Introducing our new thumbwheel switch

for 8-mm thumbs.
It's a skinny switch that we call the 1800 Series.
It has many of the features of our notorious 1776 Series—but simpler, more standardized, and cheaper.
For example, just $2.50 for one, less for more, with a choice of five codes, gloss or matte finish, with or without stops, and readable by 20/20 eyes from 10 feet away.

It's got PC board terminations for plug-in or solder connections, and it snaps into a panel for mounting (no tools needed).
It mounts singly or ganged (up to 20 stations), and will give at least 500,000 detent operations before it tires.
So now we've left you with no excuse for not choosing EECO when you need a thumbwheel switch.
We've got more versions for more applications than any other switch maker in the country.
And more offices to buy from (87 in the U.S. and Canada).
For any thumbwheel switch, see us first.

WE'VE GOT YOUR SWITCH.

1441 East Chestnut Avenue, Santa Ana, California 92701 Phone 714/835-6000
Distributed in the U.S. by Half-Mark, G.S. Marshall, and Schweber. In Canada by R.A.E.

CIRCLE 1 ON INQUIRY CARD
World Travelers

Kennedy tape recording equipment—it's the finest in the world, and that's why it's in use around the world. Kennedy recorders are monitoring and recording airport traffic and arrivals in Holland; solar activity to determine the Earth's weather, in Switzerland; gasoline usage at stations in Sweden; banking systems for up-dating payments and billing in Japan; computerized feed lots in India; utility power distribution to industry in England and telephone usage analysis, toll ticketing, message switching control and automatic program load for virtually every country with a telephone service.

These are only a few of the countries and applications where Kennedy products are solving problems.

Asynchronous tape drives, vacuum column tape drives and a complete line of cartridge recorders are available for any application.

To service Kennedy products, there is a European service center and parts depot to handle factory warranties, repairs and parts stocking. If you're an OEM doing business in Europe, that's something to think about. Kennedy tape products—they're the finest in the world. If you're thinking international, think

KENNEDY CO.
540 W. WOODBURY RD., ALTADENA, CALIF. 91001
(213) 738-0893
CIRCLE 2 ON INQUIRY CARD

KENNEDY • QUALITY • COUNT ON IT
TALLY LINE PRINTERS
AT NEW LOW PRICES.
As the volume builds, the prices drop.

Significant Cost Reductions.
OEM's will realize substantial savings totalling hundreds of dollars. Quantity buyers — thousands of dollars. If you thought you couldn't afford Tally quality before, try again. Re-examine the low cost of ownership you get with Tally. Installation records prove the Model T-2200 requires far, far fewer maintenance calls than the competition.

10,000 Units Delivered.
10,000 astute users is ample testimony to the field proven merit of the Tally reliability story. And now because production volume is up, we can pass along our quantity savings to you. And you, in turn, can offer your users the plus performance benefits of Tally line printers.

Zero Maintenance.
Tally's unique comb matrix printing technique is the reliability key. Belts, clutches, lubrication points are eliminated. Never any adjustments. Nothing moves if the unit isn't printing. No duty cycle limitations. No preventative maintenance except routine cleaning. A one year warranty.

Interfaces? Lots of Them.
Whatever your mini, micro or remote terminal, the T-2200 works with it. For years, it has been running successfully with:

Data General Prime
DEC InterData
Hewlett-Packard DCC
Lockheed Intel
MicroData . . . and many others.

CALL TODAY
Get in touch with your nearest Tally sales representative for the new prices. And remember, the more units you buy, the bigger the price reduction. Tally Corporation, 8301 S. 180th St., Kent, WA 98031, Phone (206) 251-5524.

Regional Offices:
Boston (617) 742-9558
New York (516) 694-8444
Chicago (312) 956-0690
Los Angeles (213) 378-0805
Melbourne Beach (305) 724-0480
San Jose (408) 247-0897
Seattle (206) 251-6730

TALLY
INTERNATIONAL ELECTRON DEVICES MEETING
1976 IEEE IEDM will present 26 technical sessions stressing solid-state devices, device technology, energy conversion devices and quantum electronics, image transducers and optoelectronic devices, and integrated electronics

PROCEDURE EVALUATES COMPUTERS FOR SCIENTIFIC APPLICATIONS
by Louis Wolin
Based on a scientific mix, technique can be used to evaluate computer systems, selecting an optimum system and calculating an approximate required solution time for a given problem

IMPACT OF LSI ON TERMINAL ARCHITECTURE
by Peter G. Cook and Thomas B. Cheek
LSI technology offers the opportunity to reduce cost and increase reliability of terminals, and holds promise of a real breakthrough in product design if engineers watch for opportunities

CHALLENGES IN MICROPROCESSOR SYSTEM DESIGN
by Tom Jones and Peter Thomas
By treating a microcomputer system as if it were a small minicomputer, specifically designed for an entire line of products, manufacturers can take full advantage of today's microprocessor technology

LOW POWER COMPUTERS: A MAKE OR BUY DECISION
by Jerry Washburn
Many advantages exist for buying traditional low power minicomputers rather than building computers using microprocessor chips and other ICs

SMALL BUT VERY FAST MINICOMPUTER OFFERS LARGE-MACHINE PERFORMANCE
Smallest member of computer family meets computational and data collection requirements of scientific and data communications applications
ONCE YOU HOOK UP WITH US, YOU'RE HOOKED.

Your watch and wallet will tell you why, once you've used our QT solderless breadboarding Sockets and Bus Strips. Because of the time and money you'll save by eliminating soldering, desoldering and resoldering on every circuit you design or test.

With the QT system, you can instantly connect and reconnect all kinds of components—as fast as you can push in (or pull out) a lead. Durable 5-point terminals provide fast, easy interconnections between components, and jumpers, where necessary, are lengths of #22 AWG solid wire.

You'll save money because components can be reused again and again, with no heat to damage delicate semiconductors. You can start off inexpensively—as little as $3.00** for a compact socket with 70 solderless tie-points—and expand with interlocking units to any size you need.

Problem is, once you see how much time, money and aggravation our QT system saves, you'll never want to breadboard any other way. (For more information, see your CSC dealer, or write for our catalog and distributor list.)
While other mini-makers have been pushing & shoving...

one company has quietly become number 2.

They've quietly shipped over 9,000 computers. In fact, over 400 of their minis are going to OEM's every month.

Because so many computer makers use their minis, they're often called the Computer Company's Computer Company.

Others deliver a mini or two to get an OEM roped in... then make them wait for 9 months. While this quiet company ships quantities in 45 days.

They offer a full family of compatible micros thru minis. With price/performance, technology, features and benefits to delight the most demanding designers.

And all the software you'll ever need. Field-proven. In thousands of installations. Plus a variety of support services, and other protection to their customers. Over 300 OEM's use their minis. It's...

DIGITAL COMPUTER CONTROLS INC

The Quiet Mini-Maker. We're Number 2.

For further information, contact: Digital Computer Controls, Inc.,
12 Industrial Road, Fairfield, N.J. 07006, (201) 575-9100
TWX 7107344310

*In the number of minicomputers currently being shipped to Original Equipment Manufacturers.
NOV 18, JAN 18, and FEB 14—1976/77
Invitational Computer Conferences, Dallas, Tex; Orange County, Calif; and Fort Lauderdale, Fla. INFORMATION: B. J. Johnson & Associates, 2003 Eastbluff Dr, Suite 204, Newport Beach, CA 92660. Tel: (714) 644-6037

NOV 23-25—COMPEC-UK (Computer Peripheral, Small Computer, and Systems Exhibition), Wembley Conf Centre, Wembley, Middlesex, England. INFORMATION: Trident Conferences and Exhibitions Ltd, Abbey Mead House, 23a Eastbluff Dr, Tavistock, Devon PL19 8AU England

NOV 23-27—Conf-Exhibition of Automation and Instrumentation, Milan, Italy. INFORMATION: Federation of Scientific and Technical Associations, Piazzale Rodolfo Morandi, 2 (Piazza Cavour)-20121 Milano, Italy

NOV 25-DEC 1—electronics 76 (7th International Trade Fair for Components and Production Facilities), Munich Fairgrounds, Munich, Germany. INFORMATION: Munchener Messe- u. Ausstellungsgesellschaft mbH, Munchen 12, Postfach 12 10 09, Messelgeinde, Germany

NOV 29-DEC 1—Nat'l Telecommunications Conf, Fairmont Hotel, Dallas, Tex. INFORMATION: J. H. Tilley, Gen'l Chm, Collins Radio Group, 1200 N Alma Rd, Richardson, TX 75080

DEC 6-8—Winter Simulation Conf, Nat'l Bureau of Stds, Gaithersburg, Md. INFORMATION: Dr Harold J. Highland, Chm, Data Processing Dept, State U Technical College, Farmingdale, NY 11735. Tel: (516) 420-2190

DEC 6-8—IIEEE International Electron Devices Meeting, Washington Hilton Hotel, Washington, DC. INFORMATION: C. Neil Berglund, Bell-Northern Research, 5500 Canoga Ave, Woodland Hills, CA 91364

FEB 16-18—IEEE Internet's Solid State Circuits Conf, Philadelphia, Pa. INFORMATION: Lewis Winner, 152 W 42nd St, New York, NY 10036. Tel: (212) 279-3121

FEB 24-25—Sym on Design Automation and Microprocessors, Paio Alto, Calif. INFORMATION: W. M. van Cleemput, Gen'l Chm, Digital Communications Laboratory, Stanford Uni, Stanford, CA 94305. Tel: (415) 497-1270

FEB 28-MAR 3—COMPCON '77 Spring, Jack Tar Hotel, San Francisco, Calif. INFORMATION: IEEE Computer Society, PO Box 639, Silver Spring, MD 20901. Tel: (301) 439-7007

MAR 9-11—DATACOMM '77, Washington, DC. INFORMATION: Carol Iredale, DATACOMM '77, Box 639, Silver Spring, MD 20901. Tel: (301) 439-7007

MAR 21-23—IECI '77 Conf (Industrial Electronics and Control Instrumentation), Philadephia, Pa. INFORMATION: W. W. Keesel, Program Chm, IECI '77, Dept of Electrical Engineering, Kansas State U, Manhattan, KS 66506. Tel: (913) 532-5600

MAR 23-25—Fourth Annual Computer Architecture Sym, College Park, Md. INFORMATION: Dr Bruce Wald, Superintendent, Communications Science Div, Naval Research Laboratory, 4555 Overlook Ave, Washington, DC 20390


SEMINARS

NOV 22-24 and DEC 15-17—Intelligent Terminals; DEC 8-10 and FEB 2.4—Applied Network Engineering; and DEC 13-15 and JAN 24-26—Microprocessors and Microcomputers, San Francisco, Calif, New York, NY; Washington, DC, San Francisco, Calif; and Arlington, Va, Houston, Tex. INFORMATION: Institute for Advanced Technology, Control Data Corp, 6003 Executive Blvd, Rockville, MD 20852

NOV 29-DEC 1—Input/Output Systems Seminar, City Squire Motor Inn, New York, NY. INFORMATION: Input/Output Systems Association, PO Box 1333, Stamford, CT 06904. Tel: (203) 323-3143

DEC 6-8 and JAN 24-26—Data Entry Management and Supervision, Cherry Hill Inn, Cherry Hill, NJ. INFORMATION: Management Information Corp, 140 Barclay Center, Cherry Hill, NJ 08034 Tel: (609) 428-1020

DEC 6-8—Minicomputers; Project Management for Computer Systems; and Data Communications; and DEC 13-15—Systems Analysis and Design, New York, NY; Miami Beach, Fla; and New York, NY; and Houston, Tex. INFORMATION: Heidi E. Kaplan, Information Services Mgr, Dept 14NR, New York Management Ctr, 360 Lexington Ave, New York, NY 10017. Tel: (212) 953-7262

SHORT COURSES

DEC 1-3—Introduction to Microprocessor Based Systems Design, State U of New York at Stony Brook, Long Island, NY. INFORMATION: Kenneth Short, Dept of Electrical Engineering, SUNY at Stony Brook, Stony Brook, NY 11794. Tel: (516) 246-5985


DEC 3—Microprocessor for Management, DEC 7-10—Basic Technology, and DEC 16-17—Integrated Circuits Failure Mode, Scottsdale, Ariz; Scottsdale, Ariz; and Phoenix, Ariz. INFORMATION: Integrated Circuit Engineering Corp, 6710 E Camelback Rd, Suite 211, Scottsdale, AZ 85251. Tel: (602) 945-4594


DEC 6-10 and DEC 14-16—Designing with Microprocessors, Monterey, Calif and St. Louis, Mo. INFORMATION: Edwin Lee, ProLog Corp, 2411 Garden Rd, Monterey, CA 93940. Tel: (408) 372-4593

DEC 13-17—Mini Computer Systems, Milwaukee, Wis. INFORMATION: John T. Sneuleker, Dept of Engineering, U of Wisconsin-Milwaukee, 926 N Sixth St, Milwaukee, WI 53203. Tel: (414) 224-4193

DEC 14-16—Applications of Modular Microelectronics and Microprocessors, Biscayne College, Miami, Fl. INFORMATION: Director, Continuing Engineering Education, George Washington U, Washington, DC 20052. Tel: (202) 676-6106

COMPONENTS
Six smart reasons that make the MDS 4025 Tape Drive the Intelligent Choice.

