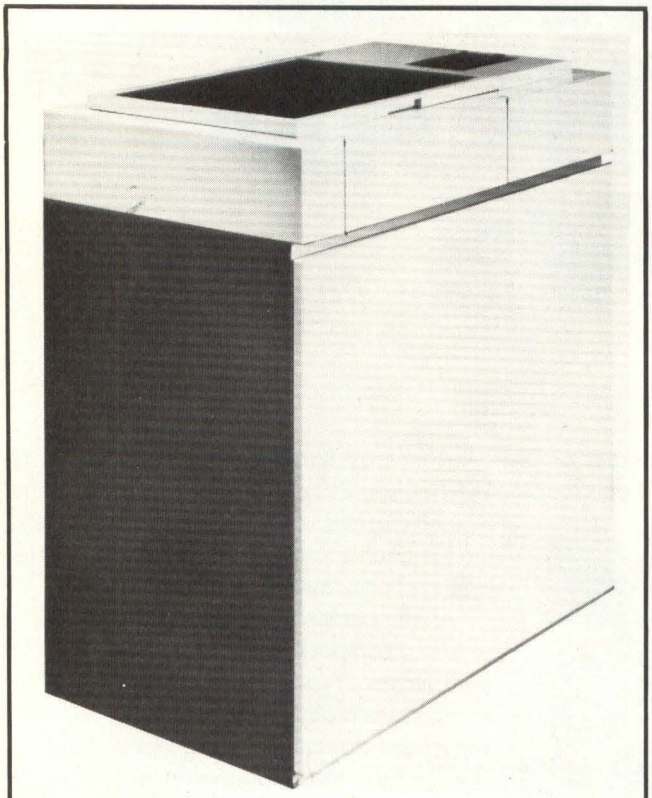


**Fig 2 Exemplifying a controller that can upgrade a variety of its maker's drum, flatbed and beltbed off-line plotting systems, this CalComp 921 unit contains an integral magnetic tape drive and performs automatic read-error detection and searching for producing high-volume computer-generated hard copy graphics.**

handled special algorithms for generating sharp corners on lines and for solving very difficult problems of mechanical dynamics in plotters. For example, the system could allow the driver to tune a plotter for maximum throughput by selecting the pen-up and pen-down delays via software in the minicomputer off-line driver rather than relegating that function to hard-wired logic. This type of system required the operator to perform some program loading or entering of constants. In general, these worker tasks created no problems, because off-line plotters already required operators with special skills.

Currently, off-line plotter drivers have eliminated the need for operator intervention by using ROM to store the program and pertinent constants. These plotters have not lost flexibility; they are upgradable to fully programmable models. Of greater interest, microprocessor-based plotter controllers that use floppy disks or magnetic tapes for storage promise the same capabilities and flexibility as minicomputer-based controllers.

## The Future

Hard-copy computer graphics appears to be going in two directions. One way points towards the production of graphics, per se; the other, towards facilitating the assembly of a graphics-oriented work station.

**Newest Plotters.** The latest equipment for producing graphics, minicomputer-based off-line systems which generate plots, charts and drawings, use a minimum of the total time of a CPU or a large-scale minicomputer system. Because of their long history, the plotters present virtually no software problems – many sophisticated application software packages are batch/production oriented. The newest controllers drive all classes of ink-on-paper electromechanical plotters. The off-line concept recognizes the need for a specially-trained operator who can give undivided attention to producing virtually publication-ready computer generated graphics.

**The Work Station.** As previously noted, by 1980 about 83% of the users will connect their plotters directly to the source of computerized information, either on-line or remote/time-sharing. This forecast intimates that the users of plotted computer data will operate the plotters. Obviously, these plotters will operate in conjunction with calculators, microprocessor-based electronics or minicomputers, or connected via communication links to a computing network. Consequently, anyone purchasing a plotter controller should choose one that contains a microprocessor. The microprocessor should have the I/O characteristics to provide a large number of interfaces, should they be required, and make it easier to add input and storage peripherals in the future. You should select your mode of plotting by choosing equipment that is flexible enough to meet a wide range of applications and that can be enhanced in the future for more sophisticated tasks. When buying future potential, get the plotter from a source that will be able to deliver the interface hardware and software you may need at that time. The key element in taking full advantage of technological advancements in our fast evolving computer industry is to buy flexibility and growth potential in your peripheral controllers. **DD**

**Ronald C. Derby** *is Manager of Product Technology Analysis for California Computer Products, Inc., Anaheim, CA.*

# KERONIX

- MINI COMPUTERS
- PERIPHERAL CONTROLLERS
- ADD-IN MEMORIES
- ADD-ON MEMORIES
- TERMINALS
- SYSTEMS

# TROUBLESHOOTING WITH LOGIC ANALYZERS

by Ken Pine

In the September issue of DIGITAL DESIGN, we covered the basic functions and features of logic analyzers. Now we turn to analyzer applications, as varied and diversified as the field of digital logic itself. The applications presented here show you how to use the analyzer for problems as simple as single chip errors and as complex as computer system failures.

**Single chip error.** Engineers working with new designs often face chip problems separate from design or layout errors; one such chip problem solved using a logic analyzer would have entailed considerable work without using the logic analyzer, since both layout and circuit were unproven and the duty cycle was too low to properly view with an oscilloscope.

A miswired 13 input nand gate caused the problem. Fig 1 shows a simplified version of this problem using a 3 input nand. To observe the malfunction shown, the analyzer probes were connected to the inputs and the output; the channel connected to the output was set to trigger when the data transition from '1' to '0' occurred. The data immediately preceeding the trigger revealed the malfunctioning input; further information was obtained by changing the output recording channel so that it would trigger on a transition from '0' to '1'.

The two sets of data in Fig 1 clearly showed that the logic of the nand gate was incorrect; the problem did not result from component failure, but rather from miswiring of the C input. In the actual problem, the chip was replaced and the unproven circuit came up functioning exactly as designed. Thus the logic analyzer's ability to freeze actual logic events eliminated much frustration that would occur if the analyzer was not available.

**Timing Problem.** In the circuit shown in Fig 2, a clock transition from low to high saves a memory address; this address than serves as a comparison to generate a flag in sync with the last data recorded in memory. The problem encountered with this circuit was that incorrect data was being strobed across the shift register, and an improper amount of setup time on the shift register was suspected. Since the data rate shifted from record speed of 20 MHz to display speed of 500 KHz, when the clock went low to high, it appeared that up to 1 $\mu$s (500 KHz half cycle) was available in which to set up the data and strobe the shift register. Inserting several values of delay from a hundred nanoseconds to a microsecond did not help. An asynchro-

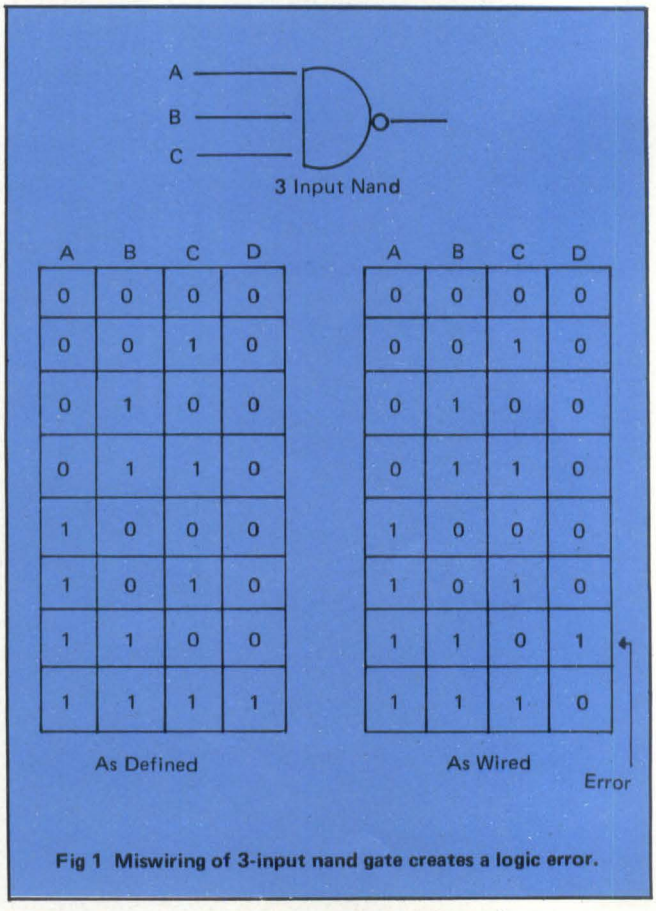
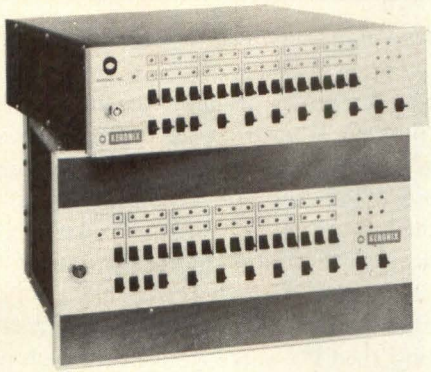



**Fig 1 Miswiring of 3-input nand gate creates a logic error.**

# A Total Systems Capability



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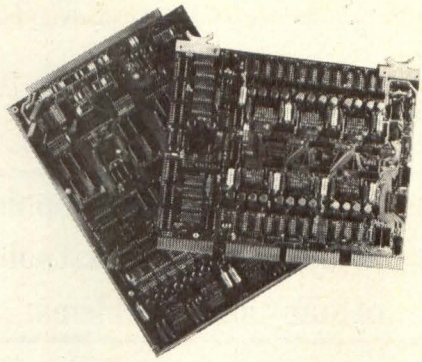

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nous logic analyzer triggered on the clock transition from low to high, revealing that the first 500 KHz clock edge could occur within 100ns of the last 20 MHz clock edge. See Fig 3. Delay of greater than about 50ns in the clock transition caused the shift register to clock while the address data was changing. Setting the delay to 15ns solved the problem – the circuit has performed exactly as planned ever since.

**Design Bug and Chip Error.** In the Master Slave D type flip flop circuit shown in Fig 4, cycle of the reset input C from high to low to high sets the Q output to '0'. Subsequently, a high to low transition on any of the A inputs places a '1' on the D input, which is clocked to the Q output upon a positive edge at B. The Q output going to '0' locks the output of the nand to '1' (the D input of the flip flop), and the Q output will remain a '1' regardless of any further changes in the A inputs. In actual practice, the circuit was resetting without Reset C being cycled. An asynchronous logic analyzer found an obvious source for malfunction, an ions negative going pulse on the Reset line (input C). The analyzer was triggered when the Q went from '1' to '0' readily capturing the pulse on input C. After eliminating the pulse, the circuit should have worked as designed. However the circuit continued to reset itself.

**Logic analyzers now provide sophisticated timing analysis, allowing fast solution of many logic problems.**

**Logic analyzers can solve problems as simple as single chip errors and as complex as computer system failures.**

All inputs and outputs were recorded with an analyzer and triggered when reset from '1' to '0'. Also, after lockup, a change in an A input caused pulses to appear at the D input to the flip flop. Whenever one of the pulses was high at the positive clock edge, the circuit would reset. Since the Q was a solid '0' the nand gate was obviously faulty; after replacing the bad chip, the circuit operated correctly.

**Field Service.** The illustration in Fig 5 represents an actual computer installation in which a cardreader error condition defied solution for over 8 years. Whenever cardreader #2 was operating, the CPU would store error signals from cardreader #1 on an intermittent basis. All components of the system functioned properly when operated alone, but when operated as a system, errors were generated. Further, the errors were "once a day problems" and didn't show up on an oscilloscope.