Just a few of the reasons why over 5000 units are satisfying customers around the world.

**Air bearings** The MDS 4025 features air bearings at all tape turnaround points. The tape travels on a pillow of air, so the edge wear and tape friction commonly produced by roller bearings are eliminated.

**Automatic threading system** Quick. Transports automatically thread and load all industry hub-compatible reels. Error-free. Tape safety sensors are located at strategic points throughout the threading system—a system that MDS has engineered to proven perfection in thousands of tape drive units world-wide. For your consideration, IBM-type wrap-around cartridges are available as an option.

**Linear reel servo sensor system** Molded vacuum column sensor rails and photoelectric sensors create the simplest (and therefore, most reliable) reel servo sensor system on the market today. Linear photoelectric solid state limit sensing in the vacuum columns results in precise tape position indication. In addition, gentle, stable program-restriction-free tape handling is provided at all speeds, including high speed rewind.

**125 ips** The fastest speed ever achieved in a unit this compact (23½" x 19½" x 16½") to preserve tape durability and data integrity, the tape comes in contact only with the read/write head and the tape cleaner.

**500 ips rewind** The quickest rewind speed a machine this size has ever been able to offer. During high speed rewind, tape flies out of contact with the head and cleaner. Consequently, tape wear is minimized.

**Volume production** Mohawk Data Sciences is recognized as a leader in the OEM equipment field. Our 4025 Tape Drives are highly regarded for their unsurpassed quality and performance record. It's no wonder that the largest OEM companies have installed over five thousand 4025 Systems to date. Proven quality. Proven capability. MDS turns smart reasons into many intelligent choices.

For more smart reasons about the MDS 4025 Tape Drive, call or write your nearest MDS OEM Sales Office.

**Mohawk Data Sciences**

The Intelligent Choice.
The only microcomputer with the power of a PDP-11. 
The PDP-11/03.

If you've been looking for a microcomputer with minicomputer power at a micro price, join the hundreds of OEMs who've already found it with the DIGITAL microcomputer. The PDP-11/03.

The 11/03 gives you everything you could ask for in a small computer. High performance. High reliability. And a low price — just $1,357 in quantities of 50. And that micro price buys you mini features that quickly translate into benefits OEMs appreciate. Features like full PDP-11 instructions with eight general purpose registers for fast program development. RAM (MOS or Core) and PROM memories that let you match the memory with the application. Hardware vectored interrupts with stack processing for real computer power. And multiple-sourced components for sure delivery.

Buying our 11/03 also buys you the chance to start small without staying small. Because you can add up to 32K words of memory, fast floating point instructions, and more. Whenever you and your customers are ready.

Besides growing bigger in size, the 11/03 lets you grow bigger in scope. It's software compatible with every other PDP-11 we offer. From our LSI-11 all the way up to our medium scale PDP-11/70. That means you can take full advantage of Digital PDP-11 software and services.

You can also take advantage of Digital's OEM Referral program — your chance to take on an international marketing and support team without hiring them. The OEM Referral program can help you locate new customers.
ers and new markets around town and around the world. And it can all start with the PDP-11/03. So if you’re looking for a proven microcomputer with proven power and performance, get the micro with all the power and performance of a PDP-11.


Digital Equipment Corporation, Maynard, Massachusetts
☐ I’m interested. Please send information.
☐ I’m more than interested. Please have your nearest Digital sales representative contact me.

Name__________________________Title__________________________
Company__________________________
Address__________________________Phone__________________________
City__________________________State__________________________Zip__________________________

CD116
To the Editor:

We are writing in regard to John Buckley's "Communication Channel" on "Computerized PBX Systems" in the May 1976 issue of Computer Design, pp 14, 19.

The IBM 3750 is mentioned as being recently introduced into the U.S. markets. We would be interested to learn of actual sales being made by IBM.

Martin W. Fletcher
ComQuest
Palo Alto, Calif

The Author Replies:

In response to your inquiry, you are correct in stating that IBM has only marketed the 3750 in overseas locations. While the 3750 has not been actively presented to the U.S. market, it has been selectively discussed in the context of a market study. Descriptive literature and manuals are available in the U.S.; however, they are written in terms applicable to the overseas communications environment. We also understand that there are 3750s installed in the U.S. at some IBM facilities. While there are a number of reasons for IBM's lack of direct 3750 U.S. marketing efforts, one of the more valid is the fact that the next generation 3750 is presently being developed by IBM in France under the project name "Rosebud."

Admittedly, the May column tended to imply that the 3750 was more active in the U.S. market. We can realistically anticipate, however, that IBM will aggressively enter this market at some time in the near future.

John E. Buckley
Telecommunications
Management Corp
Cornells Heights, Pa

Correction

An error was made in compiling the table showing the increase in word length caused by error correcting and detecting codes, appearing on p 180 of the article, "Automatic Error Correction in Memory Systems," by Bryan Rickard, Computer Design, May 1976. In the last six rows, the number of extra bits shown was incorrect in both columns; consequently, the percentage increase also was incorrect. The complete corrected table follows.

<table>
<thead>
<tr>
<th>Data Word Length</th>
<th>Single-Error Correction</th>
<th>Single-Error Correction and Double-Error Detection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Extra Bits</td>
<td>Increase (%)</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>75.0</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>50.0</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>40.0</td>
</tr>
<tr>
<td>12</td>
<td>5</td>
<td>41.7</td>
</tr>
<tr>
<td>16</td>
<td>5</td>
<td>31.25</td>
</tr>
<tr>
<td>18</td>
<td>5</td>
<td>27.8</td>
</tr>
<tr>
<td>20</td>
<td>5</td>
<td>25.0</td>
</tr>
<tr>
<td>24</td>
<td>5</td>
<td>20.8</td>
</tr>
<tr>
<td>32</td>
<td>6</td>
<td>18.75</td>
</tr>
<tr>
<td>48</td>
<td>6</td>
<td>12.5</td>
</tr>
<tr>
<td>60</td>
<td>7</td>
<td>11.7</td>
</tr>
<tr>
<td>64</td>
<td>7</td>
<td>10.9</td>
</tr>
<tr>
<td>72</td>
<td>7</td>
<td>9.7</td>
</tr>
<tr>
<td>96</td>
<td>7</td>
<td>7.3</td>
</tr>
</tbody>
</table>

Bryan Rickard

To the Editor:

While we appreciate the attention given to us in the "Communication Channel" column entitled "Satellite Business Systems" by John E. Buckley, Computer Design, June 1976, pp 10, 14, we would like to call attention to several inaccuracies in the article which should be corrected.

The estimated average cost of SBS earth stations to be supplied during the 1980-85 time frame is approximately $350,000, as our filings with the Federal Communications Commission show. Mr Buckley's estimate of $2000 is totally unrealistic for the kinds of stations SBS will utilize—each with a high power 14-GHz transmitter, a 12-GHz receiver with low noise amplifier, TDMA burst modulator/demodulator, and a satellite communications controller—all designed for reliable unattended operation.

While SBS will offer switched telecommunications services, they will be private network offerings to large industrial and governmental users. SBS services will not be analogous to direct distance dial service or to the Execunet service, and there is no intent to provide such services in the future.

SBS's private network common carrier services are not the "closed" system service that the article postulates. The SBS system, as our filings emphasize, will include industry-standard interfaces and network accessibility without regard to the source of the customer's data processing equipment, and the service will be provided under tariffs which are non-discriminatory.

Larry Weekley
Satellite Business Systems
Washington, DC

The Author Replies:

Many thanks for the acknowledgement of the June column. I regret that it appeared to reflect "inaccuracies" from your perspective. Perhaps the following additional views will resolve these concerns.

The primary earth stations for the SBS systems will indeed incur costs greater than $2000. One of the unique advantages of the SBS systems is that because of its frequency
If you want to do business abroad, fly Data General.

If you want to use your systems somewhere outside of the country, you don't have to go it alone.

Put Data General equipment in your systems and we can be there to take care of it.

Chances are, we already have support people wherever you want to go. So we're in a good position to stand behind every piece of Data General equipment you buy.

If you ever happen to need service, someone can be right over. Chances are, trained people are already there. And if your systems need replacement parts, we won't have to send across the ocean and go through foreign customs offices to get them. Because we've placed Data General parts all over the world.

You won't have to send your customers (or employees) to the USA for training. Because we can do that right on the spot.

And if you need software support, we can have systems engineers wherever you need them.

Our equipment will also be right at home wherever you take it. Because we've designed it to work just about anywhere in the world. For example, all you have to do to make our microNOVA computer meet different power requirements is change the power cord. (As opposed to other manufacturers who make you rewire the power supply.)

If you want to know more about the above, clip your business card below.

It's a lot easier to do business abroad when you know the right people to fly with.

Clip your business card here and send it to Data General, Department CD-1
Southboro, Mass. 01772
We'll send you a copy of our support brochure.

Data General

©Data General, Route 9, Southboro, Mass. 01772 (617) 485-9100. Data General (Canada) Ltd., Ontario.
Data General Europe, 15 Rue Le Sueur, Paris 75116, France. Data General Australia, Melbourne (03) 82-1361
NOVA is a registered trademark of Data General Corp.
WP Embedded Controllers
for your Tape and Disc drives
are best on all your
PDP-11 & NOVA computers

Because they are
- Available for all PDP-11, NOVA and NOVA-emulating computers
- Usable with virtually all tape and disc drives
- PE and NRZ compatible up to eight drives (tape)
- Usable with four single, dual or ten-high drives (disc)
- Lowest in cost

SEND FOR COMPLETE INFORMATION

western peripherals™
(714) 991-8700 • TWX: 910-591-1687 • Cable: WESPER
1100 Claudina Place, Anaheim, CA 92805

CIRCLE 8 ON INQUIRY CARD

WE SUPPORT YOUR FLOPPY!!
...With a complete line of Floppy-Disk power supplies for single and dual drive applications.

Another New Series of Microcomputer dedicated models from Power-One.