The logic analyzer as it existed 3 to 4 years ago was of little use, since you did not have combinational trigger settings that could trap the error conditions. A recently developed logic analyzer feature, call Delayed Trigger or "Window Triggering", can provide the trigger condition that could trap the error condition every time it cocurred. Trigger Delay provides the ability to screen short term anomalies from the combinational trigger, preventing triggering on un-

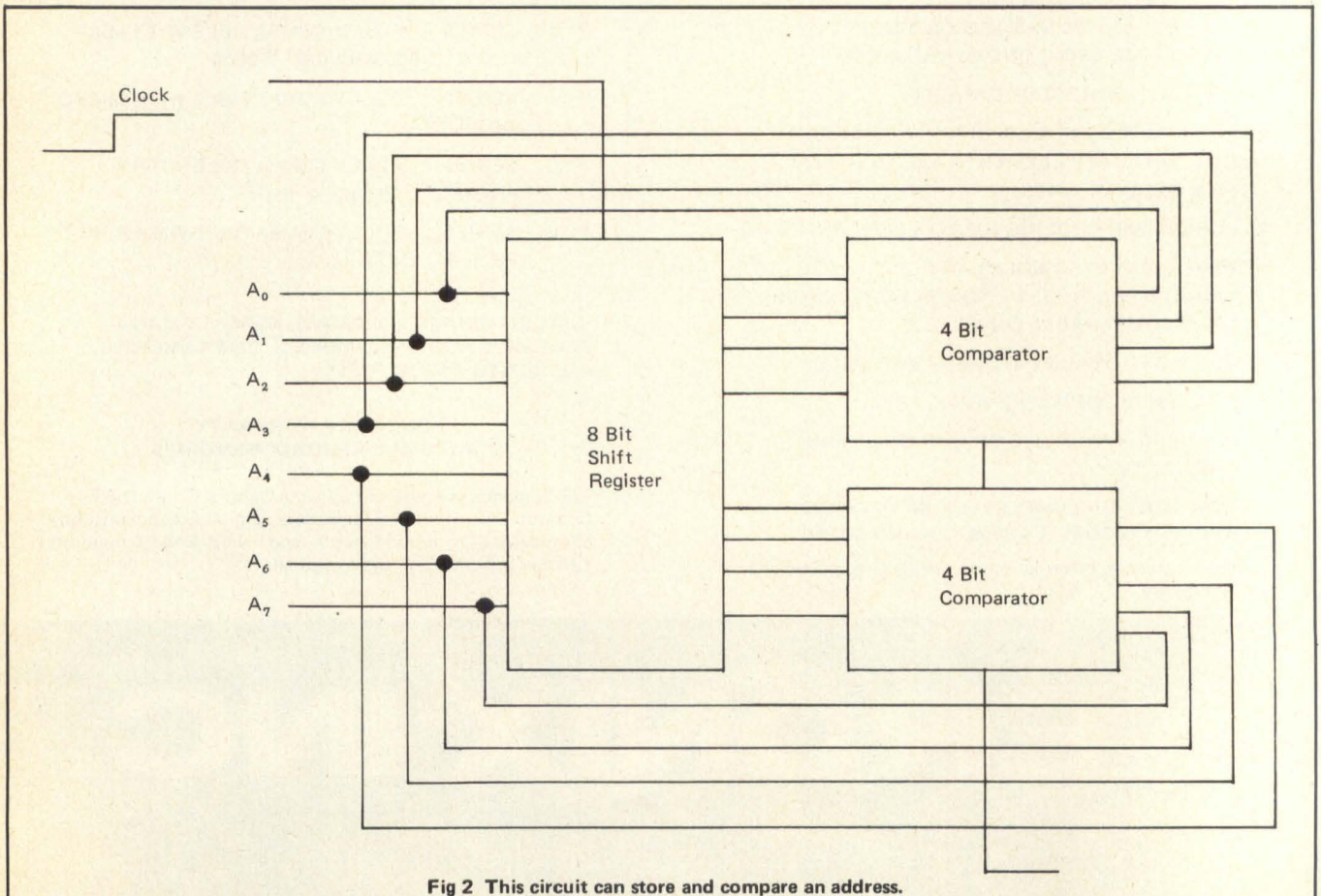


**Fig 2 This circuit can store and compare an address.**

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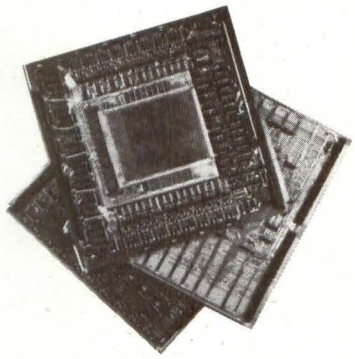

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wanted or between-clock events. In the analyzer used, Trigger Delay was available in single sample bit increments up to 3 bits. Set in a 3 bit delay, the trigger must be valid for the complete 3 sample bit period or else it would not be recognized. This provided a basis for triggering whenever the cardreader error occurred. In the logic diagram shown in Fig 6,

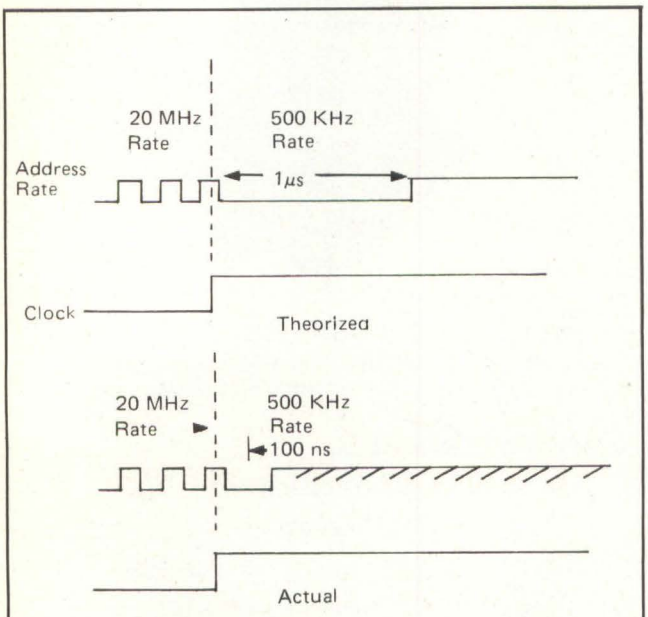


**Fig 3 Comparison of actual and theoretical operation of the circuit shown in Fig 2.**

the correct response of the "handshake" data exchange is characterized by the Data Request line going low and the Cardreader Ready line following within 165ns. Whenever the cardreader does not respond within the 165ns delay an error is generated. It was a simple matter to set up a trigger

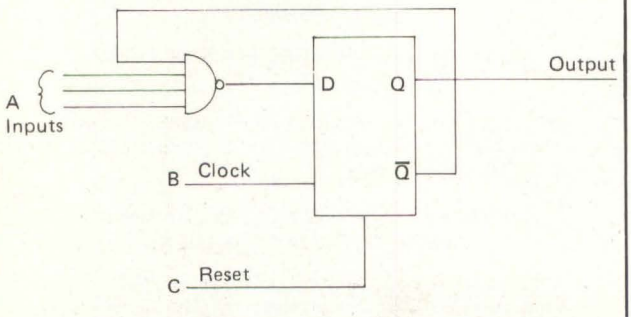


**Fig 4 A nand gate and a D flip flop form this multi-input trigger circuit.**

condition using the Delayed Trigger – trigger with 3 bits of trigger delay at 10MHz sample rate with the combinational trigger set on the condition of the Data Request line at "0" and the Cardreader Ready at "1". Whenever the condition of the Data Request at low and the Cardreader Ready at high existed for a period of 300ns (3 sample bits x 100ns per sample) or greater, the analyzer would trigger, allowing data capture in the other available channels in sync with the error. The correct response, existing for 165ns during a normal Data Request cycle, never triggered the analyzer since the low-high combination doesn't exist after the 300 ns Trigger Delay. Thus the use of a logic analyzer quickly solved a long-term problem.

**Computer System Troubleshooting.** The Peripheral Control Unit (PCU) shown in Fig 7 intermittently generated a Lost Data Status (LDS) bit whenever disc Reads were exe-

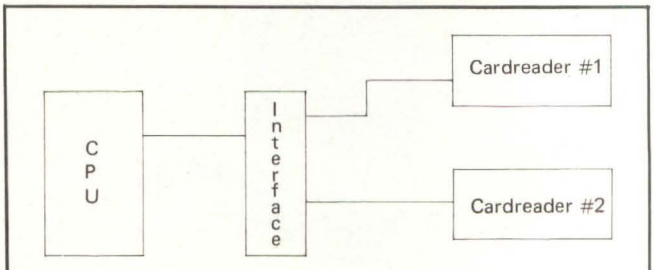


**Fig 5 Computer installation with two card readers.**

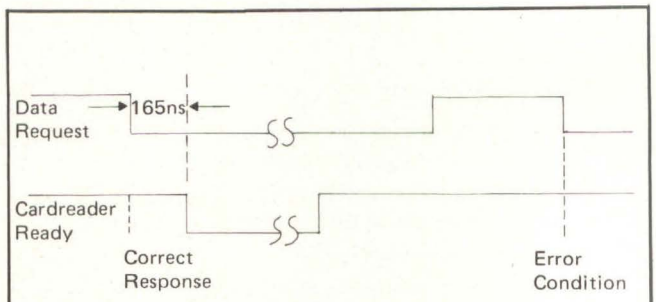


**Fig 6 Timing diagram illustrates cardreader error condition.**

cuted. Because the PCU has no real time data buffer to match data rates coming from the Input/Output Controller (IOC), the IOC must answer data requests with a data acknowledge (IDA) in a time period determined by the disc speed.

If the IDA is not received in time, an LDS bit is generated. The CPU does not see this indicator until the entire operation is complete; because prior triggering information was required conventional techniques such as the oscilloscope could not be used. In addition, it was unclear at the outset whether hardware or sofware malfunctions caused the problem; also, the failure was intermittent.

A logic analyzer monitored the signals shown in Fig 7. The LDS signals triggered the logic analyzer, providing pretrigger information. Examining the captured data showed that the PCU was intermittently generating LDS as a result of reading the last word on the disc sector (CRC).

This 16-bit word (as opposed to the normal 32-bit word length) is not sent to the CPU. When reading the last word, the PCU sometimes expected a response from the CPU; if the CPU did not respond, LDS was generated. The problem was solved by inhibiting the PCU from issuing LDS upon reading CRC. By providing pretriggering, long memory and high speed (up to 10ns resolution), the asynchronous analyzer helped to solve the problem.

**Disc Pack Malfunction.** A disc pack whose normal busy period (data being taken) lasts 500ms or less intermittently stuck in "busy" for up to 10 seconds at a time. The technician monitoring the "busy" line could see when the unit became "stuck," but didn't have enough time to develop any useful information on an oscilloscope. He reasoned that

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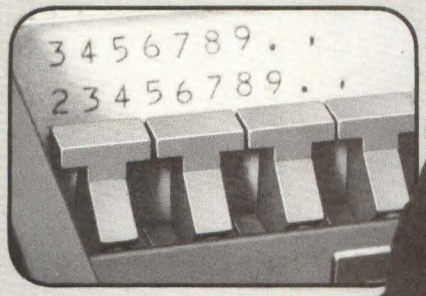


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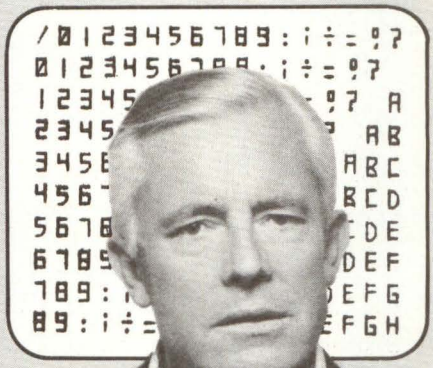

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if he could monitor a number of control lines and "freeze" the information generated at the time the disc went unstuck he could determine the source of the problem. In this case, an asynchronous logic analyzer with a bit-wide trigger delay solved the problem.

Fig 8 shows a representation of the "busy" line in the disc pack during normal and "stuck" periods. In order to trigger the logic analyzer when the disc went unstuck, it was necessary to screen out the normal busy periods up to 500ms long and only trigger when the reported busy exceeded that period of time.

In the asynchronous 16-channel analyzer used, trigger delay was available for periods up to 3 sample bits in length.

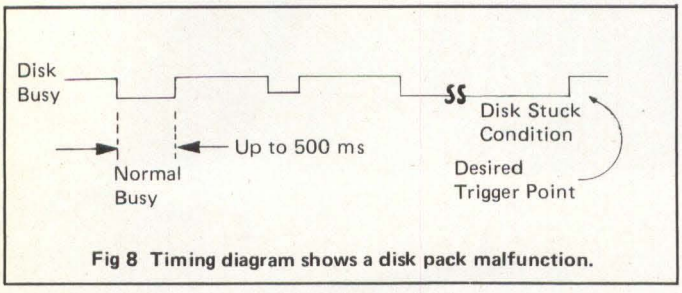



**Fig 8 Timing diagram shows a disk pack malfunction.**

Setting the internal timebase to 200ms per sample established a delay period of 600ms. Now with the trigger set to "1" (positive edge) in the channel recording the "busy" signal, the analyzer could pretrigger record up to 15 channels of data coincident with the disc going "unstuck". Finding the errant control line then cleared up the problem quickly.

**Troubleshooting the IEEE Bus.** The advent of a widely accepted standard, the IEEE 488-1975 communicaiton bus for instrumentation systems, has brought a new set of testing problems that logic analyzers can handle. The IEEE bus transfers data under control of a 3-wire handshake; this handshake assures that all data destination devices are ready for new data (the bus wire-ANDed signal NRFD-Ready for Data-goes true) or have accepted it (the wire-ANDed signal NDAC-Data Accepted-goes true). Generally, we can break the IEEE bus problems into four classes: handshake, controller errors, noise and timing errors.