<table>
<thead>
<tr>
<th>Disk-Drive Series</th>
<th>Output Ratings</th>
<th>Price (Single Qty.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>+24V</td>
<td>+5V w/OVP</td>
</tr>
<tr>
<td>CP-205</td>
<td>1.7A</td>
<td>1A</td>
</tr>
<tr>
<td>CP-206</td>
<td>3.4A</td>
<td>2.5A</td>
</tr>
<tr>
<td>CP-162</td>
<td>6A</td>
<td>3A</td>
</tr>
</tbody>
</table>

It's a Fact!
531 Dawson Dr. • Camarillo, CA 93010
Phone: 905/484-2806 TWX: 910-338-1297

CIRCLE 9 ON INQUIRY CARD

Letters to the Editor should be addressed:
Editor, Computer Design
Professional Building
221 Baker Avenue
Concord, MA 01742

COMPUTER DESIGN/NOVEMBER 1976
MOTOROLA introduces

micromodules...

Micromodule Family

Monoboard Microcomputers
M68MM01 Monoboard Microcomputer 1
M68MM01A Monoboard Microcomputer 1A

Micromodule CPU
M68MM02 CPU Module

Micromodule System Expanders
M68MM03 32/32 Input/Output Module
M68MM04 8K/16K AROM/ROM Module
M68MM05A 8-Channel Differential 12-Bit A/D Module
M68MM05B 16-Channel Single-Ended 12-Bit A/D Module
M68MM05C Quad 12-Bit D/A Module
M68MM06 2K RAM Module
M68MM07 Priority CPU Module
M68MM08 Microbug Module
M68MM09 CMOS/RAM Battery Module
M68MM10 Programmable Timer Module
M68MM12 GPIB Module
M68MM13 Ref State Detector Module

Applicable EXORciser Modules
ACIA Module
EROM/RAM Module
8K RAM Module
16K RAM Module
Systems Analyzer

the flexible

M6800 microcomputer alternative

Looking for a fast, low cost, microcomputer hardware design? Trying to avoid the costs of designing and building your own microcomputer system for relatively low-use rates? Looking for ways to build a custom computer with standard boards without big working capital requirements, increased labor force, big inventories, and a drain on cash flow?

Motorola's new M6800-based Micromodule Family has the answers. You now have the choice you didn't have before. Take the single-board approach, or reach into our assortment of mix-n-match module options and build your own customized system with standard boards.

Micromodules 1 and 1A are M6800-based 8-bit single-board microcomputers, Monoboard Microcomputers. MM 1 features all parallel I/O. MM 1A has both serial and parallel I/O.

Micromodule 2 is the M6800-based CPU module, the heart of the Micromodule Family's modular microcomputer concept. Use it with your choice of I/O, RAM, AROM/ROM, A/D, D/A, Programmable Timer and other Micromodule options.

Orders may be entered now for Micromodules 1, 1A, 2, 3, and 10 additional Micromodules are already defined for this new microcomputer concept. As an example of the cost savings inherent in the concept, a single Micromodule 1, the M68MM01, sells for $485.00, and drops to $275.00 in 100 lots.

The total resources of Motorola's system development tools including the EXORciser*, EXOR-disk*, and a full complement of software back up the Micromodule Family. The family also offers card cages, rack-mount chassis, and power supplies. Remember, too, that Micromodules and EXORciser modules are bus compatible.

*Trademark of Motorola Inc.

MOTOROLA Microsystems
— making it happen in microcomputers
Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036

CIRCLE 10 ON INQUIRY CARD
Dynamic Multiplexing Applications

Accessibility of information systems today is constantly being extended. System designers continue striving for a direct system interface that will provide closer access to the primary source data of a given application. Evolution of data communications terminals has been characterized by more lower speed, applications-oriented terminal devices. In order to improve the timeliness of source data as well as to increase the availability of existing data base information, the trend toward specialized terminals and low cost low speed terminals has continued.

Early online data communications systems used batch transmissions or remote job entry (RJE) terminals to develop and access a data base system. The primary system characteristic in need of improvement was the time-consuming task of manually collecting and preparing the required source data for system entry as well as the complexity of accessing that processed source data. Development of an interactive system capability has allowed the application of lower speed data communications terminals, permitting actual source data to be entered in a more timely manner. Most important has been the companion capability of enabling remote low speed terminals to interrogate and manipulate a centralized data base in order to obtain the desired information.

The increased number of low speed interactive terminals was paralleled with their increased geographical distribution. While the cost per remote terminal significantly decreased, the cost of centralized system access increased, if traditional network access methods were maintained. Batch or RJE terminals typically accumulated a large volume of data prior to system access. Access could then be established by means of a dial or switched connection. After the high speed exchange of data with the central processing site, the transmission connection could be disconnected, terminating any communications cost such as toll charges or measured WATS charges. If the terminal had a predictably large data volume and/or generated a number of batch data transmissions over an extended period of time, a leased line could be cost-justified. Such a line would be permanently installed between the terminal and the central processing site.

As lower speed data terminals were applied, data were not accumulated in any significant volume at remote locations. As each piece of source data became available it was to be directly entered to the centralized data base. With the same degree of urgency, immediate access was required when the need for data base information occurred. A number of truly interactive applications require availability of centralized information at the remote terminal location before new source data can be entered. This dual requirement intensifies the need for constant access to the central processing site.

In the United States, the primary communications channel in use is the voice grade channel. With a nominal bandwidth of 4 kHz, this channel is the vehicle for virtually all communications systems. Use of a batch or RJE terminal can easily fill the capacity of such channels during data transmission. A low speed interactive terminal operating at 150 bits/s or less does not begin to challenge the ultimate capacity of a voice grade channel. The solution to resolving the direct access, yet lowering cost access requirements of interactive applications, is to allow a number of low speed terminals within the same geographical area to share a common voice grade channel to the centralized computer site. This sharing must create the illusion at each remote terminal that a direct, dedicated connection exists to the centralized computer site without the awareness or participation of any other low speed terminals. This is done through multiplexing.

Multiplexing of digital data has been accomplished by allocating either the frequency spectrum or the time availability of the voice grade channel among the connected low speed terminals. Allocation of the frequency spectrum is known as frequency division multiplexing (FDM), while allocation of the time availability is known as time division multiplexing (TDM). FDM is also correctly referred to as space division multiplexing. With either technique, a fixed assignment of a portion of the frequency spectrum or the time availability of the shared voice grade channel is made to each of the connected low speed terminals. More information on these methods is contained in the May 1971 issue of Computer Design, "Communications
Introducing
The compact 1
from number 1:

The minifloppy
from Shugart

Give your system the performance of a floppy at a cassette price. Gain the random accessibility, mechanical reliability and data integrity of a flexible disk in a more affordable size.

Go minifloppy.

This little half-pint is half the size, half the cost of a standard floppy but Shugart packs a lot of proven technology into that itty-bitty box (3.25" x 5.75" x 8.0").

The same proprietary glass bonded ferrite/ceramic read/write head and recording technology used in 40,000 standard-sized Shugart floppy drives give the SA400 minifloppy dependable data integrity—1/10^8 soft errors, 1/10^11 hard errors. You'll be hard pressed to find that integrity in any cassette.

You won't get 110 K byte storage capacity at 125 K bit/second data transfer rates either.

Special minifloppy drive features include direct drive stepping motor actuator, DC servo-controlled spindle drive, and less power dissipation than any standard floppy.

The minidiskette media is just like the standard flexible disk, only smaller. Available in hard or soft sectored formats from several media sources, it shares the same oxide formulation, technology and technique of manufacture.

Protective jacket is just 5.25" square.

The Shugart minifloppy drive keeps data safe, too. Positive media interlock prevents minidiskette damage.

Our standard write protect circuitry prevents loss of recorded information.

Low power consumption of only 15 watts in continuous duty and 7.5 watts in standby produces low heat and eliminates noisy fans.

Whether you build word processing equipment or an entry level microprocessor system, an intelligent calculator or a hobby computer, the Shugart minifloppy drive can help you bridge the price/performance gap between cassette and standard flexible disk.

The gap is gone.

So put the minifloppy drive to work in your system before your competitor does. Write, call or run to Shugart for complete OEM information.

The leader in low-cost disk storage.

Shugart Associates
435 Indio Way Sunnyvale, CA 94086 Phone (408) 733-0100
East Coast Sales/Service: Phone (617) 890-0808
Europe Sales/Service: 3, Place Gustave Eiffel, Sille 311
94588 Rungis, France Phone (1) 686-00-85

MiniHoppy and minidiskette are Shugart trademarks.
Our bright idea.

More computer power for your dollar.

The SEL 32 family of high performance 32-bit computing systems offers a balance between big computer performance and minicomputer prices. Microprogrammable input/output processors, compatible central processing units, high-speed memory systems, and efficient data processing peripherals make up the hardware elements. On the software side, operating systems, language processors, libraries, application packages, and interactive terminal support balance the scales. Together, SEL 32 hardware and software provide a cost-effective solution to your current requirements, with expansion capability to meet your growth needs.

The SEL 32/35 is the strongest price-performer of any 32-bit single or multiple-CPU system available today. These computers can be configured from 64K bytes to 512K bytes of 900 nsec memory. Resembling its more powerful brothers, the SEL 32/35 is a complete package, including central processor with floating-point arithmetic, memory, chassis, power supplies, and cabinet.

The SEL 32/55, offered in a variety of both single and multiple CPU configurations, can be configured from 32K bytes to 1 million bytes of 600 nsec memory.

The SEL 32/50 is a single chassis computer providing the same CPU, I/O, and memory capability as the 32/55, but for dedicated applications.

Just circle our number on the Reader Service Card, or call us today. We'll send you the powerful story of the SEL 32 family.

SYSTEMS ENGINEERING LABORATORIES

6901 West Sunrise Boulevard
Fort Lauderdale, Florida 33313
(305) 587-2900

European Inquiries 85 bis Avenue Albert ler 92500 Rueil, France Tel 967 8314

CIRCLE 12 ON INQUIRY CARD
Channel,” “Digital Multiplexer Fundamentals,” pp 14, 17. (The author will forward a copy of this article to readers who send a self-addressed, stamped envelope with their request.)

Capacity of fixed multiplexing methods can easily be calculated by the following methods. With FDM, the effective bandwidth of the voice grade channel is an aggregate of the bandwidth required by each of the low speed terminals. If each of the terminals operates at 150 bits/s, each will require a bandwidth of at least 200 Hz. The effective bandwidth of a voice grade channel is typically 2400 Hz. This means that a total of 12 such terminals can jointly use the common voice grade channel. With TDM, the capacity of the common voice grade channel is a multiple of the highest data rate of the low speed terminals. If the voice grade channel is operating at 4800 bits/s and the terminals at 150 bits/s, approximately 32 terminals can jointly use the common channel.

With these traditional multiplexing methods the assignment of a low speed terminal to a specific portion of the common frequency spectrum or to a defined time interval within the data bit stream being clocked on the common voice grade channel is fixed or static. Even when the associated low speed terminal is not generating a data character, the assigned, yet unused frequency spectrum or time slot may not be reassigned to any other terminal's data.

Examination of typical interactive low speed terminal operational characteristics indicates that most of these terminals are direct keyboard or manual entry. Physical depression of a key results in a coded byte being generated to the communications line of the character represented by the depressed key. If a key is not being depressed, the associated input communications line is idle, which occurs 70 to 80% of its available time. It seems logical that if this time could be assigned to other input data sources, the capacity of the shared voice grade line would be significantly increased. Thus, reallocation of idle input time is the basis for the dynamic multiplexer.

Limited to TDM, the dynamic multiplexer maintains an awareness of the activity level of each associated low speed terminal. When a character is being generated from a terminal, a time slot on the common voice grade line is assigned for transmission to the central processing site. During the subsequent frame transmission, that same time slot will be used to transmit a character for another low speed terminal. The term statistical or pause multiplexing describes this same technique of dynamic multiplexing.

In theory, such a dynamic allocation of available time slots can significantly increase the capacity of the common voice grade channel over the absolute limits of static TDM. In practice, the advantage of increased capacity is coupled with two disadvantages—data entry contention and data byte identification.

It is highly probable that more characters than available time slots will be generated simultaneously by the terminals. If the common voice grade channel is operating at 4800 bits/s and the low speed terminals at 150 bits/s, only 32 time slots exist within a single frame. If 33 characters are generated simultaneously, one of them must wait for the following frame. This wait means that data queues or storage must be assigned to each input low speed terminal. Occasional contention conditions can then be compensated for by storing the delayed characters until later frames. Probability of manual data entry indicates that terminals which generated characters for the first frame will not have generated characters by the time the second frame must be transmitted.

The key to successful static time division is that each time slot is fixed to each low speed terminal's input. The first time slot of the frame is always from terminal 1, the second is always from terminal 2, etc. Since the source of the data content of each time slot changes with dynamic multiplexing, some means of constantly identifying the source of the time slot's data must be established. Two methods are used. The first is to assign an address byte with each time slot to identify the data content’s low speed terminal source. As the number of terminals increases, size of the address field with each time slot must also increase. It is quite easy to begin to limit the capacity of such a system by the number of bits required for identification rather than data.

The second method is to affix to each frame a polynomial that, when modified and expanded by the previous polynomial and/or constants stored in the multiplexer, will map the input activity of each low speed terminal represented by that frame. This method is most frequently used with high capacity multiplexers. A possible disadvantage is that it is undesirable to directly interface the common multiplexed voice grade channel to the central computer. A companion multiplexer is required at the computer site for processing the polynomial and demultiplexing into individual low speed interfaces.

So far, we have only discussed dynamic multiplexing with respect to manual data entry. If low speed terminals use automatic data entry by means of remote terminal storage, the advantages will be sharply impacted. Use of paper tape, cassettes, etc to accumulate manually entered data prior to transmission will result in a burst of data characters that can exceed the limited data storage queues in the multiplexer. If each terminal is capable of generating 50 contiguous characters at 150 bits/s each time transmission is initiated, the incident of lost characters due to exceeding the limits of the input queue may be quite high. Future plans to perhaps implement such automatic transmission terminals should be considered carefully with any decision to implement dynamic multiplexers.

This concern for burst transmission must also be evaluated with respect to output data transmission. In response to an inquiry, the central computer attempts to transmit contiguous characters at the established low speed data rate. The computer must be programmed to recognize a full queue condition in the multiplexer and hold further output data character transfer to that low speed channel. Such recognition is naturally contingent upon the central site multiplexer providing the computer with some indication of when a full queue condition occurs. The decision to implement dynamic multiplexers must, therefore, also include an evaluation of the increased interface controls as well as processing overhead at the central computer site.

As with any device or technique, there are corresponding advantages and disadvantages. Both must be identified and evaluated in view of the capabilities and requirements of each specific application and system.
Replacing four 2102s

If you're designing the 2102 into any application, stop. Look at our new SEMI 4804A.

It will quadruple your density, cut your power per bit in half. One SEMI 4804A static 1K x 4 RAM replaces four 2102s (or 2112s). It operates on 5V (but will protect data down to 1.5 Vdd), reads and cycles in 450 nsec., and is packaged in an 18-pin DIP.

The SEMI 4804A is second-sourced, and is available now from your local EMM SEMI distributor. (If you need 4K x 1 organization, ask about our new SEMI 4801. That's available immediately, too.)

Write or call today
for full details.

EMM SEMI
A subsidiary of
Electronic Memories & Magnetics Corp.
3883 N. 28th Ave., Phoenix, Ariz. 85017
(602) 263-0202

CIRCLE 13 ON INQUIRY CARD
Early Approval By FCC Requested for Domestic Communications Satellite

In response to petitions opposing its entry into the field, Satellite Business Systems (SBS) of Washington, DC has requested the FCC to approve—without further proceedings—its applications for a domestic satellite communications system. The company, a partnership formed by subsidiaries of COMSAT General Corp, IBM, and the Aetna Casualty and Surety Co, claims that its system proposals fully meet the broad domestic satellite policies established by the FCC. "meticulous attention" was supposedly paid to conformance with the particular standards and conditions of the balanced CML entry option set forth in the Commission's CML decision of Feb 1975.

Applications were filed with the FCC in Dec 1975 for authority for SBS to construct a domestic satellite system to operate at the higher 12/14-GHz frequencies. This would reportedly provide customers with their own all-digital, switched private communications networks and with end-to-end voice, data, and image services among small satellite earth stations located on their premises. A favorable decision was requested by late 1976 so that the system could begin operation in 1979.

Claims for the proposed system include system concepts and communications techniques that would promote the public interest by serving important private network communications requirements and fostering a pro-competitive environment. Systems applications are said to be "developed fully within the context of the Commission's efforts to infuse competition into the provision of specialized or private line communications services."

The company said that its applications "provide copious detail which equals or exceeds the quantity of information the Commission required in granting initial authorizations to the carriers already providing domestic satellite services. In addition, further particulars are being provided in this response to assure that the Commission has before it all of the relevant information necessary to support a finding that grant of the applications will advance the public interest."

An evidentiary hearing "would not yield additional information of a substantial or material nature," according to SBS. "Instead, such a hearing would increase the risks the company must already face in entering the field, and would effectively advance the carriers' private interests, by postponing, and perhaps aborting, the advent of a vigorous competitor. An evidentiary hearing would certainly frustrate the FCC's public interest goals and radically depart from the procedural standards which the Commission has adopted and applied consistently in the past with respect to domestic satellite applications for competitive services."

SBS also noted that "although the Department of Justice had joined the carriers in calling for an evidentiary hearing on antitrust questions, the Justice Department has not previously interposed objections to consortium arrangements such as SBS in the domestic satellite field which might be considered to have antitrust implications. Instead, the Justice Department has wisely encouraged the Commission to permit entry by any qualified applicant, and it has recognized the dampening effect which lengthy evidentiary hearings are likely to have. To insist upon a hearing to determine unascertainable future facts would be contrary to the public interest and to the goals of the antitrust laws."

Data Communications Newsletter Introduced For Management Readers

A monthly newsletter "designed to take the myth out of data communications" was scheduled to begin publication in October as an information aid for business executives. Datacomm Awareness Report, published by Management Information Corp, 140 Barclay Center, Cherry Hill, NJ 08034, at $70 per year, is intended "to give the reader, over a period of time, a well-rounded basic education on data communications; and to each month brief the reader on what is happening in the data communications field that may affect his business. This newsletter will also serve as a vehicle to bring data communications users together so that they may share their ideas and problems."

Fully involved with data communications, each issue will include commentaries on current items of significance, important news and interpretation as to how it may affect users, products and services of interest to users, tutorials on data communications basics written for the non-technical-oriented, analytical reports on one or two data communications products or services, application case histories describing how users in various businesses and industry sectors successfully applied equipment or services to solve their problems (or how they failed to do so and why), and an "Ask-the-Expert" section for specific questions related to user installations.

Charter Rates Reduced For Subscribers to Data Communications Report

Reduced charter rates have been announced for subscribers to Datapro Reports on Data Communications, a monthly updated information service for persons responsible for data communications oriented systems and networks. The service will contain comprehensive, in-depth information on the complete spectrum of data communications products, services, and techniques and will include three looseleaf volumes of reports; monthly report supplements; Datalink, a monthly data communications newsletter; and the firm's telephone inquiry service. Charter subscriptions from Datapro Research Corp, 1805 Underwood Blvd, Delran, NJ 08075 are $390, a $40 reduction from the regular rate of $430. Designed to provide users and vendors with current, highly concentrated, and objectively prepared information to help them in planning, designing, and costing communications systems and networks; and to assist them in evaluating and selecting data communications equipment, software, and services, the service also includes operational and management guidelines to aid in measuring and optimizing installed systems. Major information categories are: glossary; concepts; standards; management/system guidelines; computer vendor systems; processors; software; terminals; programmable terminals; batch terminals; display terminals; teletype terminals; transmission facilities; modems; multiplexers; test, monitor, and control equipment; special equipment and services; remote computing services; and telephone systems.
Our readers make light work.

Decitek photoelectric punched tape readers were all designed with state-of-the-art reliability—a fiber optic light distribution system and a beautifully simple patented dual-sprocket drive, which eliminates the need for level switches, tape guides and keepers. Since fewer actual parts go into our readers, greater performance comes out. It also gives us the lowest spare parts volume in the business. Decitek has, in a few years come from nowhere to such a strong penetration of the market that we are now the number one supplier to the photo-typesetting OEM industry and gaining in the machine control and mini-micro computer field. We got where we are purely because of performance, quality, reliability and price.

We will work with you to make your equipment work better.

The more you know about punched tape equipment, the better you read us.

DECITEK
A DIVISION OF JAMESBURY CORP.
250 CHANDLER STREET, WORCESTER, MASSACHUSETTS 01602, U.S.A. (617) 798-8731

CIRCLE 14 ON INQUIRY CARD
High Capacity Cable Expands Transatlantic Data Communications

Built to keep pace with the increasing volume of voice and data communications between the U.S. and Europe, a transatlantic telecommunications cable system dedicated on Sept 1 carries the equivalent of 4000 telephone conversations at one time. The 17-nation TAT-6 facility, which spans the 3402 nautical miles between Green Hill, RI and St. Hilaire de Riez, France, has the largest capacity of any undersea cable now in service. Increased capacity resulted from improved transmission capability and advances in repeater design that permit the use of much higher frequencies than earlier systems.

TAT-6 was developed jointly by the British Post Office, the French Secretariat of Posts and Telecommunications, and the American Telephone and Telegraph Co (AT&T). International partners include AT&T, ITT World Communications, Inc; RCA Global Communications; Inc; Western Union International, Inc; and telecommunications entities in Austria, Belgium, Denmark, France, Finland, Germany, Greece, Ireland, Italy, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. About 20 other nations throughout Europe, the Middle East, and Asia will have circuits in the facility to serve their communications needs.

Bell Laboratories was responsible for the overall system design including specific design and development of equalizers and repeaters that amplify and control communications signals as they move along the undersea path and precision power supplies to energize these components from the terminal stations. Because the system operates at extremely high frequencies, the strength of the signal diminishes more rapidly than in previous cables. Therefore, repeaters must be placed every 5.1 nautical mi, compared to every 10 nautical mi for the next most recent Bell Labs-designed transatlantic system. Each repeater, built by Western Electric in Clark, NJ, will boost the signal power it receives as much as 10,000 times to compensate for transmission losses along the way. It must withstand water pressure at ocean depths of more than 3 mi during its 25-yr design life span.
When it comes to flexibility, the model 40 gives you a lot of ways to go.

When we designed the model 40 system, we included a long list of features and options to give it the flexibility for practically any data transmission requirement.

Whatever your industry or application.

First, there's a variety of speeds ranging from 110 to 4800 bps, along with a choice of interfaces, half/full duplex operation, and character and batch mode transmission. The model 40 system also has a number of on-line controls, even/odd parity generation and a destructive scrolling feature that permits continuous bottom line reception with no loss of data until memory overflow.

Flexibility features don't stop there, either. There's an expandable memory with line and page scrolling, protected format with variable field transmission, plus many other features and options to select from. And since the entire system is modular, it can be custom-tailored to fit your needs.

These are just some of the many reasons why the model 40 has the flexibility to fit just about any system. But the model 40's strongest suit is economy. Because on a cost/performance basis, nothing even comes close. And delivery is a lot sooner than expected.