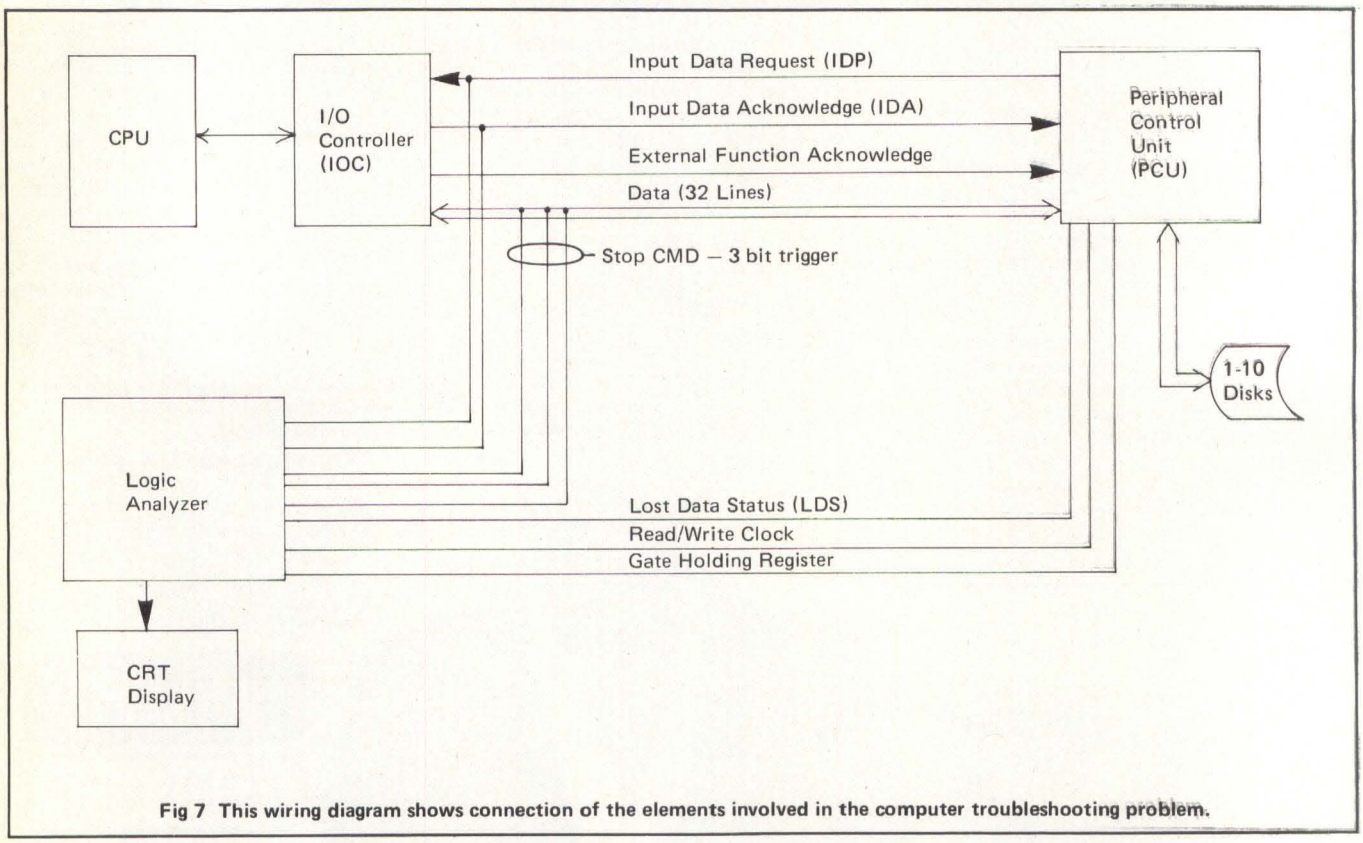


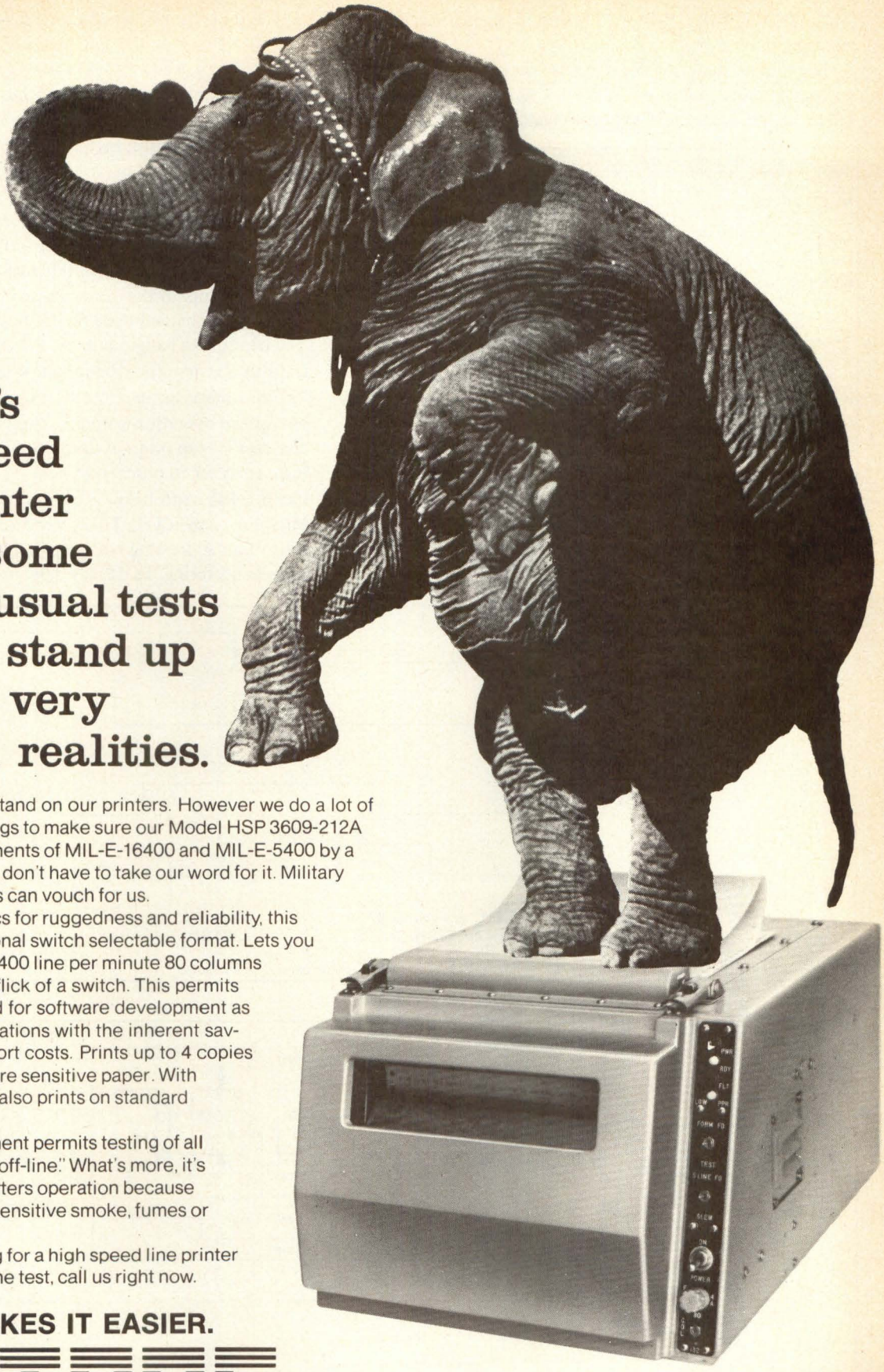

**Fig 7 This wiring diagram shows connection of the elements involved in the computer troubleshooting problem.**

The first step in trying to isolate problems due to the operation of the bus is to assure that the handshake operates properly. To do this, connect probes to ATN and to the three handshake lines, NRFD, DAV and NDAC, in that order (see Table 1), so that the signal timing interlocks are clearly displayed next to each other. The probe connected to the ATN line permits selecting either address/control transfer or data transfer triggering, and also provides a means for identifying the type of information being transferred. This setup allows immediate detection of most IEEE bus problems.

**TABLE I – IEEE-488 PIN ASSIGNMENTS**

| | | | |
|---|---|---|---|
| 1 | D101 | 13 | D105 |
| 2 | D102 | 14 | D106 |
| 3 | D103 | 15 | D107 |
| 4 | D104 | 16 | D108 |
| 5 | E01 | 17 | REN |
| 6 | DAV | 18 | GND(6) |
| 7 | NRFD | 19 | GND(7) |
| 8 | NDAC | 20 | GND(8) |
| 9 | IFC | 21 | GND(9) |
| 10 | SRQ | 22 | GND(10) |
| 11 | ATB | 23 | GND(11) |
| 12 | Shield | 24 | Gnd Logic |

**Handshake Problems.** Triggering on DAV going LOW with an appropriate amount of pretrigger delay gives a display as shown in Fig 9. Note the handshake steps "a", "b", "c",



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"d", "e" and "f" – if these steps do not occur repetitively in exactly this order, then the handshake is not functioning normally.

The normal data transfer sequence may not take place during the transition from Controller Active to Controller Idle, which occurs when ATN goes high. In this case, the timing diagram shown in Fig 10 may be observed.

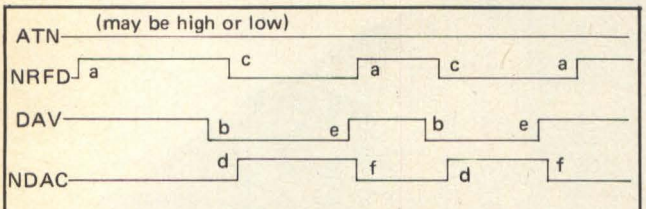


**Fig 9 Timing sequence for the IEEE bus handshake.**

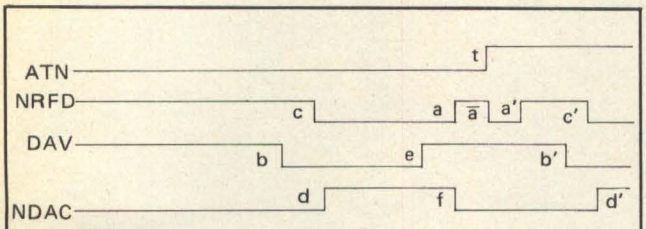


**Fig 10 Timing diagram shows the transition from Controller Active to Controller Idle on the IEEE bus.**

The transition between Controller Active and Controller Idle must occur after event "e" and before event "b". If it occurs before event "a" then the sequence will not be any different from normal. If it occurs after "a" then a double transition "a"-"a" may be observed in normal bus operation. The double transition may not happen at all, but if it does, the trailing edge "a" must occur within 200ns of "t" or the Listener is faulty.

A common "Talker" error is detection of NRFD true before "a" occurs. This initiates a data cycle which may result in "b" before "a", in this case the handshake cycle might hang up, or the Listener may drop the first byte. The display characteristic of this failure is shown in Fig 11. The handshake hangs up if the Listener is waiting for the transition at b' rather than the low level. In this case, even "a" may never occur. Note that you cannot observe the handshake operation with an externally clocked "state analyzer" – an internal time base is a must if you want the logic analyzer to observe asynchronous control sequences like the 488 handshake.