For complete information, please contact our Sales Headquarters at: 5555 Touhy Ave., Skokie, Ill. 60076. Or call Terminal Central at: (312) 982-2000.

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

The Teletype model 40 system. Nothing even comes close.

CIRCLE 17 ON INQUIRY CARD
time domain.
data domain.
Biomation's new logic analyzers give you both.

When your job is to interface, integrate and program a complex new digital logic system, you want as much information as you can get. That's why we're providing a new set of tools which let you display timing information as well as logic word content—in the language of your choice.

Our new 1650-D logic analyzer gives you 16 channels at 50MHz. Our 851-D gives you 8 channels at the same speed. Accessories can now give you a logic state (1's and 0's) display of any 16 stored words; hex or octal translation; and a vector map of memory contents. The 8 and 16-channel logic analyzers feature:

- Pretrigger and delayed trigger recording
- Trigger point can be easily identified
- Latch record mode for fast pulse capture
- Combinational triggering (true or false)
- Movable display cursor that stays with the data when you switch display modes
- Display expansion, mixed or full, X5, X10 or X20

These are complex instruments and we can't give you all significant details here. But please write, call, or use the reader service card. We want to get this useful information into your hands. Biomation, 10411 Bubb Road, Cupertino, CA 95014, (408) 255-9500. TWX: 910-338-0226.

Biomation's new 1650-D produces a repetitive display output reconstructing precisely 500 bits per line for a 16-line timing diagram on a conventional oscilloscope or CRT display. Separate selection of individual channel outputs allows viewing of 1, 2...16 channels at one time with automatic vertical expansion.

Map—each word in memory is transformed via two DAC's to form a unique dot which characterizes that word. All 512 words of the 1650's memory can be accessed for mapping. The cursor word is circled in the map as well as displayed at the top of the screen in alphanumeric form. The cursor may be moved to any of the points in the map for positive identification of that word. In addition, a map of only 16 words may be selected.

Logic state—provides memory address location, binary output of the 16 channels and selectable octal or hexadecimal translation. 16 words are displayed at one time with the cursor address location at the top of the screen. Movement of the cursor control allows accessing any 16 words of the entire 512 words stored in the 1650-D. The display control memory can store 16 words while a different set of 16 is selected from the 1650's main memory (or a new recording is made). These two sets of 16 words can then be overlayed on the CRT. Any differences will blink and be easily identified.
TURNKEY 620 SYSTEMS FROM NEFF USING THE HP 9825 CALCULATOR...
the logical next step in data acquisition.

You're involved in a scientific, engineering, or industrial project that could use a high performance, low cost data acquisition system. But you know that system integration and software costs of most systems actually exceed the hardware. And your need is now, so you want a system that will take data immediately with minimum user training.

Our turnkey 620S was designed for you. ....

620S is a sophisticated data acquisition system with amplifier-per-channel or differential multiplexer analog signal processing and using the H.P. 9825 computing calculator for system control, data analysis and recording.

Neff systems are known for high performance and the 620S is no exception. Consider 0.1% accuracy with 50kHz channel scanning rate, fullscale input sensitivities from 5 millivolts to 10 volts, up to 256 channels or 2048 channels fully expanded, and 120dB rejection of common mode voltages up to 300 volts. Selectable data filters, simultaneous sample and hold and input signal conditioning are but a few of the many available features.

The Hewlett-Packard 9825 calculator provides the 620S computer performance with the operating convenience of a calculator. Programming is simple with HPL, an easy to learn, high level language designed for scientists and engineers. Standard features include a live-keyboard, alpha numeric printer and cassette recorder. Up to 24K memory is available. Plug-in peripherals include floppy disk, line printer, x-y plotter, and tape punch. It also attaches to H.P. Interface Buss.

A complete, integrated data acquisition system thats easy to use — thats our turnkey 620S.

Like to know more? Call us today at 213-357-2281 or write for our free brochure.

NEFF
INSTRUMENT CORPORATION
1088 E. Hamilton Rd., Duarte, Calif. 91010
Tel. (213) 357-2281 TWX 910-585-1833
CIRCLE 19 ON INQUIRY CARD
Small Computer Systems Offer Fast Processor To Speed Program Execution

A family of small computer systems, 1000 Systems provide the high performance needed to meet demanding computation, instrumentation, and operations management applications. Priced typically about 9% below presently available equipment, the systems offer a sprint-speed processor, complete data base management software, and networking software. A disc-based real-time executive operating system allows multiprogramming, batch spool monitoring, and multilingual operations; the system supports four or more terminals concurrently.

Developed by Hewlett-Packard Co, 1501 Page Mill Rd, Palo Alto, CA 94304, the systems are available in desk style or cabinet models, and are programmable in BASIC, FORTRAN, ALGOL, and HP assembly languages. The system processor achieves 60 to 100% faster execution of programs using the concept of dynamic microcycle timing. Instead of allowing time for the slowest operations, the control processor is capable of recognizing the need for and allotting 280 ns to the occasional slower function, while completing most operations within 175 ns. Memory cycle time is reduced to 550 ns.

Three features permit the user to increase the processor's power at will. A control processor address space of 8.5K 24-bit words is provided for the user's microprogrammed subroutines—enough to completely reconﬁgure the machine. A complete set of microprogramming software is offered to help in utilizing this feature; the set includes microassembler, microeditor, loader, and debug utilities. In addition, the processor enables routines to be transferred from disc or other source directly into control store under software control; this makes the control processor available as a dynamic resource under operating system control.

Standard on large systems (optional on others) IMAGE/1000 data base management software is augmented with QUERY, an English-like inquiry procedure which requires no programming experience. QUERY allows the user to easily obtain information from his data base and to generate reports in whatever form is desired.

Standard system console is the 9600-baud model 2645 CRT terminal, which is equipped with two built-in minicartridge drives. Programmers on multiple terminals can plug-in, modify, and walk away with their programs stored on the convenient cartridgtes. System software is provided on the cartridges, eliminating inconvenient storage of paper tapes.

Appropriate as the main computation resource in an engineering design facility, the desk-styled model 30 consists of computer with 64K bytes of semiconductor main memory, a 15M-byte cartridge disc subsystem with 25-ms average access time, and RTE II real-time executive operating system software. Up to four term-
Universal One

The Microprocessor Development System for the 8080, 2650, and 6800.

It's universal. Millennium's Universal One System interfaces to the most commonly used microprocessors today and others in the near future.

And, it's universally accepted. It's so well accepted that design engineers call it a hardware development aid. It's so powerful, application programmers call it a complete software development system. And project managers? They know it as a great time and money saver and don't worry about what it's called.

Can the project manager be right?
The ability to interface with the different microprocessors of today and the new microprocessors of the future is the key benefit of Universal One. Universal One will never be obsolete and therefore provides the greatest Return On Investment of any microprocessor development system available today.

The universality of the system is based on Universal One's innovative multiple CPU architecture. One CPU, the Master CPU, is the controlling element of the system and executes all application independent functions; file management, text editing, system utilities, system I/O and software debugging.

The second CPU, the slave, which is controlled by the master, executes those functions that are application dependent; the microprocessor Assembler, in-circuit testing, user application programs, and user I/O. Additional microprocessor slaves are readily added by interfacing the new slave to the system bus and integrating it into the system software.

By meeting all the staff's needs, Universal One cuts costs. It's not necessary to have special test fixtures for design engineers and software development systems for programmers. Universal One saves on personnel training expenses since only one system interface need be learned.

Can the programmer be right?
Universal One's software capabilities rival those found on many powerful minicomputer systems. Universal Disk Operating System (UDOS) was developed specifically for and tailored to the multiple CPU architecture. The operating system is executed by the Master CPU in its own totally protected Master memory to prevent disruptions by application programs.

UDOS is floppy disk file oriented. The system was designed specifically for the characteristics and peculiarities of a floppy disk and as such makes maximum use of it's benefits. Many file management functions, normally required to be performed by the user, are performed automatically by UDOS. You need not concern yourself with the structure or internal workings of the file management system. You need only direct that certain data be stored on or taken from a file.

μBASIC™, Millennium's proprietary high level compiler, is a flexible version of BASIC tailored for microprocessor development applications. Unlike interpretive systems the final output of μBASIC is the object code for the microprocessor. μBASIC can also be intermixed with Assembly for memory space reduction and faster program execution.

With Universal One's dynamic trace capability, the activity of a program is traced, instruction by instruction. For break-point analysis two hardware registers provide a break and display of the breakpoint address and contents on memory fetch only, memory write only or on memory read/write access.

Universal One contains a powerful text editor which is file oriented and has macro and iteration capabilities for combining commands.

Millennium provides comprehensive diagnostics which not only test the system's processors, memory & I/O but also check peripheral devices and interrupt logic.
Can the design engineer be right?
Universal One provides two modes of development system emulation for saving time during initial hardware debug and during hardware/software integration. In the first mode, Universal One emulates the prototype’s microprocessor and its memory, while I/O functions are controlled by the user hardware. In the second mode, the prototype uses its own memory and I/O. Universal One’s two-stage emulation eases the transition from initial test to full prototype implementation.

The front panel PROM sockets accommodate the most commonly used PROMs, the 2708, the 1702A MOS erasable and 82S115 family of bipolar PROMs. Others will be added in the future.

Can they all be right?
Obviously yes! Universal One has the capabilities to get development projects completed on time and within budget. And, Universal One will be just as valuable in the future as it is today. The universal architecture assures the product will never be obsolete.

Universal One’s powerful operating system is easy to use so personnel get the most out of it whether they are inexperienced or advanced programmers. µBASIC saves vast amounts of software development and maintenance time.

Last but not least, development system emulation simplifies hardware and software integration. Put it all together, it’s the Universal One for 8080s, 2650s, *6800s, application programmers and design engineers.

* Available January, 1977

A better hardware solution
If you already have good techniques for assembling and debugging your programs but need hardware and PROM programming capabilities, Millennium has a solution. It’s Universal Emulator, an advanced product that provides all the hardware emulation and PROM programming capabilities of Universal One at a lower price. And, it can be upgraded to the Universal One in the field at any time.

You can be right, too!
Universal One and Universal Emulator are available for immediate delivery. A complete Universal One System with a single slave and dual flexible disc is $8,900. Additional slaves are $1,250. A single slave Universal Emulator is $4,500. For a prompt direct reply, return the coupon.

I'm tired of doing it the hard way. Show me a better way. My need is Immediate. Within the next six months. for information only.

Name
Title
Company
Address
City/State/Zip
Application
Phone

MILLENNIUM
420 Mathew Street
Santa Clara, CA 95050
(408) 243-6652

CIRCLE 20 ON INQUIRY CARD
Small Diskette Drives Provide Large Diskette Speed/Reliability

Designed to fit into many applications where conventional diskette drives are physically inappropriate, the series 50 family Mini-Diskette Drives (MDD) require the space of a cassette tape unit yet provide electrical and mechanical parameters which allow their incorporation into a larger system or subsystem. Developed by General Systems International, Inc, 1440 Allec St, Anaheim, CA 92805, the drive consists of read/write and control electronics, drive mechanism, read/write head, track positioning mechanism, and the removable diskette.

Three members of the family—MDD 50, 51, and 52—provide capacities for 100K, 200K, and 400K bytes/disc unformatted or 65.5K, 131K, and 262K bytes/disc formatted with transfer rates of 125K, 250K, and 500K bits/s, respectively. Recording is FM on the model 50, MFM on the 51 and 52. The electronic interface is arranged to be a subset of the GSI 110 industry compatible interface. This together with the track/sector configuration allows easy incorporation into developments where large diskette drives have previously been used. Elimination of ac power requirements makes the device insensitive to variations in the U.S., European, and Asian power sources.