**Microprocessor Cycle Time.** Measuring the overall cycle time of an addressing system in a microprocessor involves address buffering, ROM chip selection logic and 3-state buf-

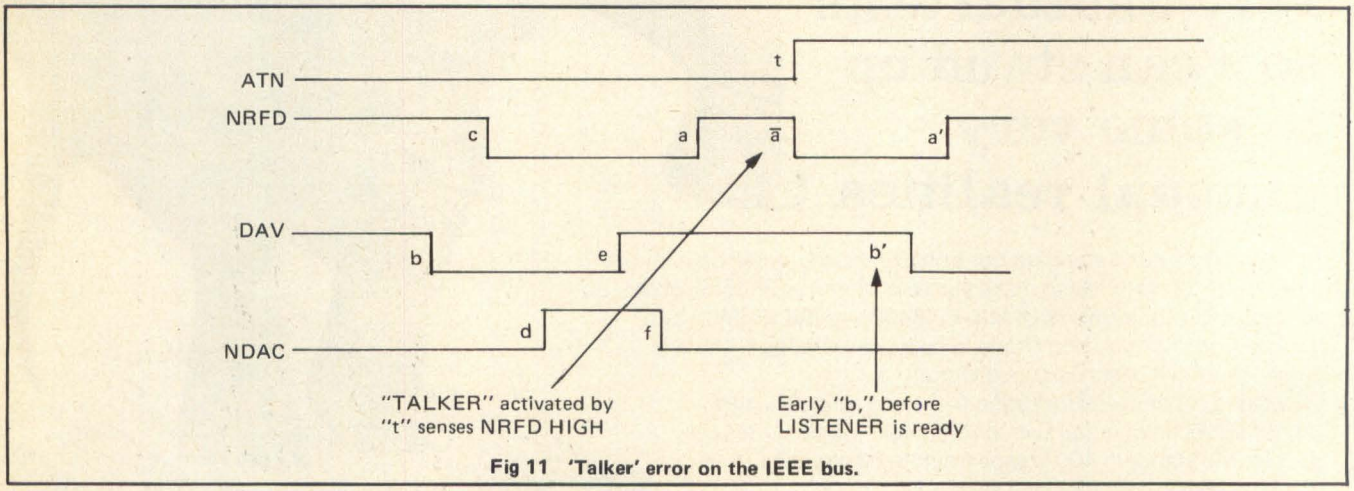


**Fig 11 'Talker' error on the IEEE bus.**

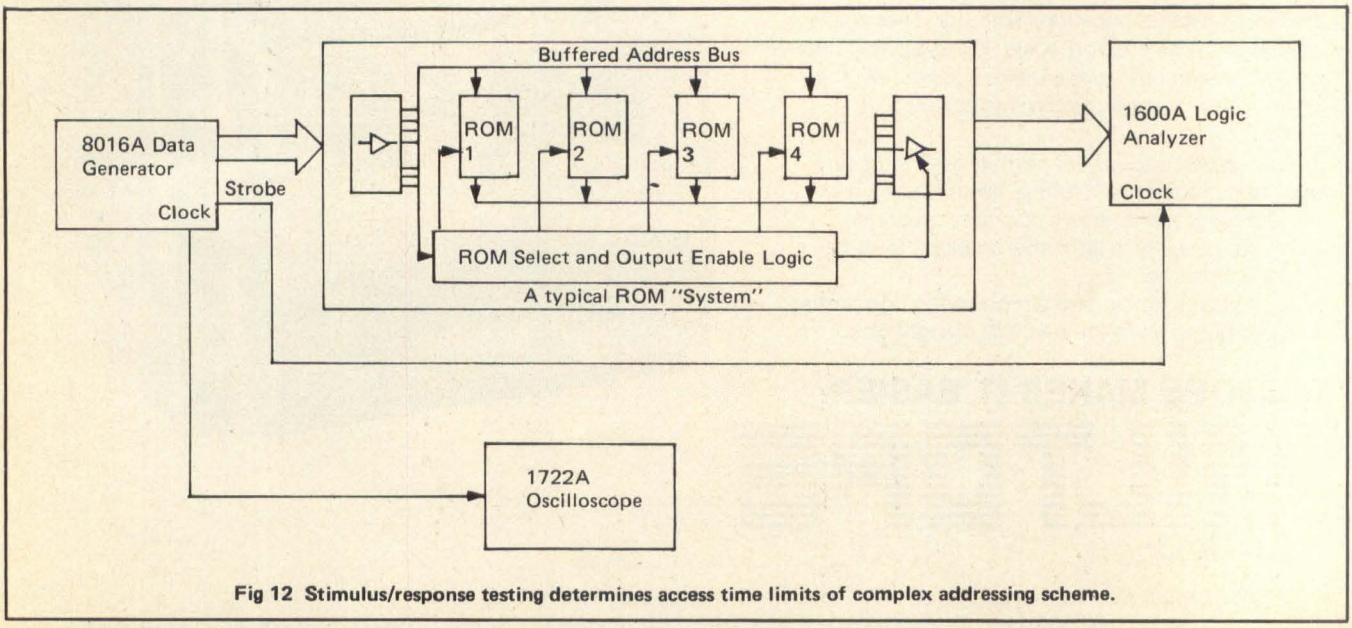


**Fig 12 Stimulus/response testing determines access time limits of complex addressing scheme.**

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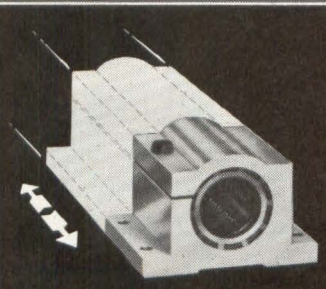
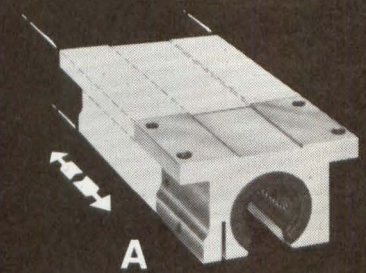
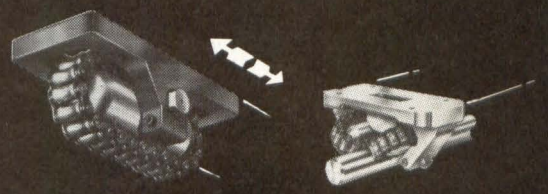


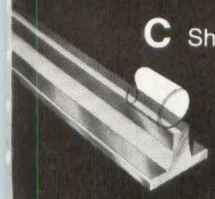
Single and Twin Pillow Blocks



**A** Single and Twin OPEN Pillow Blocks



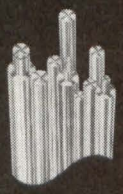
**B** ROUNDWAY Concave-roller Bearings (Single and Dual-V)



**C** Shaft Support RAILS

**D** BLOCKS


**E** WAYMOUNTS™



**F** 60 Case Shafts/Ways

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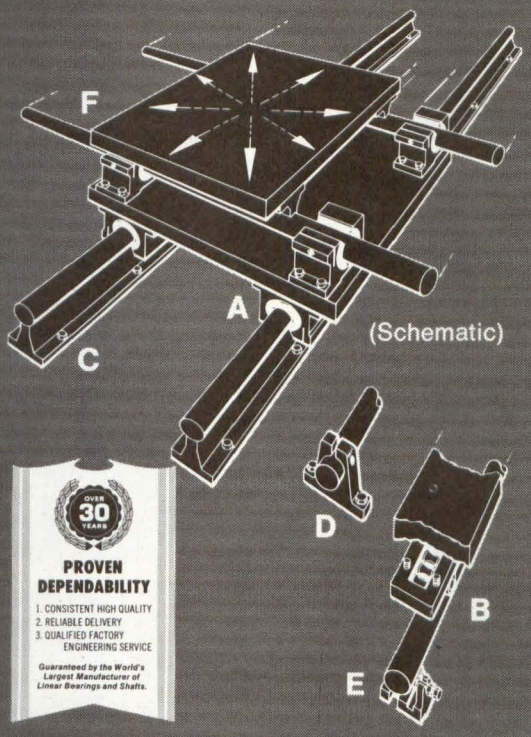


(Schematic)

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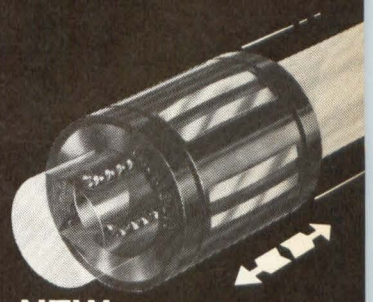

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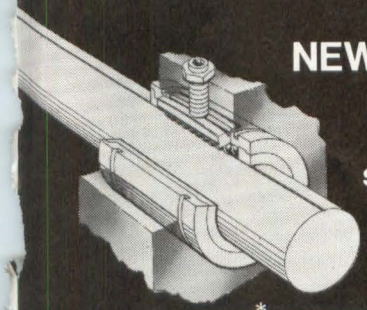

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fering of the data bus. A theoretical calculation of one addressing scheme's access time can yield at best only hypothetical results. To determine the system's actual speed, the experiment shown in Fig 12 was used, replacing the microprocessor with a stimulus that was fully controllable in both frequency and state value, allowing generation of addresses at a variable rep rate. To measure the response of the system, a data monitor was needed that read the memory

| | | |
|---|---|---|
| 11 101 010 | 11 101 010 | |
| 01 100 011 | 01 100 011 | |
| 01 100 100 | 01 100 100 | |
| 00 100 111 | 00 100 111 | |
| 10 101 011 | 10 101 011 | |
| 10 101 100 | 10 101 100 | |
| 10 101 111 | 10 101 111 | |
| 10 110 001 | 10 110 001 | |
| 01 110 011 | 10 110 011 | |
| 01 110 101 | 01 110 101 | |
| 01 110 100 | 01 110 100 | |
| 01 110 111 | 01 110 111 | |
| 01 111 001 | 01 111 001 | |
| 00 111 000 | 00 111 000 | |
| 10 111 011 | 10 111 011 | |
| 10 111 110 | 10 111 110 | a |
| 11 101 010 | 00 000 000 | |
| 01 100 011 | 00 000 000 | |
| 01 100 100 | 00 000 000 | |
| 00 100 111 | 00 000 000 | |
| 10 101 011 | 00 000 000 | |
| 10 101 100 | 00 000 000 | |
| 10 101 111 | 00 000 000 | |
| 10 110 001 | 00 000 000 | |
| 01 110 011 | 00 000 000 | |
| 01 110 101 | 00 000 000 | |
| 01 110 100 | 00 000 000 | |
| 01 110 111 | 00 000 000 | |
| 01 111 001 | 00 000 000 | |
| 00 111 000 | 00 000 000 | |
| 10 111 011 | 00 000 000 | |
| 10 111 110 | 00 000 000 | b |
| 10 101 010 | 01 000 000 | |
| 01 100 011 | 00 000 000 | |
| 01 100 100 | 00 000 000 | |
| 00 100 110 | 00 000 001 | |
| 10 101 011 | 00 000 000 | |
| 10 101 100 | 00 000 000 | |
| 10 101 111 | 00 000 000 | |
| 10 110 001 | 00 000 000 | |
| 01 110 011 | 00 000 000 | |
| 01 110 101 | 00 000 000 | |
| 01 110 100 | 00 000 000 | |
| 01 110 110 | 00 000 001 | |
| 01 111 001 | 00 000 000 | |
| 00 111 000 | 00 000 000 | |
| 10 111 011 | 00 000 000 | |
| 10 111 110 | 00 000 000 | c |

**Fig 13 (a) An entire data table can be duplicated in the B-memory as a stored reference for comparison with active data. (b) The B-memory can be reduced to an Exclusive-OR display of the stored data and the active data being strobed into the A-memory. (c) The presence of intensified 'I's in the Exclusive-OR display indicates that logic differences have been detected between the data in the two memories.**

utput data and indicated when that data was no longer orrect – a logic analyzer functioned as a response monitor.

For the experiment, the word generator provided an addressing pattern then ran at a moderate speed and stored he data (Fig 13) as correctly read by the logic analyzer in .he B-memory as a reference. Having stored this data, the Exclusive-OR display mode was used to show if the data currently being read compared exactly to that stored as a reference. The repetition rate of the word generator could then be increased until the instrument began to detect differences. Then, reducing the frequency just slightly from that point, the rate was measured. Converted to cycle time, the frequency thus read was the actual, not simulated or theoretical cycle time of the memory addressing system.

**Microprocessor Timing Errors.** Another fairly common problem requiring real-time analysis occurs when a flag signal is incorrectly read. See Fig 14. At program address 1002, the external I/O signal must be "set" so that the machine can correctly exit from the loop. An oscilloscope or logic probe verifies the presence of the flag signal, but the machine fails to recognize it. For proper analysis, this problem requires that the oscilloscope be synchronized to the proper moment in state time, not triggered from the detection of the signal itself. Using a logic state analyzer, the pattern trigger output can be used directly, because it is known exactly at which program address, 1002, the flag

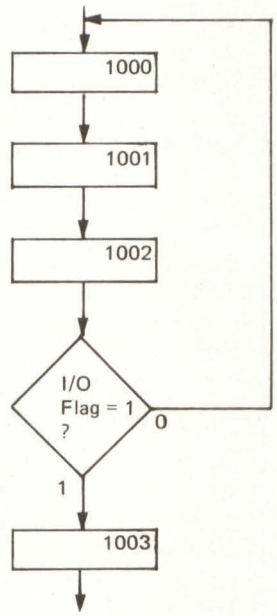
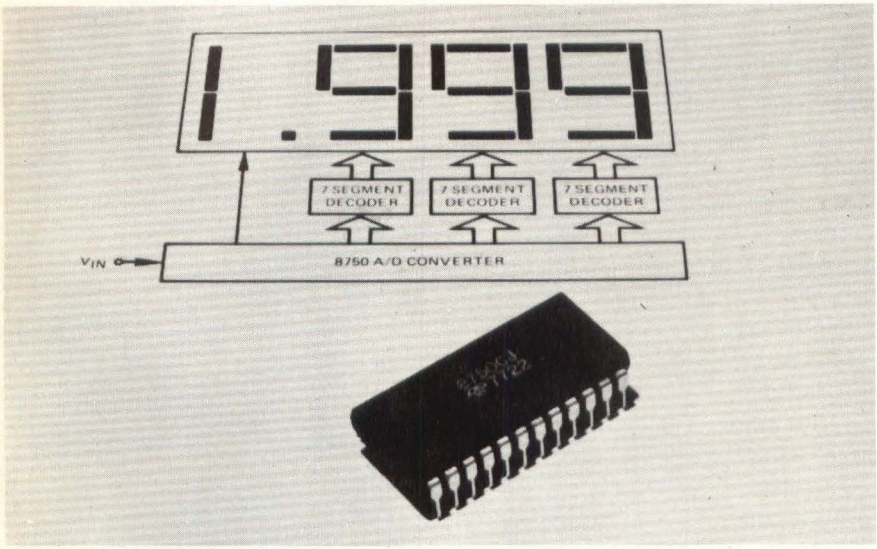