Basic electronics are packaged on one PCB, which contains index/sector detector circuits, head position actuator driver, head load actuator driver, read/write amplifier and transition detector, write protect, and drive select circuits.

A programmable dc drive motor rotates the spindle at 300 or 600 rpm through a belt driven system. The minidiskette is positioned by a registration recess on the face of the spindle. A centering cone that moves in conjunction with the front latch fixes the diskette to the spindle.

Read/write head is positioned with an electrical stepping motor and lead screw. The single element ceramic read/write head has tunnel erase elements to provide erased areas between data tracks preventing normal interchange tolerances between media and drives from degrading the signal/noise ratio, insuring diskette interchangeability. The head is mounted on a carriage on the head position actuator lead screw; the diskette is held perpendicular to the head by a platen, and is loaded against the head with a load pad actuated by the head load solenoid. Contact with the diskette occurs only during data transfer operations, and the head surface is designed to obtain maximum signal transfer with the magnetic surface with minimum wear.

Recording medium is a small flexible disc (Mini-Diskette, specification 100106) permanently housed in an envelope with the apertures necessary for drive spindle, head, and sector hole access. The envelope measures 5¼-in, sq but otherwise is conceptually similar to the IBM diskette.

Disc Storage Subsystem Fills System/370 Storage Needs Economically

The 3650 direct access disc storage subsystem, for attachment to System/370 computers, models 135 through 168, offers full 3350 compatibility plus enhanced software features, improved configuration flexibility, and lower cost/byte for large storage capacity. Developed by Memorex Corp, San Tomas at Central Expressway, Santa Clara, CA 95052, the subsystem uses advanced Data Mark™ 70 and 70F data modules, which incorporate media, read/write heads, and associated circuitry in a removable, self-contained unit, and features optional os and dos/vs native mode support.

Instead of the six recording surfaces with 300-track/in. density used by Data Mark units, the 3650 storage module contains 15 recording surfaces with 480 tracks/in. Higher densities make head-to-track align-
Intel is now shipping high speed, low cost memory for two of the hottest new minicomputers, DEC's PDP-11/04 and PDP-11/34.

That means you can get 30-day delivery and 30 to 50% savings by specifying Intel, the largest independent manufacturer of semiconductor memory.

We can give you add-in memory and add-on memory, both totally compatible with PDP-11 hardware and software. Our in-4711 is an add-in memory for the PDP-11 family and slides into an available memory slot, without modifications. For add-on memory capacity, simply attach the in-4011 memory system. You can add memory in 16K x 16 bit increments, up to 128K words.

Built with the proven Intel 21078 4K RAM, the in-4711 memory is fully transparent to the CPU, with greater processing speed. For maximum throughput you can interleave two memories.

The in-4711's lower power consumption permits wider operating margins on the main frame power supply and results in a cooler running, more reliable system.

If you've picked DEC to be your computer supplier, go with the best for memory, too. Intel delivers a complete line of add-in and add-on memory for the entire PDP-11 family.

That puts two good names together. Add a third — yours — with the coupon.

Intel Memory Systems
1302 N. Mathilda Avenue
Sunnyvale, California 94086

Please send me information on the following

Intel Memory Systems:
☐ for PDP-11/04, 11/34
☐ for PDP-11/05, 11/35
☐ for PDP-11/_______

Name/Title________________________________________
Company________________________________________
Address___________________________Mail Station_____
Phone___________________________
City/State/Zip___________________________

CIRCLE 21 ON INQUIRY CARD
Word Processing System Incorporates Video Display, Text Editing Facilities

The WP5000 family of word processing systems is keynoted by operational simplicity. While providing video display, automatic printing, and text editing and revision facilities, N. V. Philips Gloeilampenfabrieken, Eindhoven, The Netherlands organized the system around the operator—it provides instant feedback by indicating on the video screen all operations entered on the keyboard.

To produce typewritten documents, the operator enters text from the keyboard; text is stored in an electronic memory and simultaneously appears on the visual display unit (VDU). The operator modifies text appearing on the VDU if necessary, and at the touch of a key causes the high speed printer to provide finished text. Texts can be recorded on magnetic tape or flexible disc and reproduced on screen or printer.

Redundant Computer Configuration Will Control Space Shuttle

NASA's space shuttle orbiter, being readied for flight, will have an Orbiter Avionics Data Processing System onboard for guidance, navigation, control, and performance monitoring. The system, developed under contract to Rockwell International Corp's Space Div by International Business Machines Corp's Federal Systems Div, 10215 Fernwood Rd, Bethesda, MD 20034, will also collect and analyze data from hundreds of onboard sensors and display information in real-time to the shuttle's flight crew. System components include onboard computers, interface equipment, displays, and mass memories.

Five computers, arranged in a redundant configuration, will allow a mission to continue even if multiple failures are experienced. In this "digital fly-by-wire" configuration, the vehicle is controlled by electrical signals developed by a digital computer and sent to mechanical actuators. The computers are modified versions of the AP-101 model, part of the Advanced System/4 Pi avionics computer series.

Input/output processors act as the interface between the AP-101 and other Orbiter systems. These units perform detail management and buffering of I/O data for the computers. Mass memory units support the computers and displays by providing storage for computer programs and display formats. Multifunction CRT display subsystems provide the interface between the flight crew and the data processing system.

Computer Graphics System Produces Shaded Images in Real Time

An advanced computer graphics system has demonstrated the capability to produce either vectored or shaded real-time images of dynamic 3-dimensional environments. A graphics extended ALGOL compiler implemented on the system at Case Western Reserve University, Cleveland, OH 44106, allows the user to deal with the system at a high level. Images can easily be produced, turned in any direction and colored, and then recorded on film.

Objects can be described to the computer mathematically, a set of points can be entered from the keyboard, or a data tablet with two special pens can be used to draw designs. Three-dimensional environments are specified using planar polygons as the primitive structure. The system conceives all drawings in basic units of polygons. It turns or cuts polygons to form any shape, creating images having up to 1000 polygon edges in real-time (30 images/s) for animated sequences. Im-

(Continued on p 41)
When you’re buying low-cost computers, it pays to look beneath the surface.

Floppy Disk Controller. Model 14566-01. Provides interfaces for one to four IBM-compatible standard floppy disks, or equivalent. Cabling separate.

Piggyback Teletype Interface. Model 12635-01. For LSI-3/05 processor. On-board mounting provides bit-serial interface. (For byte-serial interface, use Distributed I/O System with Current-Loop Serial Intelligent Cable.)

I/O Terminator Module. Model 14511-00. Convenient means for terminating user-designed I/O cables. Plugs onto rear of I/O cards (uses 100 pin connector) with rigid termination. Pads for mounting termination components provided.

Utility I/O Interface Module. Model 14223-00. General purpose interface with 8 or 12-bit output transfers with 4 control bits in parallel.

64-bit Input Module. Model 13219-00. Provides 64, 32, 16 or 8-bit inputs with individual strobes.

16-bit Digital Input/Output Module. Model 13213-00. Provides input and output registers which may be used as one 16-bit or two 8-bit registers. DTL/TTL compatible.

I/O Driver Module. Model 13222-00. Units drive the computer I/O bus up to 25 feet, buffer internal I/O bus from external noise. Does not include memory signals.

Moving Head Disk Controller. Model 14530-XX. Provides interfaces for one to four standard moving head disk drives, or equivalent. 1500 or 2400 RPM. Cabling separate.

32-bit Relay Input Module. Model 13215-00. Operates as one 32-bit, two 16-bit, or four 8-bit inputs.

32-bit Relay Output Module. Model 13214-20. Operates as one 32-bit, two 16-bit, or four 8-bit outputs.

Asynchronous Modem Controller. Model 14535-XX. For one asynchronous line (point-to-point, multipoint, or dial). Fully programmable for mode, character size, parity, echoplex, diagnosis loop-back, special character detect, variable stop bits. Send/receive speed individually selectable with jumpers—up to 9600 baud. Available as EIA Interface with full Data Set Controls or as Current Loop Interface.

Asynchronous Modem Multiplex. Model 14512-XX. As above, but for two or four independent asynchronous lines. Multiple vectored interrupts for each line.
NAKED MILLI LSI-3/05 CPU, Type 0. Model 10300-00. Small low-cost processor offers exceptional power and features. 95 instructions, Power Fail Restart, vectored priority interrupts and 16-bit DMA port.

NAKED MINI LSI-2/10 CPU. Model 10600-00. 16-bit minicomputer processor offers twice the speed of LSI-3/05 processors. Includes Power Fail Restart option. See ALPHA LSI-2/10 description.

RAM/ROM/PROM Memories. Model 11650-XX. Includes semiconductor RAM in choice of 256, 1K or 2K words; sockets for 8K words of ROM and sockets for 2K words of PROM. Available with On-card Battery Backup.

RAM/EPROM Memories. Model 11530-XX. Includes semiconductor RAM in choice of 1K or 2K words and sockets for 4K words of ultra-violet Erasable Programmable ROM. Available with On-card Battery Backup; also, optional EPROM Programmer.

Half-card Core Memory. Model 11671-XX. 4K words. For either NAKED MILLI/ALPHA LSI-3/05 or NAKED MINI/ALPHA LSI-2 Series Computers.

RAM-only Memories. Model 11642-XX. Choice of 4K or 8K words. Available with Battery Pack.

Full-card Core Memories. Model 115X0-XX. Choice of 8K words of Core 980 Memory or 16K words of Core 1200 Memory. For Standard or Jumbo Chassis only.

I/O Distributor. Model 14629-XX. In conjunction with Intelligent Cables (see text), the I/O Distributor provides up to eight interfaces—serial or parallel in any mix. Small version accommodates four interfaces. A DMA version allows data transfer rates up to 250K bytes per second.

Magnetic Tape Controller. Model 14224-00. Provides interfaces for one to four 9-track standard tape units, or equivalent. Cabling separate.

Intelligent Cables. Model 14631-XX. A broad assortment of models offers off-the-shelf interface for most standard and special user devices: Line Printer, CREader, Paper Tape Reader, Paper Tape Punch, Current Loop, CRT, Modem, etc. General Purpose and Custom Programmed versions.

16-channel Priority Interrupt Module. Model 13220-00. 16 interrupts with acknowledgement lines.
Knowing what the OEM needs... understanding the OEM predicament. That’s what sets Computer Automation apart. It’s the reason we ship over 100 computers per week—the second highest shipping rate in the industry.

**Guaranteed savings.**
OEM's buy our computers because they're the most reliable machines made.
Every IC, subassembly, memory subsystem and completed computer is temperature, shock and vibration tested.
That’s why Computer Automation can offer the only one-year warranty in the industry—when we send a computer out, we know it’s not coming back for a long time.

**We deliver.**
In an industry where one delinquent diode can (and sooner or later will) shut down an entire assembly line, that’s saying a lot.
It especially says a lot to OEM's who know they’re at the mercy of their sole source computer supplier. One thing you can’t do is stick somebody else’s machine in that slot.

So here’s a thought you might want to stick in the back of your mind for future use:
Computer Automation delivers on time.
The reason is that we deliver from inventory—usually a comfortable 30-day cushion of computers sitting around getting more reliable by the minute because they’re kept under power and constant test scrutiny.
A lot more trouble for us, but a lot less worry for you. And it does tend to prove our point. We understand the problem.

**From the people who brought you the NAKED MINI.**
The people who brought you the first solution to high-cost computers.
And the most recent solution as well.
And all the solutions in between. Including low-cost memory. And the Distributed I/O System. Plus on-time delivery. And the only full-year warranty in the business.
The total solution to computerization.
So if you can’t spare the time and money to re-invent the wheel, there’s a simple solution... from the people who came up with all the other solutions.