**Fig 14 Failure to detect or properly read the 'flag' signal at program address 1002 causes infinite looping.**

signal is to be read. Externally triggering the scope when that address occurs enables examination of the flag signal synchronized in time to the software. After establishing a state-time reference, it is a simple task to determine whether the signal arrives early or late. **DD**

**Ken Pine** *is with BP Instruments Corp., 10601 DeAnza Blvd., Cupertino, CA 95014.*

# PRODUCTS




## A/D CONVERTER HAS LATCHED BCD OUTPUT

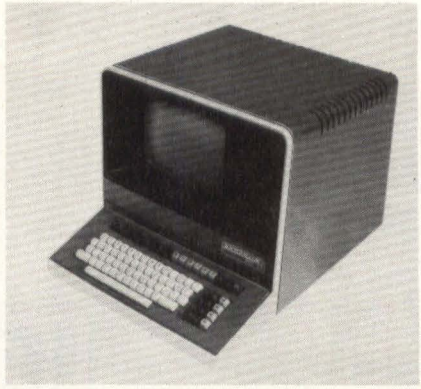
A 3½-digit CMOS A/D converter with latched parallel BCD output, the 8750, comes on a single chip mounted in a 24-pin DIP. It operates on the integrating principle, completing 100 conversions per second. At the end of conversion, the count is latched into the digital outputs as a 3½-digit BCD signal. Applications include LCD's and gas discharge displays. The power drain (2 mA on ±5V supply) makes it suitable for battery operation. Price: (100 unit quantities) $9.75 for the plastic package, and $14.85 for the ceramic. Teledyne Semiconductor, 1300 Terra Bella Ave., Mountain View, CA. 94043. (415) 968-9241. **Circle 153**

## TAPE TRANSPORT INCLUDES FOUR MOTORS

A variable speed electronic cassette tape transport includes four-motor control, remote control capabilities, fast start/stop, less than 30 second rewind, AC or battery-operated and variable speeds. In addition to use in microprocessors, the unit has applications in data recording/logging/storage, programming, instrumentation, industrial controls, data duplicating, security/automatic warning systems, testing apparatus, audio-visual education and hi-fi. In the Phi-Deck,® which incorporates few moving parts, four separate motors control take-up, rewind, play or record and head engagement. The separate motors allow complex tape deck functions to be accomplished by remote control. Control Boards for the Phi-Decks are compatible with TTL, DTL and CMOS. Triple I, 4605 North Stiles, P.O. Box 18209, Oklahoma City, OK 73118. (405) 521-9000. **Circle 157**

## TERMINAL TRANSMITS SERIAL OR PARALLEL

The MC77 terminal incorporates a keyboard with up to 84 stations and a 12-inch diagonal display, and it can transmit data rates from 50 baud to 38.4 kilobaud serial and 10,000 characters parallel. Available



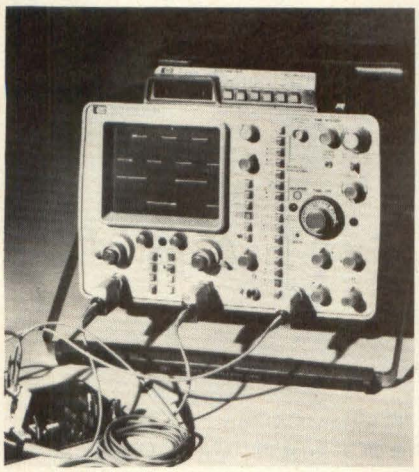
as a firmware (PROM) pre-programmed terminal, the MC77 supports up to 3K of internal program, 1K of program storage and 4K of internal data store. Computer interfaces available for the terminal include synchronous, isochronous and asynchronous data exchange; interfaces can be supplied to meet RS232 and RS422. The MC77 functions in a stand-alone configuration or interfaces up to eight terminals at one data port. Applications of the MC77 include broad-based data entry systems, multi-drop communications networks, text editing and entry systems for automated publishing and pre-pressed computer systems and broad based data transaction systems. Prices start at $1950. Megadata Corp., 35 Orville Dr., Bohemia, NY 11716. (516) 589-6800. **Circle 133**

## HEWLETT-PACKARD OFFERS THREE AUTOMATION SYSTEMS FOR LAB USE

The minicomputer-based HP 3351B, HP 3352D and HP 3353A systems offer software for calculation procedures used by chromatographers for processing output signals of gas and liquid chromatographs. Software includes time of day, external event control, slice width integration, data fields, integrator timed events with new events, summing designated peaks and data storage on tape cartridges. The systems can handle up to 11 I/O devices. Cassettes or cartridges built into consoles, CRT terminals, thermal line printers, teleprinters or other EIA devices. Cassettes or cartridges built into the terminal load software and store user-developed chromatographic methods, sequences or raw peak data. The data cartridges are also used for automatic storage and retrieval of data. The HP 3351B and HP 3352D systems include an HP 21MX processor with 16K words of memory, an A/D converter and a 30-cps printer and console with built-in dual cassettes. The HP 3353A includes an HP 21MX with 16K of memory, A/D converter, thermal line printer and an HP 2645A CRT terminal with 12 Kbytes of memory and dual-tape cartridges. Price start at $10,000. Hewlett-Packard Company, 1507 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. **Circle 175**

## SCOPE MEASURES TIME WITH 1% ACCURACY

Model 1725A Delta Time 275 MHz Oscilloscope measures time between two events with 1% accuracy. Dual channel, delta time capability comes built in; in delta time mode, the oscilloscope can measure time intervals as short as 1 ns. A standard rear panel scaled voltage output fits most DVM's. The CRT beam intensity regulates automatically to prolong CRT life and



enhance viewing on the 8 x 10 cm screen. Stable internal triggering to 275 MHz requires 1 cm of varical deflection (0.5 cm to 100 MHz); stable external triggering requires 50mV peak-to-peak to 100MHz, increasing to 100-mV peak-to-peak at 275 MHz. Vertical deflection factors range from 10mV to 5V per division over the 275 MHz range. Price: $3,300. Hewlett-Packard Company, 1507 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501.

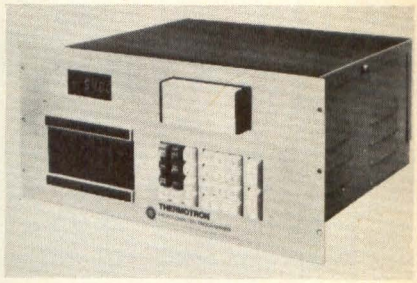
**Circle 173**

## FOAM & CLEANER FOR RECORDER HEADS

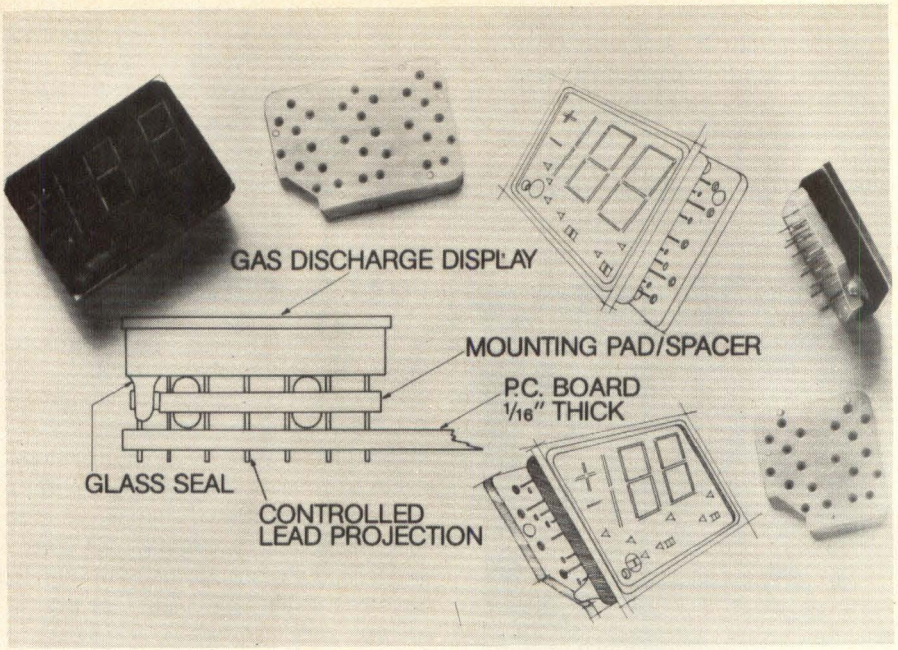
QM-85 Foam & Cleaner, an all purpose tape head cleaning combination, works on audio, video, instrumentation and digital recording equipment. The kit contains a quantity of cellular foam swabs to be used in conjunction with the liquid head cleaner supplied to loosen oxide and dirt accumulations. The liquid head cleaner, specially formulated for use on rubber parts and tape heads, will not leave any residue. A special orifice on the cleaner bottle prevents accidental contamination and dispenses liquid properly to be held, without waste, by the foam structure of the swabs. Nortronics Co. Inc., 8101-10th Ave. North, Minneapolis, MN 55427. (612) 545-0401. **Circle 194**

## μCOMPUTER PROGRAMS SIMULATION TESTS

The Thermotron Microcomputer Programmer provides lighted annunciator display panel for programming environmental simulation tests. Operation requires no com-



puter background. The unit can program up to 50 test segments with repetition of test cycles up to 200 times. The unit comes with a temperature controller, recorder and Productsaver temperature limit mounted in an instrument control console. The Microcomputer Programmer is also available separately for retrofit to existing chambers or for other process control applications. Thermotron Corp., Kollen Park Dr., Holland, MI 49423. (616) 392-1492. **Circle 148**

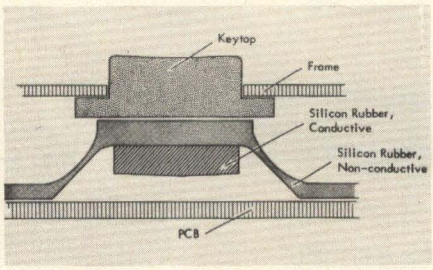



### BECKMAN DISPLAY MOUNTS ELIMINATE PARALLAX

Made of nylon, these mounting, pads space Beckman displays above PCB surfaces. Parallel surfaces of the mount assure the elimination of parallax. With funnel shaped lead entry holes, the pad acts as a pin straightener, guiding the leads into the PCB hole pattern. Posts on the tops and feet on the base of the mount provide for cleaning and inspection. The rigidity of these mounts allows the use of weights when wave soldering. Price: $90.00/K in 10K lots. Bivar Inc., 1617 E. Edinger Ave., Santa Ana, CA 92705. (714) 547-5832. **Circle 130**

### SWITCHES USE CONDUCTIVE SILICON RUBBER

These keyboard and individual switches have a membrane of molded non-conductive silicon rubber on their undersides. A disk of conducting silicon rubber, joined to a cup shaped compartment of the non-conductive material, bridges two elements when the switch




is closed, making contact. When pressure is removed from the switch, the membrane draws the disk back and the switch returns to its normally open state. Applications include calculators, TV remote control switches, cash registers, terminal equipment and telephones. Price: less than 3¢ per switch in quantity. Current Industries Inc., 3359 Ocean Ave., Oceanside, NY 11572. (516) 678-3895. **Circle 176**

### MODEM OPERATES OVER 2- OR 4-WIRE NETWORKS

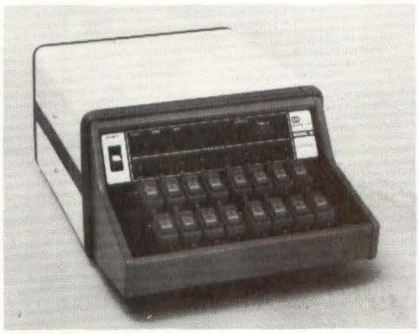
The 2400 LSI modem, designed for 2400/1200 bps operation over 2-or 4-wire dedicated or dial networks, employs a four-phase modulation technique conforming to CCITT Type A or B. The 2400 LSI comes with an equalizer that is strappable in either the transmit or receive sections. Built-in local digital and analog loopback diagnostic capabilities reduce the time required to localize system malfunction, according to the manufacturer. A built-in test pattern generator and receiver pattern detector simplify on and off line testing and troubleshooting. Card size: 5" x 12". Price $789.00. Penril Corp., 5520 Randolph Rd., Rockville, MD 20852. (301) 881-8151. **Circle 167**

## EPROM WITH STANDBY MODE SAVES ENERGY

The model 2758 8K EPROM, a 5V, 8Kbit erasable programmable read-only memory operates on one +5V power supply, upgrades to a 16K masked ROM and can vary storage capacity in 1Kbyte increments with no design changes. It stores 1024 x 8 bits (1Kbyte), is TTL compatible in all modes and has maximum access time of 450 ns. In active operation, the 2758 uses 525 mW, in standby mode, power use drops to 125 mW. All 1024 bytes of memory can be written into the 2758 in less than a minute, according to the company. 100-piece price: $26.60. Intel Corp., 3065 Bowers Ave., San Santa Clara, CA 95051. (408) 246-7501. **Circle 129**

## GANG PROGRAMMER OUTPUTS ALMOST 1 MBYTE/HR

Model 16 PROM programmer delivers EPROM programming rates approaching one megabyte per hour for program output rating based upon 2716 type



EPROM @ $t_{PROG}$= 2 min. This gang programmer simultaneously programs 16 EPROMs, includes a built-in calibration mode, provides fault-finding PROM continuity tests and automatically pretests programmer voltages. The Model 16 uses automatic checksum sequences to test data integrity, includes RS232C serial I/O with selectable baud rates and has an interactive display. Model 16 programs both 2708 and 2716 type EPROMs. To change programmer personality, simply replace the socket adapter on the programmer's front panel. It comes in an enclosure measuring 8 x 13 x 23 inches, and weighs 38 pounds. A 2K-byte by 8-bit expandable RAM is standard. Prices start at $4,800. Data I/O, P.O. Box 308, Issaquah, WA 98027. (206) 455-3990. **Circle 191**

## LINE PRINTERS COMPATIBLE WITH IBM 1403

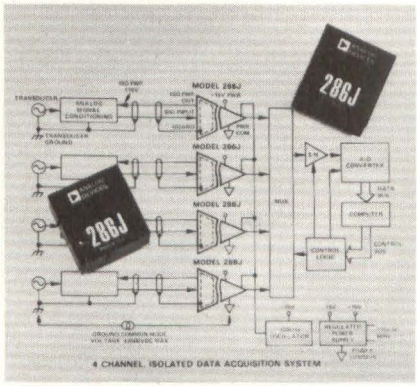
The DOC 1250 and DOC 1500 line printers, aimed at the IBM 1403 market, come fully buffered and print 1250 and 1500 lines per minute, respectively. The DOC 1250 and 1500 printers include power driven forms stacker and cover, six part form printing, ranging from 4 to 18 ¾ inches in width and 3 to 24 inches in length, in-

terchangable print bands using a Universal Character Set Buffer, forms spacing through a forms control buffer, vertical line spacing at 6 or 8 lines per inch and a slew rate of up to 75 ips. The integrated controller communicates through its interface with the host system, decodes all commands, controls printer hardware and reports various errors and status. Price: DOC 1250 $45,000, DOC 1500 $50,000. Documation Inc., P.O. Box 1240, Melbourne, FL 32901. (305) 742-1111.

**Circle 174**

## ISOLATION AMPLIFIER FOR DATA ACQUISITION

Up to eight of these Model 286J isolation amplifiers, optimized for multichannel use in data acquisition systems for industrial and medical applications, can be driven by a single external synchronizing oscillator. Model 286J offers an internal isolated dual 15Vdc @ 15mA supply which powers external transducers and signal conditioning devices. The 284J incorporates an internal oscillator optimizing it for single channel operation. For industrial data acquisition applications, Model 286J provides ground loop isolation and protection from common-mode voltages of ±2500V, continuous or a maximum ±6500 peak, 10ms pulse. Its nonlinearity of ±0.05% at 10V pk-pk output makes the device suitable for systems requiring 10-bit accuracy. Model 286J exceeds the patient safety requirements of Underwrit-

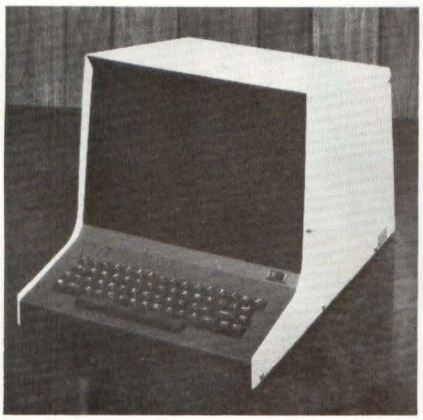



ers Laboratories' Standard 544. Model 286J has low input noise performance of 8μV pk-pk, 100Hz bandwidth, at gain = 100V/V. The isolation amplifier comes in a 1.5" x 1.5" x 0.62" module with a single unit price of $59. Analog Devices Inc., Route 1 Industrial Park, P.O. Box 280, Norwood, MA 02062. (617) 329-4700. **Circle 190**

*(Continued on page 83)*

## INTELLIGENT TERMINAL RUNS AT 9600 BAUD

The MAS/T2 intelligent terminal modules include a 12 or 15 inch CRT displaying 24 lines of 80 characters, 5x7 or 7x9 dot character matrix, baud rates selectable to 9600, RS-232C and 20 mA interfaces, selectable parity, stop bit(s), full/half duplex, composite video interface and inverse video. The firmware of the MAS/T2 incorporates all cursor functions, remote cursor



placement and readback, insert/delete by character or line, transmit with space suppression by line, page or from/to an embedded code and protected fields. Micro Application Systems Inc., 4345 Lyndale Ave., Minneapolis, MN 55412. (612) 522-6591.

**Circle 168**

## SINGLE-CHIP COMPUTERS COME IN 0.6"W DIP

The uCOM-4 4-bit LSI microcomputers, designed for applications in high-production volume industrial and consumer products, include an arithmetic logic unit, user-specified masked ROM for program storage and RAM for data storage and multiple input/output lines. ROM capacity ranges from 640-by-8 bits to 1920-by-10 bits. Each microcomputer has a powerful applications-oriented instruction set featuring multi-function instructions. The 4-bit family has full documentation, prototyping tools, software and software development systems. Each is a PMOS processor that requires a single 10-volt power supply and comes packaged in a 0.6" plastic DIP. Prices range from $2-$8 per unit. NEC Microcomputers Inc., 5 Militia Dr., Lexington, MA 02173. (617) 862-6410. **Circle 128**

## CARTRIDGE DISK DRIVE WITH LINEAR MOTOR

A 50 Mbyte removable cartridge disk drive, the M2201, is directed at OEM manufacturers. Typical applications include small business systems, intelligent terminals, and other microcomputer based systems. The M2201, a front loading disk drive, mounts in racks or desk-type cabinets. Two disks within the cartridge hold the data – up to 50 megabytes unformatted, 40 megabytes formatted. The actuator of the M2201, a linear motor, uses a track following servo system. The linear motor actuator results in fast access times of 6 ms track to

track, and 30 ms average. Price in 100 quantities: $3,900 for the drive, $215 for the cartridge. Fujitsu America Inc., 2945 Oakland Village Ct., Santa Clara, CA 95051. (408) 735-0735. **Circle 144**

## PROBE POD HAS COMBINATIONAL TRIGGERING

A 10-channel, active probe pod detects combinational triggers from up to 36 signals. The Model 10-TC probe pod, useful for troubleshooting microprocessor-based circuits, uses ultraminiature clips, which can be connected to IC pins without the need for DIP clips. This accessory combines high input impedance, combinational trigger with qualifiers, clock qualifying and independent threshold detection: the logic analyzer provides power. The pod may be used as a signal interface, or it can be used to expand the combinational trigger capability up to 36 channels. Model 10-TC also includes fast and slow triggering, selectable thresholds (TTL, ECL, variable) and miniature color-coded input leads and clips. Price: $480. Biomation, 10411 Bubb Rd., Cupertino, CA 95014. (408) 255-9500. **Circle 177**

## SMART MOTOR CONTROL GUIDES TELETYPES

The Model TR20, a smart motor control that allows a Teletype® to print and punch paper tape without producing junk characters during an on-off cycle, has an external motor control with a six character delay for the Teletype® motor to speed up and print. The control requires no programming changes or lead in characters. Mounting by magnet to the Teletype® pedestal, the TR20 connects directly to the motor through a fuse-plug device; solid state relay controls this motor. The Model TR20 measures 6″ x 3½″ x 3″, weighs one pound and operates on 110V current. Price: $175.00. Digital Laboratories, 600 Pleasant St., Watertown, MA 02172. (617) 924-1680. **Circle 169**

# THE WORLD'S FIRST MASS PRODUCED COMPUTER $595.

## HERE WE GO AGAIN . . .

Two years ago it was the pocket calculator. Last year it was the digital watch. Now, incredibly, it's the computer itself.

During the past two years, we've seen the impact that large, vertically integrated manufacturing companies, such as Commodore, can have on the prices of micro electronic products.

In a matter of months, prices for such exciting space age products as multi-function calculators and digital watches fell from hundreds of dollars to less than $10. Until now, however, these products incorporated one, or at most, a handful of integrated circuits.

Now, Commodore Business Machines, one of the largest and most successful calculator manufacturers in the world, has begun mass production of a powerful, general purpose computer system. It's called the PET, for Personal Electronic Transactor.

The PET includes a video display, an alphanumeric and graphics keyboard, and a cassette tape unit for program and data storage. It also contains a standard 4K user memory, and, almost unbelievably, a resident 14K operating system.

The PET is designed to be used by six year olds as well as design engineers. It's ready to run at the flip of a switch. There's no waiting for the operating system to load.

It operates on ordinary current, available in any office, home or factory.

Because the PET will be used for a variety of computer applications, it uses BASIC language, the easiest to learn and simplest to use of all high-level programming languages.

Because of the widespread use of BASIC, a large number of programs are already available from computer time sharing services and from the libraries of computer manufacturers.

Despite its impressive operating characteristics, the PET has fewer parts than a black and white TV set, making it surprisingly easy to service.

In fact, a TV serviceman, equipped with a PET service manual, should be able to service the unit.

## GROWTH POTENTIAL

Additional scheduled products include additional programs, additional memory boards, a telephone interface, printers, and floppy disk drives. A second cassette recorder will attach through a built-in interface.

Pricing for peripherals is anticipated to be as relatively low as the PET is to competitive computers.

## PET SERVICE

The PET Computer was designed to facilitate service. In keeping with the most advanced philosophies of computers today, the PET is composed of three modular circuit boards and a few peripheral components. The main circuit board contains the microprocessor, memory and input-output circuitry. The cassette board replaces the normal audio circuits in the recorder with digital versions for increased data retrival reliability. The TV display board is almost identical to the video section in any standard television. Other components within the unit are the conventional power supply, a standard nine inch picture tube and a removable ASCII keyboard.

Any of these components, in case of defect, may be quickly removed for service. Service is available from Newman Computer Exchange or you may elect to return components for replacement directly to Commodore.

Additionally, Commodore itself will maintain a network of its own Authorized Dealer service centers.

## SPECIFICATIONS:

Dimensions: 16½'' wide; 18½'' deep; 14'' high • Weight: 44 lbs.

**MEMORY:** 14K ROM Operating System
(8K BASIC interpreter • 4K Operating system • 1K Machine language monitor • 1K Diagnostic routine)

**RAM User Memory**
4K standard ($595)
8K optional ($795)
32K maximum RAM

**VIDEO DISPLAY UNIT**
9'' enclosed, black and white, high-resolution CRT • 1000 character display, arranged 40 columns by 25 lines • 8 x 8 dot matrix for characters and continuous graphics • Automatic scrolling from bottom of screen • Winking cursor with full motion control • Reverse field on all characters (white on black or black on white) • 64 standard ASCII characters; 64 graphic characters

**KEYBOARD**
9½'' wide x 3'' deep; 73 keys • All 64 ASCII characters available without shift. Calculator style numeric key pad • All 64 graphic and reverse field characters accessible from keyboard (with shift) • **Screen Control:** Clear and erase
**Editing:** Character insertion and deletion • Easy screen-line-edit capability

**CASSETTE STORAGE**
1400 bits/sec Commodore designed redundant-recording scheme, assuring reliable data recovery • Cassette drive modified by Commodore for much higher reliability of recording and record retention. • High noise immunity, error detection, and correction • Uses standard audio cassette tapes. • Tape files, with up to 80 character file names. • Operating system makes it impossible to forget file names. • Second cassette drive from Commodore plugs in easily.