---

**Temperature chambers stress computers to isolate marginal components. Computers are continuously tested during 72-hour burn-in at 50°C. Any error starts the test over from the beginning. To further stress the computer, power is cycled on and off approximately 2000 times during test.**

**Computers awaiting shipment idle away the hours under test. Reliability benefits from the additional component aging.**

---

Computer Automation
Naked Mini Division


LITHO IN U.S.A.
The cost of an OEM computer can be a lot different than the price on the PO. In fact, everything considered, the purchase price could be as little as ten percent of the costs incurred over the life of the computer. To be brutally blunt, it all depends on whose hardware you buy. That's because the cost of computerizing goes way up with most machines.

The cost of hardware integration, for example.
The cost of developing interface electronics.
The cost of developing software.
The cost to maintain the machine once it's out in the field.
Any one of which could seriously impact the profitability of your product. Given that possibility, here's what you need to know to protect those profits.

**Engineering Costs.**
Prototyping and systems integration is a high-cost area where, traditionally, the OEM has been left to his own devices, so to speak.
ComputerAutomation doesn't work that way. We've accumulated enormous experience in systems integration because we get involved in our customer's projects.

What's more, we've put together a program for sharing that experience with our customers...free, of course. Part of it includes extraordinarily comprehensive documentation provided on an ongoing basis. But more importantly, it's a people-to-people program that even provides on-board support personnel when they're needed.

**Programming Costs.**
No other endeavor consumes time and money quite like programming. For the OEM who's usually racing to release a new product ASAP, even a minor programming effort can be a major setback.

The solution is to concentrate on the applications end of it and not re-invent software that's already on somebody's shelf—ours. ComputerAutomation has an enormous library of powerful software that will cost you next-to-nothing. Everything from humble assemblers to high-powered compilers in BASIC and FORTRAN IV.

The powerful instruction set that comes with our computers will spare you countless hours of programming effort, too, because it's designed with that objective in mind.
Remember, too, that all our computers are buss compatible. Which means you won't have to start programming all over again when you switch to another computer in our LSI Family.

**Interface Costs.**
Many times an OEM is forced to invent his own interface...usually a very expensive proposition...because the supplier he's
ALPHA LSI-3/05, NAKED MILLI Series. Model 10373-XX. Includes LSI-3/05 CPU (Type 1), with LSI Family compatibility, three half-card chassis, 10-Amp power supply and Operator's Console. This small, low-cost computer offers exceptional power and features, including 95 instructions, Power Fail Restart, vectored priority interrupts, Real-Time Clock, AutoLoad capability and 16-bit DMA port. Full memory options.

ALPHA LSI-3/05 B, NAKED MILLI Series. Model 10375-XX. Includes LSI-3/05 CPU (Type 1) described at left, plus 5 half-card chassis with fan, 15-Amp power supply and Operator's Console. Full memory options.

ALPHA LSI-3/05 C, NAKED MILLI Series. Model 10376-XX. Same as LSI-3/05 B configuration with addition of Programmer's Console.

ALPHA LSI-3/05 D, NAKED MILLI Series. Model 10356-XX. Includes LSI-3/05 CPU (Type 1) as above, standard five full-slot processor chassis, 25-Amp power supply and Operator's Console. Core memory in either 4K, 8K or 16K word sizes.

ALPHA LSI-3/05 E, NAKED MILLI Series. Model 10366-XX. Same as LSI-3/05 D configuration with addition of Programmer's Console. Either RAM-only or Core Memory in 4K, 8K, or 16K sizes.


ALPHA LSI-2/20 G, NAKED MINI Series. Model 1055X-XX. Same as LSI-2/10 G configuration except with high performance LSI-2/20 CPU, as above.

ALPHA LSI-2/10 T, NAKED MINI Series. Model 1074X-XX. A 16-bit mini-computer offering twice the speed of our LSI-3/05 computers. CPU provides 188 major instructions, including multiple stack handling, hardware multiply/divide, memory scan, and extensive byte capability. Five vectored priority interrupts are expandable to 256; two direct memory channels may be increased to 64. Direct Memory Access is standard. Includes Power Fail Restart. Also includes chassis with power supply and Operator's Console. Available in either 5-card or 9-card versions. 4K or 8K Core 980 Memory or 16K Core 1200 Memory. Memory modules may be added up to 256K words using Memory Bank Control.


Software and Documentation Packages. Advanced software and documentation packages, including BASIC, FORTRAN IV, Real-Time Executive and Operating System are available. Plus a complete inventory of diagnostics, editors, assemblers.

Variables, Teletype or EIA CRT interface, Real-Time Clock, AutoLoad ROM Set. Full Memory options.
picked doesn't offer all the interface he needs. 

Or, in some cases, the supplier's interface solution is so expensive it forces the OEM to go his own way.

So, at a time when he needs to concentrate all his energies on his own product development, the OEM finds himself committing substantial resources to a peripheral project. One that can be deceptively time-consuming and costly.

Suddenly the designers are coming in, more test equipment is being designed/built/ordered, ditto for new jigs and test fixtureing, the documentation hassle is getting under way, and the dollar and time costs start really piling up.

ComputerAutomation is the only computer company that has solved that problem. You can see it here in the picture. Our exclusive Distributed I/O System. Probably the closest thing to a universal interface you'll ever come across.

The Distributed I/O System only works with our computers, but it works with all our computers.

The way it works is this: one half-card I/O Distributor handles the commonalities for up to eight interfaces. (There's a four interface version, too.) The actual interface is accomplished by an Intelligent Cable—so-called because of the microcoded PicoProcessor molded into the cable.

This system offers amazing versatility: any and all kinds of interface can be mixed in any combination—serial, parallel or whatever. And not just standard peripherals, either. The Distributed I/O System accommodates special purpose black box kinds of things, too. There's even a version you can custom microcode yourself.

The cost? Typically under $200 per interface in OEM quantities of 100.

Maintenance Costs.
The cost of keeping a computer in service over the long haul can be enormous. The proof of which is the huge service revenues reported by some computer companies. (Up to $2,000 per year per computer!)

ComputerAutomation's service revenues, by comparison, are minuscule. The reason is that our equipment is so reliable that breakdowns are few and far between. And when there is a malfunction, the fix is almost always a matter of plugging in a spare board and sending the bad board back to us. No tricky fine-tuning to worry about and no high-priced junior technician in there messing around with your customer's equipment.

The Computerization Solution.
The computerization problem obviously goes far beyond computers. So it makes sense that the solution is not only a computer solution, but a systems solution as well.

To find that solution you have to look at the big picture—which we invite you to do by turning the page.

Synchronous Modem Controller. Model 14513-00. Double buffered, half or full-duplex interface for synchronous communications line (point-to-point, multipoint, or direct dial). EIA RS232C/CCITT compatible, programmable synchronous character, and one special character detect. Odd, even or no parity and 5-8 bit frame size program selectable. Transfer to 9600 baud.

Model 14513-01 provides internal clock with strappable options for 1200, 2400, 3600, 4800, 7200 or 9600 baud operation and full Data Set Controls.

EIA RS232 Interface. Model 14236-5X. For one CRT at baud rates from 110 to 9600. Half-duplex operations only.

EIA RS232 Interface. Model 14236-5X. For one CRT at baud rates from 110 to 9600. Half-duplex operations only.

64-bit Output Module. Model 13216-00. Provides output for use as 64-bit word or multiples of 32, 16, or 8-bits with individual strobes.


Card Expansion Modules. Model 12098-00/12099-00. Five and nine-slot versions include chassis, blank panel with expansion buffer controller, interconnecting cables and power supply.

Card Cage, LSI-3/05. Model 12095-0X. Available in either 3-card or 5-card versions. Includes motherboard, card guides, and retaining hardware.

Automatic Calling Unit (ACU) Multiplexer. Model 13523-0X. Provides interfaces for one to four Model 801 ACU’s, or equivalent. Simultaneous operations, full digit buffering and sense date-line busy. Four vectored interrupts per ACU. Available for either two or four ACU’s.

Standard Power Supply. Model 12044-00. Supplies +5V @ 25 Amp +12V @ 4 Amps and −12V @ 9 Amps.

Power supplies for LSI-3/05. Model 12046-0X. Open frame power supplies mount in any plane. Supply +5V @ 10 Amps, +12V @ 0.8 Amps, −12V @ 0.8 Amps, +12V @ 1.1 Amps, −12V @ 1.5 Amps. With fan.

Jumbo Power Supply. Model 20441-00. Supplies +5V @ 36 Amps, +12V @ 5.6 Amps, −12V @ 10.7 Amps.

MegaByters. Model 109 Series. High-speed 16-bit systems for real-time, communications and business applications. Features include LSI Family compatibility; four standard input-output modes, including Direct Memory Access; vectored priority interrupts; and a comprehensive set of 224 instructions. Includes Jumbo Chassis, Jumbo Power Supply, Programmer’s Console, Power Fail Restart, Basic Time Clock, AutoLoad test equipment or options not covered, please contact the factory or your regional sales representative.
DIGITAL TECHNOLOGY REVIEW

Semiconductor Laser Solves Problems of Videodisc Pickup Systems

High operating costs and difficult adjustment and maintenance associated with conventional optical videodisc pickup systems have been overcome using a semiconductor laser pickup. Developed by Hitachi Ltd, Central Research Laboratory, Tokyo, Japan, the pickup is directly compatible with conventional HeNe systems but easier to adjust and maintain, requires a smaller power supply, and is one-twentieth the size and volume.

Developed for Philips type videodiscs, the pickup uses a buried heterostructure injection laser for the light source. In the optical system a laser beam is focused as a microspot on the videodisc, and the reflected beam is detected by a photosensor. Conventional systems employ a large HeNe (helium neon) laser as the light source and a complex composition of mirrors and lenses for reproduction, resulting in high operating costs and difficult adjustment and maintenance. By using a semiconductor laser as light source and by bringing into one axis the laser beams for detection of video and servo signals, the optical system has been significantly simplified. Testing conducted with the laser pickup functioning at an output power of 0.5 mW has resulted in images with 40 dB signal/noise ratio—equivalent to the level used for ordinary color TV.

The ultra-small-size semiconductor laser which serves as light source has a 1 micron (1/1000 mm²) radiant surface. Active region is made of filamentary GaAs buried completely in GaAlAs, a substance which causes no optical loss in the lasing. This buried heterostructure, achieved by using a successive liquid-phase-epitaxial growth technique, provides added advantages of reduced adjustment and maintenance associated with conventional HeNe systems but easier to adjust and maintain, requires a smaller power supply, and is one-twentieth the size and volume.

High operating costs and difficult adjustment and maintenance associated with conventional optical videodisc pickup systems have been overcome using a semiconductor laser pickup. Developed by Hitachi Ltd, Central Research Laboratory, Tokyo, Japan, the pickup is directly compatible with conventional HeNe systems but easier to adjust and maintain, requires a smaller power supply, and is one-twentieth the size and volume.

Developed for Philips type videodiscs, the pickup uses a buried heterostructure injection laser for the light source. In the optical system a laser beam is focused as a microspot on the videodisc, and the reflected beam is detected by a photosensor. Conventional systems employ a large HeNe (helium neon) laser as the light source and a complex composition of mirrors and lenses for reproduction, resulting in high operating costs and difficult adjustment and maintenance. By using a semiconductor laser as light source and by bringing into one axis the laser beams for detection of video and servo signals, the optical system has been significantly simplified. Testing conducted with the laser pickup functioning at an output power of 0.5 mW has resulted in images with 40 dB signal/noise ratio—equivalent to the level used for ordinary color TV.