**OPERATING SYSTEM**
Supports multiple languages (BASIC resident) • Machine language accessibility • File management in operating system • Cursor control, reverse field, and graphics under simple BASIC control • Cassette file management from BASIC • True random number generation or pseudo random sequence

**INPUT/OUTPUT**
Cassette I/O see Cassette Storage • 8 bit parallel user port • All other I/O supported through IEEE-488 instrument interface which allows for multiple intelligent peripherals • All I/O automatically managed by operating system software • Single character I/O with GET command • Flexible I/O structure allows for BASIC expansion with intelligent peripherals

**BASIC INTERPRETER**
Expanded 8K BASICS; 20% faster than most other 8K BASICS • Upward expansion from current popular BASIC language • Strings, integers and multiple dimension arrays • High precision (10 significant digits) • Direct memory access through PEEK and POKE commands

## OUR OFFER TO YOU

We honestly believe the announcement of the PET is a significant event in the history of computing. No one, not even IBM, has ever mass produced a computer.

For at least a year, demand could exceed supply.

In order to insure our customers the earliest possible delivery of this exciting product, NCE/CompuMart placed a large, pre-paid order with Commodore approximately six months ago. Ours was the first volume order which Commodore received for this product.

Because of our priviledged delivery position, we are now quoting ninety day delivery from receipt of order.

Given the unprecedented nature of this product, however, it is possible that demand will exceed even our own expectations.

You may cancel at any time and receive a full refund.

## NCE WARRANTY

The PET Computer is warranted for ninety days from date of shipment. Any defective components within the warranty period returned to NCE or Commodore will be replaced by a brand new component. Exceptions: abuse, misuse, alteration, neglect or shipping damage. NCE/CompuMart, Inc. will not be responsible for any consequential damage resulting from such defect.

Send for our catalog

***FREE!***

*with your business card or send $1.00 (refundable on first order)*


COMPUTER DEALERS ASSOCIATION

## ORDER FORM

**ORDERED BY:**

Company Name _____
Contact _____
Address _____
City, State, Zip _____
Telephone _____

| Quantity | Description | Each | Total |
|---|---|---|---|
| | PET 2001 with 4K RAM memory | $595 | |
| | PET 2001 with 8K RAM memory | 795 | |
| | Total for Goods | | |
| | Shipping, Handling, and Insurance | | $16.00 |
| | Add 4% Sales Tax—Michigan Residents | | |
| | TOTAL AMOUNT | | |

*All orders must include bank check, postal money order, BankAmericard Visa or Master Charge number, or qualify for open account (see Terms and Conditions.)*

Signature _____

**PLEASE FILL IN BELOW FOR CREDIT CARD ORDERS**
*(Please include all raised numbers.)*

☐ BankAmericard/VISA ☐ Master Charge
Credit Card Account Number _____
For Master Charge only (No. above your name) _____
Expiration or "Good Thru" Date of Card _____

**TERMS AND CONDITIONS:** All orders must be signed by authorized person. Equipment may be purchased by cash or credit card. (no COD's.) Open accounts for only D&B rated businesses with rating of BA2 or better, federal and state institutions or established educational institutions. A formal purchase order must be included, conforming to all terms and conditions stated herein. Net 15 days from date of order. FOB Ann Arbor, Michigan. Shipments will be insured for full value, customer responsibility for setting transit damage claims. Prices and specifications subject to change without notice. NCE/CompuMart makes no warranty (other than that stated in ad) with respect to merchantability or fitness of said material for any particular purpose. NCE/CompuMart assumes no responsibility for any errors that may appear in this ad.

# Newman Computer Exchange/CompuMart

**1250 N. Main St., Ann Arbor, Mi. 48104 Dept. DD2 (313) 994-3200**

## CRT TERMINAL OFFERS HIGH-RESOLUTION

This CRT terminal, designed to present 100 line-per-inch displays of standard 8½" x 11" page formats, uses a 15-inch diagonal CRT screen with its long axis vertical. The terminal refreshes the display from a built-in semiconductor memory in raster scan fashion. The 9" x 11½" CRT image consists of a 908 x 1152 dot matrix, fully controllable by the host processor. 1,046,016 dots are stored within the terminals dynamic random-access memory and each dot is either on or off; no gray scale is presented. 65,376 bits of semiconductor memory provide cursor capability, with one bit assigned to each 4 x 4 image block. Applications include alphanumeric displays, general purpose graphic arts, photo-composition and word processing. Price: about $5,000. DataCopy Corp., 3408 Hillview Ave., Palo Alto, CA 94304. (415) 493-3420. **Circle 170**

## 40-PIN CONTROLLER FOR 3 PRINTER TYPES

Model CY 480 Universal Printer Controller controls and interfaces 5" x 7" dot matrix printers with print speed up to 200 characters/s. The CY 480 works with impact, thermal and electrostatic dot matrix printers, including those from Victor, LRC, Practical Automation and Amperex. One +5V power supply powers the controller, which interfaces a printer with a microcomputer or minicomputer system through standard 8-bit ports. The controller accepts RS-232 serial or parallel ASCII input and includes a 5 x 7 dot matrix character generator, upper and lower case ASCII characters and internal line buffer storage. Price: $92.00. Cybernetic Micro Systems, 2460 Embarcadero Way, Palo Alto, CA 94303. (415) 321-0410. **Circle 171**

## LOWER COST 0.5" LED DIGITS AVAILABLE

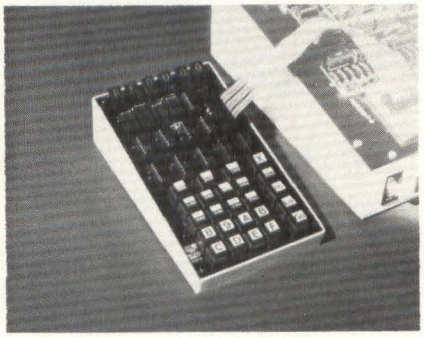
A line of 0.5" LED digits priced 30% to 40% lower than any others of the same size and comparable eye appeal were developed through computer-aided optical design. The large, bright, uniformly-lit digits use a low-cost manufacturing technique and can be seen clearly over a viewing angle of nearly 180°, according to a Litronix spokesman. The DL-520 series of 0.5"H digits come in 1, 1½ and 2 digits DIPs and in 2 to 6 digit modules with PCB edge connectors. The 1½ digit DIP includes a polarity indicator. The displays operate off a +5V TTL supply and incorporate decimal points after each digit, have common anode or common cathode terminals and come with a red plastic cap or a clear plastic cap suitable for use behind a transparent red window. Litronix, 19000 Homestead Rd., Cupertino, CA 95014. (408) 257-7910. **Circle 149**

## GANG PROGRAMMER PROGRAMS 16 PROM's

This 16 Gang Programmer programs and verifies PROM's of the 2708 or 2716 families. All 16 sockets can be programmed at the same time or you can program the first tier of eight sockets while loading the second row and then program the second row while unloading and loading the first. Plug-in mother sockets permit easy changes of worn top sockets. A pass/fail light on each socket verifies good parts and a run and complete light enables the user to follow the operation of the unit. Price: $2,995. Prom Programmers Inc., 601 Nandell Lane, Los Altos, CA 94022. (415) 948-0450. **Circle 165**

## KEYPAD ACCESSORY FOR MMD-1 μC IN KIT

Two data entry and display keypads function as accessories for the Mini-Micro Designer (MMD-1) training and development microcomputer. One keypad has a two-digit hexadecimal LED display expandable to six digits. Both keypads come in assembled and kit form. MMD/HEX-1 and MMD/HEX-2 keypads provide a method for programming with the 4-bit binary hexadecimal



code. The calculator-type 16-key array with eight additional function keys permits the execution of programs, modifying or examining the contents of memory and registers and monitoring performance. One pair of 0.3-in high LED hexidecimal displays comes with each MMD/HEX-2 keypad. The 4 by 7 displays contain onboard latch, decoder and driver chips. Displays may also be added to the MMD/HEX-1 keypad. A conversion PROM, all integrated circuits, a 28-pin double-ended interconnection cable and instruction manual are included with both keypads. Price: for the MMD/HEX-1 in kit form is $105.00, for the MMD/HEX-2 in kit form, $155.00. E & L Instruments, Inc., 61 First St., Derby, CT 06418. (203) 735-8774. **Circle 152**

## SYSTEM PRODUCES HARD COPY IN 10 SECONDS

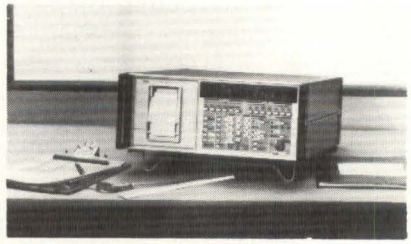
The 1640 Hard Copy System produces hard copy in ten seconds from any Hewlett-Packard 2640 series terminal. One system can serve up to eight terminals. The Hard Copy System consists of a Versatec 1600A printer/plotter and an integral plug-compatible interfacing controller. The printer/plotter provides an essentially 1:1 image size and comparable aspect ratio with resolution of 160 dots per linear inch with a maximum plot width of ten inches across eleven-inch wide paper. Replacing line printers and pen plotters, the 1640 prints 1000 100-column lines per minute. Hard copy is produced on electrographic paper at one-fourth the cost of dry silver paper. Operator controls include power ON, local/remote operation, image reversal selection, hard copy request, priority (terminal only, CPU only, automatic) and multiple copy selection (1-15). Indicators display power ON, video status and plotter status. The system measures 23"W, 18"D, 38"H and weighs 185 lbs. Price: $9950. Versatec, 2805 Bowers Ave., Santa Clara, CA 95051. (408) 988-2800. **Circle 155**

## CPU CARD HAS CRYSTAL-CONTROLLED CLOCK

The PDC-100, a SC/MP II central processing unit, is bus and card compatible with National ISP and MilerTronics PDC cards. The PDC-100, a self-contained unit with onboard RAM and PROM, controls memory and I/O lines, address decoder for system control, software half and crystal controlled clock with 600 ns/microcycle. Price: $275.00 MilerTronics, 303 Airport Rd, Greenville, SC 29607. (803) 242-9232. **Circle 140**

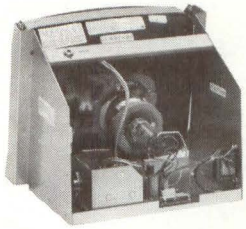
## EXPANDED DATA LOGGER LINE HAS 3 ALARMS

A family of microprocessor-controlled data loggers includes remote programming, expanded inputs and alarms. Conditioning and custom scaling options handle RTD's and inputs from any voltage, current or digital trans-

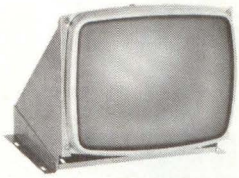


ducer in addition to a wide variety of thermo-couple inputs and DC voltages up to 40Vdc. The unit includes three alarm functions (alarms-once, all-on-alarms and all-on-alarms-once) together with basic "all-alarm" operation. Prices start at $2,700. John Fluke Mfg. Co. Inc., P.O. Box 43210, Mountlake Terrace, WA 98043. (800) 426-0361. **Circle 162**

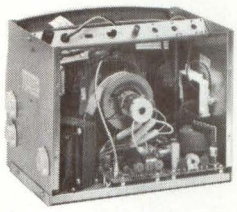
**Reliability:** Our data displays are outstanding solid-state designs with critically matched magnetics to optimize the performance levels and dependability demanded by your customers. We use the most advanced engineering and production techniques to assure consistency of performance. No data display is built with more deliberate attention to quality and reliability.



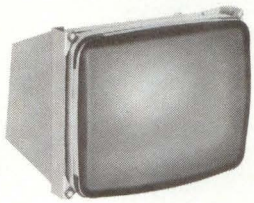
**Delivery:** We have been in the display electronics business long enough to know about rush orders. If you need it yesterday — we'll try to get it to you yesterday.



**Experience:** We've built thousands of displays for many of the major manufacturers in the country. Perhaps we already have a unit that would meet your requirements. With slight modifications. It would be less costly than starting from scratch. If you need a new, special package — we'll produce it for you, in the configuration you want, at minimal expense.



**Cooperation:** If you're developing a new data terminal, we will be glad to cooperate with your terminal design engineers in reviewing your exact specifications and developing the most economical display possible. And quickly! Whatever you need, we have the experience and talent to design it. And improve it.



But don't take our word. See for yourself by contacting us today.

You'll come up with your own reasons for using Setchell Carlson CRT display modules.

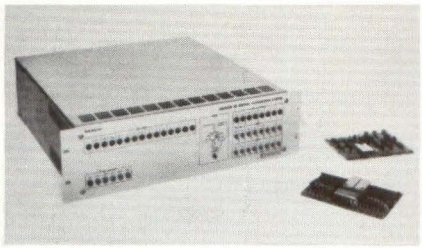
# If you make top-quality data terminals, here are four reasons to use Setchell Carlson CRT display modules in your system.

SC ELECTRONICS, INC.
A SUBSIDIARY OF AUDIOTRONICS CORPORATION
530 5th AVE. N.W. NEW BRIGHTON, MN. 55112 (612) 633-3131

CIRCLE 52

## MULTI-CHANNEL MULTIPLEXERS FOR ADCs

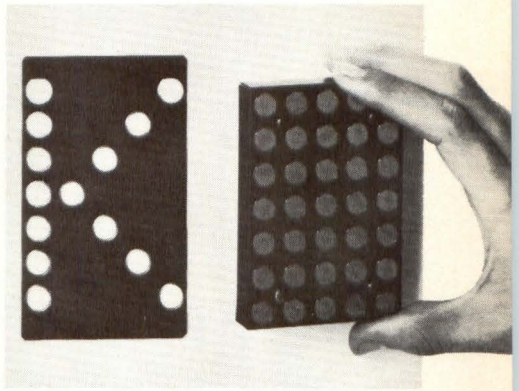
Available in two plug-in configurations for use with either single-ended or differential analog input signals, the Model GMM-4 Multiplexer provides input-to-output linearity within 0.01%, input impedance of 1000 MΩ, and input current offset of less than 20 pA. With a full scale input range of ±10V, the Model GMM-4 multiplexers, in combination with a 15 bit A/D converter, provides single-digit resolution of analog signal changes as small as 612 μV.



The sample-and-hold amplifiers have a combined stability and linearity of ±0.01% and a settling time to 0.01% of less than 2 μs. The GMAD-4 comes with 9,11 and 14 bit resolution (plus sign). Output data is delivered at a conversion rate of 50 KHz – equivalent to a conversion time of 20 μs per channel at standard TTL compatible logic levels. The GMAD-4 Analog-to-Digital Conversion Systems interface with minicomputers and controllers such as the DEC PDP-11, HP 2100, Varian V-73 and the Data General NOVA. Preston Scientific Inc., 805 East Cerritos Ave., Anaheim, CA 92805. (714) 776-6400. **Circle 183**

## LED ALPHA-NUMERIC DISPLAY 4 INCHES HIGH

An alpha-numeric LED matrix display called "Datablox" provides alpha-numeric digits 4" x 3" and uses 35 (5 x 7 matrix) high-intensity LEDs mounted in individual reflectors. The digits have a brightness and visibility which make them easily readable, with wide angle viewing, at distances of over 200 feet in normal office lighting conditions. This makes them ideal for use as indoor displays or messages in banks, brokerage houses, transit terminals and for process control applications. Available in either red or yellow, the units have the solid state benefits of low power, long life and ruggedness,



which permits their use in applications where life, shock and vibration, or heat/power consumption are of prime importance. Compatible with solid state drive, they are capable of generating the full 64 character ASCII set. Chicago Miniature Lamp Works, 4433 N. Ravenwood Ave., Chicago, IL 60640. (312) 784-1020. **Circle 161**

## μP OCTAL LATCH AND REGISTER AVAILABLE

An octal latch (SN74S373) and an octal register (SN74S374) are second sources for Texas Instruments' like-numbered standard Schottky TTL devices. The latch and register include three-state outputs designed to drive the high capacitance and low impedance required by long buses connecting processor, controller and I/O subsystems. Three proprietary versions of both the latch and register offer high $I_{OL}$'s (32mA), inverting outputs, and a device combining both 32mA $I_{OL}$'s and inverting options. All three versions are drop-in replacements for TI's standard 54/74 parts. Applications include single-board computers, discrete peripherals, minicomputers, instrumentation and memory address drivers (PROMs, ROMs, RAMs), bus drivers/receivers and clock drivers. Monolithic Memories, 1165 East Arques Ave., Sunnyvale, CA 94086. (408) 739-3535. **Circle 186**



## BENCH-TOP TESTER SOFTWARE PROGRAMMABLE

The ALMA 480B benchtop tester performs parametric and functional tests on Integrated Circuits (IC's) and is directed toward the end-user market. Input and output power and ground to device are Kelvin wired, assuring accuracy in testing when

using an autohandler or when low-level swings are involved, according to a Watkins-Johnson spokesman. The software-programmable WJ-480B sets up in minutes, using a library of over 1,800 programs provided at no cost to the user. The unit price is $9,500. Watkins-Johnson Company, 3333 Hillview Ave., Palo Alto, CA 94303. (415) 493-4141. **Circle 132**

## ERROR DETECTION SYSTEM FOR μP CONTROLLER

The Error Detection and Indication Package (EDIP) for the EPTAK Microprocessor Controller provides early warning of system degradation; immediate alarm in case of actual failures; indication of system self-correction when it occurs; and simplified software debugging and system installation. The unit is available with new systems or for those already installed. The EDIP alerts the operator to malfunctions internal to the control system – for example, an error in the printer interface module – as well as malfunctions external to the control system. The package comprises factory programmed software, an operator manual and watchdog timer and error indicator modules. Eagle Signal Division, 736 Federal St., Davenport, IA 52803. (319) 326-8120. **Circle 185**

Pardon the tongue in cheek, but we wanted to say something in a "memorable" way:

Data 100 knows what an OEM wants in a line printer.

Like high performance with low noise.

That's because line printers are often located in offices. And offices have people in them. People who think better, work better in a quieter environment.

Meet our complete line of 62-300 lpm printers in optional Whisper Quiet cabinet. It lowers the decibel reading from an annoying 77 to a people-pleasing 68. Yet delivers full performance.

Sound good to you? It should. We're proud to use these Whisper Quiet line printers in our Data 100 systems, too.

**DATA 100**
**CORPORATION**

**Data 100 knows what an OEM wants in a line printer.**

# Whisper Quiet.

## Our OEM printers are so quiet they won't shatter glass. Or nerves.

NEWPORT BEACH CA (714) 549-0982 • SANTA CLARA CA (408) 732-1530 • BRAINTREE MA (617) 848-6100 • SOUTHFIELD MI (313) 358-3984 • EDINA MN (612) 941-6500 • CHERRY HILL NJ (609) 665-5141 • WOODBRIDGE NJ (201) 634-7800 • HOUSTON TX (713) 777-4413 • McLEAN VA (703) 790-5560 • TORONTO CANADA (distributor) (416) 495-0222 • HEMEL HEMPSTEAD ENGLAND (0442) 66511 • BRUSSELS BELGIUM 251•69•72• FRANKFURT GERMANY 72•04•71 • PARIS FRANCE 630•2144 • MILAN ITALY (02) 659•52•32

CIRCLE 62

# Reach the rich European market... now


Many perceptive marketers get a third of their sales from Europe. Where U.S. technology is welcome.

There's no better time than now to parlay potential into profits. If you know where to go. And how to get your message across the Atlantic.

**DIGITAL DESIGN** gets it there. Talk to our regular U.S. readers at our normal low cost-per-thousand rates and you talk to our European readers at the same time.

Not just any Tom, Dick or Guisseppi either. Qualified prospects, all. Customers whose interests, installations and buying intentions are catalogued on our own comprehensive qualifications questionnaire. Rifle stuff, not shotgun.

We're in major international trade shows, too. With extra distribution. We monitor markets, sense trends, glean prospects, sift feedback. So that when you advertise in **DIGITAL DESIGN**, low cost-per-thousand isn't the only name of the game. It's sales.

**Digital Design**
The Magazine of Digital Systems
the market makers

**Benwill Publishing Corporation,** 167 Corey Road, Brookline, MA 02146 ★ **West** (213) 454-0624 ★ **East** (617) 232-5470

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# ALPHA BITS

## Using Semicon Memories

Recent developments in semiconductor technology give design engineers new options for system design. In order to solve your problems in an efficient and cost-effective manner, you need a comprehensive overview of the available devices. **A User's Handbook of Semiconductor Memories** covers processing and technological aspects of semiconductor memory technology, memory cell design types and tradeoffs, chip decoders and sense amps. The handbook, written by Eugene R. Hnatek, emphasizes using the more popular IC memories in practical applications such as shift registers and FIFO systems. An extensive discussion of ROM versus PROM is included; the book also covers important topics such as random access memories, content addressable memories and charge coupled devices. Published by Wiley-Interscience, the handbook costs $29.95.

## Learn About Microcomputers

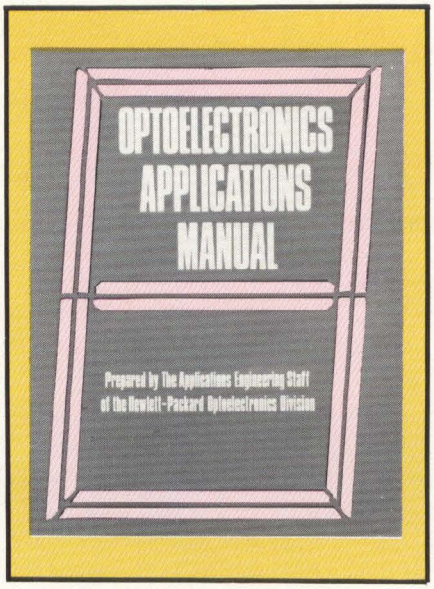
**Microprocessors and Small Digital Computer Systems for Engineers and Scientists** discusses computers, languages, architecture and software for applications in industry, commerce, education and other fields. Written by Granino A. Korn, this book provides a survey and comparison of available microprocessors and microprocessor-based computers. The book also covers input/output interfaces and interrupt circuits and their effects on programming. Also included: tips on assembly language and the use of macros for writing your own computer languages; a discussion of software systems and microcomputer development systems; and reference guides to the extended BASIC and PL/M computer languages. Published by McGraw-Hill, this book costs $24.50.

## Timing Sourcebook

**The 555 Timer Applications Sourcebook with Experiments** by Howard M. Berlin contains practical information on the 555 integrated circuit timer. The first 10 chapters detail the organization and characteristics of the 555 timer. Additional chapters cover the IC as a monostable multivibrator and its use in power supplies. Four chapters outline the use of the 555 timer in electronic games, automotive, home and telephone circuits in such hobbies as music, photography and amateur radio. The last chapter contains 17 simple experiments that you can breadboard easily; these experiments demonstrate how the timer works and what it can do for you. You can obtain the sourcebook for $6.95 from E&L Instruments, 61 First Street, Derby, CT 06148.

## Seeing Is Believing

Solid-state optoelectronic devices save time, effort and cost in many digital systems applications; Hewlett-Packard's **Optoelectronics Applications Manual** analyzes some of the available optoelectronic devices. The manual treats Current Transfer Ratio (CTR) degradation, a controversial and frequently misunderstood subject, showing you how to control the change in CTR in practical circuits. The first two chapters explore LED's, covering theory, packaging and design and digital applications, for example in telephone circuits and microprocessor systems. Chapter 3 reviews the theory and important parameters of opto-isolators, including both digital and analog applications of isolators. Chapter 4 covers photodiodes, Chapter 8 discusses reliability and Chapter 9 tells you about mechanical handling considerations for LED devices. Chapters 5-7 cover a wide range of applications: displays, wavelength filters, photometry and radiometry. The manual, published by McGraw-Hill, costs $19.25.




## Testing Logic Circuits

The second edition of the **Handbook of Logic-Circuit Testing** contains new chapters on microprocessor testing and field service testing. Descriptions of available programming, testing and fault-isolation techniques have been revised to include test systems that have recently appeared on the market. The handbook also explains how to assign priorities for boards to be programmed and how to prepare financial analyses. The handbook reduces the time required to compare techniques and testers by analyzing most of the test system vendors and describing the advantages and disadvantages of current product lines. Available as three volumes that may be purchased separately, the handbook is published by Omnicomp, Inc., 5150 North 16th Street, Suite 253, Phoenix, AZ 85016.

## Image Analysis

Optical Character Recognition, computerized tomography, fingerprint identification and detection of targets in aerial photographs are just a few ways in which computer image analysis is used. **Computer Methods in Image Analysis** draws together 32 papers on digital image analysis, from fundamental to advanced techniques. Sponsored by the IEEE Computer Society, the 472-page book costs $14.95 in a paperbound member edition or $29.95 clothbound ($22.45 for IEEE members). Order postpaid from the IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854.

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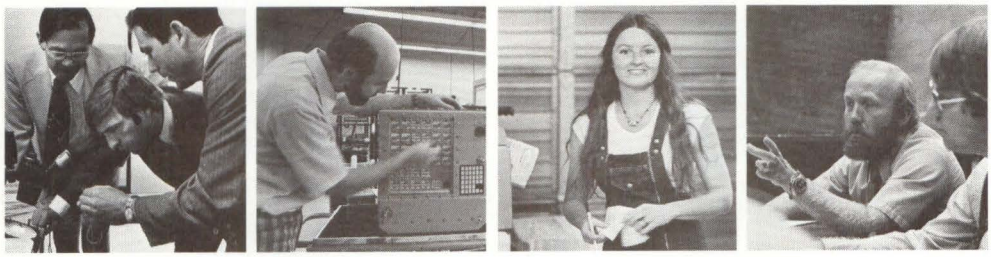

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