The ultra-small-size semiconductor laser which serves as light source has a 1 micron (1/1000 mm²) radiant surface. Active region is made of filamentary GaAs buried completely in GaAlAs, a substance which causes no optical loss in the lasing. This buried heterostructure, achieved by using a successive liquid-phase-epitaxial growth technique, provides added advantages of reduced operating current and device size. Threshold current of this laser at room temperature is a minimum of 17 mA in dc and 15 mA in pulsed operation, or about an order of magnitude lower than those of conventional devices. The filamentary active region allows superior thermal characteristics to be obtained and allows continuous operation at room temperature even with heat dissipation through the GaAs substrate. Low operating current makes a large heat sink unnecessary and permits the device to have a volume of less than 1 cm³.

Used in the optical pickup, the laser has an inherently small radiant surface, and gives steady spot

-aged having up to 4000 polygon edges can be produced at slower rates. Colored filters are used to record the finished product on 35-mm film or as 4 x 5" stills.

Most of the graphics work is produced on hardware designed by Evans & Sutherland, Salt Lake City, Utah. A PDP-11/40 is the controlling processor, handling I/O for itself and the channel controller processor. The two processors share a common memory, communicating via memory and the Unibus™. Channel control processor and associated graphics hardware appear as a peripheral to the -11/40.

A high-speed 4 x 4 array multiplier, the matrix multiplier performs rotations, translations, scaling, and perspective transformations. Accepting input from the channel controller, the unit feeds information to the shaded graphics pipeline, vector graphics pipeline, or back to the channel controller.

The shaded graphics pipeline consists of polygon clipping/divider, Y-sort memory, visible surface processor, and shaded-raster generator. Within these components data are manipulated with hardware-implemented algorithms to produce the shaded raster-scanned images that are similar to TV images. The vector graphics pipeline contains hardware which interprets data and commands from the matrix multiplier and channel controller to produce dynamic vector images, eliminating vectors outside the field of view, performing perspective division, and producing X-Y deflection signals to draw the specified vector. Output from either pipeline goes to two black/white display monitors and/or to a film recording unit.

User interaction with the system is provided through a user terminal—consisting of keyboard and alphanumeric display and a large dual-pen data tablet. Storage for system software, user programs, and data files is provided by a 10M byte disk. A communications link allows the graphics system to communicate with a PDP-11/45 and with a text editing file storage system, which provides services such as magnetic tape drives and mass storage, not available on the graphics system.

Some of the projects attempted on the system include a motion picture illustrating stresses on a supersonic aircraft in flight, illustration of fluid flows, visualization of automobile traffic patterns, and illustration of the molecular bonding of chemicals.

Circle 144 on Inquiry Card

Shaded real-time images of dynamic 3-dimensional environments can be produced using Case-Western's computer graphics system. Conceiving of all drawings in basic units of polygons (see diagram), the system creates shaded images such as that shown in the photo. Animated sequences of images having up to 1000 polygon edges can be produced in real-time; more complex images with up to 4000 polygon edges are produced at slower rates.
Look at the latest in plasma display.

alpha/graphics terminals

- Military Environments
- 10 Year Operating Life
- Low Life Cycle Cost
- High Brightness
- High Resolution
- High Contrast
- Reduced Size
- Interactive
Now look at the source.

Interstate Electronics—veteran supplier of military computer-based electronic equipment.

For over 20 years, we've designed and delivered hardware for a range of environments, from laboratory to full Mil-Spec conditions. Today, we're among the leading 100 defense contractors in America.

Now we're producing plasma display terminals under multiple military contracts. Our products range from standard off-the-shelf models to special configurations, with display features like joy-stick interactive editing and microprocessor control. All have the inherent advantages of plasma display—plus Mil-Spec capability.

Your new military display source—Interstate Electronics—a dynamic part of the Electronics Group of A-T-O, Inc.

Give us an opportunity to discuss your operational environment and performance requirements. Write Sid Wing, Military Products Manager, Interstate Electronics Corp., Marketing Department, 707 E. Vermont Ave., Anaheim, CA 92802. Better yet, call him at (714) 772-2811.
radiation at an operating current of approximately 10 mA. The diameter of the microspot has been reduced to less than 2 microns, necessary for reproduction on the videodisc and to secure output power of more than 0.5 mW.

Rather than a separate laser beam system necessary for conventional detection of the autofocusing, tracking, and image signals, the pickup detects all signals with a single beam. Using a single beam simplifies composition, improves light utilization efficiency, and allows easy adjustment. Quality of the reproduced signal is also improved because mutual interference between autofocusing and tracking signals is compensated for electrically.

Circle 145 on Inquiry Card

Developed by Hitachi, the optical pickup system for Philips type videodisc systems uses a semiconductor laser to greatly reduce both size and operating costs. One-twentieth the size of a conventional pickup, the unit's optical system has been simplified by bringing into one axis the laser beams for detection of video and servo signals, thus reducing the difficulty of adjustment and maintenance.

Circle 146 on Inquiry Card

**Commercial Computer Doubles Memory Capacity, Uses High Density Modules**

Distributed processing, commercially oriented minicomputers, and data base capability on minicomputers have been identified as existing needs by commercial computer users. The Eclipse C/330 computer and IDEA software, introduced by Data General Corp., Southboro, MA 01772, respond to these needs and provide easier implementation and use of minicomputer systems by data processing managers who must distribute processing capability to both decentralized and relatively unsophisticated users.

The C/330 incorporates 64K-byte semiconductor and 32K-byte core single board memory modules, and uses a memory allocation and protection (MAP) unit to attain main memory capacity of 512K bytes with hardware protection of user programs in dual programming applications. Dense memory results in fewer connections and interfaces, increasing system reliability; while the MAP's large memory capacity offers advantages to multiterminal interactive data entry/access (IDEA) system users.

Microprogrammed architecture of the C/330 processor includes a comprehensive instruction set tailored for data handling. Capabilities include word, byte, and bit addressing, character string move and compare, and code translation. A special edit command provides the ability to convert from packed or unpacked decimal to ASCII and to perform formatting functions such as leading zero suppression and punctuation control. Both 16- and 32-bit instructions are provided. The instruction set optimizes operating system and high level language performance by replacing software routines with a single instruction.

Operating system interrupt servicing is performed in high speed hardware, providing the fast response important to multiterminal or communications environments. A single instruction identifies the interrupt source, saves the machine state, switches from user to system stack, and alters the priority structure. Packed and unpacked decimal numeric data are handled by the extended arithmetic processor which operates in parallel with the CPU, and performs single and double precision floating arithmetic.

Core and semiconductor memory modules may be mixed in the computer, and modules may be interleaved up to eight ways to reduce effective cycle time. Both 32K-byte core and 64K-byte semiconductor modules are available as single boards for high density. Speed of the 64K n-MOS has been increased to 500 ns for read cycles, compared to the 700-ns read cycle time for previous 16K modules; write cycle is 700 ns. Memory error checking and correction is standard, detecting and correcting all single-bit main memory errors and detecting most multiple bit errors. The 32K core modules have an 800-ns full cycle time, achieved using a split sense memory technique to reduce the traditional 1-µs speed.

IDEA software (which includes an easy to use English-like language) consists of a screen-format generator for freeform format design, a compiler for specifying field processing, and an online multiterminal monitor that controls up to 16 terminals. A user-transparent interface provides access to the INFOS data management system, giving users multilevel keyed access to data base files for record retrieval, display, and updating.

The language provides a full range of arithmetic and trigonometric functions, multidimensional arrays, matrices, string, and relational operations. Extended features include the WHEN statement, which allows the user to develop programmed routines that accept and service randomly-timed interrupts.

The language provides a full range of arithmetic and trigonometric functions, multidimensional arrays, matrices, string, and relational operations. Extended features include the WHEN statement, which allows the user to develop programmed routines that accept and service randomly-timed interrupts.

The language provides a full range of arithmetic and trigonometric functions, multidimensional arrays, matrices, string, and relational operations. Extended features include the WHEN statement, which allows the user to develop programmed routines that accept and service randomly-timed interrupts.

Extended I/O statements allow the use to specify a unit number or mnemonic to identify a logical I/O device. The CALL statement allows users to call and pass parameters to assembly language subroutines. Users can set and read the date and time of day through the TIME statement.

Controller BASIC requires 8K of memory and is executed under the company's Real-Time Executive. Software and documentation are available from Computer Automation, 15651 Von Karman, Irvine, CA 92713 for a one-time charge of $400.

Circle 147 on Inquiry Card
Compare the new Sanders Graphic 7 with other interactive terminals.

You'll draw a graphic conclusion.

Sanders' new Graphic 7 is an intelligent terminal with all necessary hardware and software as standard—not cost-you-extra—features.

But the Graphic 7 doesn't just save you money when you buy it. It also saves you money after you buy it. Simply wheel your Graphic 7 through the door and plug it in. No installation problems.

Your programmer won't have to spend much time with your Graphic 7. It comes pre-programmed.

And your operators will be able to handle your Graphic 7 after a 10-minute briefing, because it works with a one-button initialize.

Application programs? Our Fortran-based graphic support package can reside in any host that supports Fortran.

And with the intelligence at the terminal, there's minimum impact on the host. You can do more work faster.

Sanders experience? Our graphic terminal systems are used in computerized production projects. Tire-tread design. Avionics defense systems. Flight training. Land-use management. Air traffic control. And dozens of other areas.

Compatible, fully equipped, low priced. What other graphic conclusion can you draw than the new Sanders Graphic 7? Send for specs and specific applications.

Sanders Associates, Graphic Systems Marketing, South Nashua, NH 03060. 603-885-5280.
Multimodule systems are designed with inter-module datalink communication to assure coordinated individual control operation. Control communication between modules is accomplished by two independent datalinks. An internal monitor and output detector are separate and distinct from each other. Each is redundant of the other, eliminating any possible common mode control failures, and providing sustained power output even if one datalink is lost.

Operator controls on the system consist merely of "start" and "stop." Operational control with self-protection for each module is completely automatic with the Logicenter. A self-diagnosing, completely solid-state annunciator in each module produces a time-stamped hard copy printout of status and sequential events in the automatic system operation. Indications are provided for more than 230 monitored items and solid-state instrumentation; a digital display is provided for the instrumentation. Each module power has built-in "early warning" detectors. Triggered by a module malfunction, the system prevents disturbance to the critical computer load while minimizing damage within the module. Detectors are simultaneously linked to the sequential, self-diagnostics annunciator.

A duplicate module control panel including the printer and display can be remotely located, permitting complete control from a remote station.

Circle 148 on Inquiry Card
The Intecolor® 8001
It's an 8-Color Intelligent CRT for $1995.*
Or a Micro Computer for an additional $1495.
The choice is yours.

A $1995 8-Color CRT. Complete.
When we say complete, we mean complete. The Intecolor 8001 has 8080 CPU, 4K RAM Refresh, Selectable Baud Rate to 9600, Keyboard, RS232 I/O, and ASCII Character Set. All in one package. It's a complete stand-alone system which features our unique Intecolor 8001 NINE SECTOR CONVERGENCE SYSTEM for minimum set-up time and exceptional stability. Three to five minutes is all it takes for outstanding color registration.

The $1495 Micro Computer Package.
You just give us the word and we'll convert the Intecolor 8001 into a stand-alone micro computer with BASIC, Roll, Insert/Delete, Additional 8K RAM Work Space, Graphics Mode with 160×192 Elements, Background Color, Lower Case ASCII, 48 Line X 80 Characters/Line, and 2X Character Height. Plus additional features which make your Intecolor personal computer the best buy in the industry. Interaction and significant error reductions in data entry and recognition. The Intecolor 8001 CRT can also be used or marketed as a complete stand-alone micro computer system with computation or control capabilities. It might even replace your whole system!

Whatever your needs, market or application — Process Control, Medical, Credit Checking, Order Entry, Financial Analysis, Research and Development, or for your own personal computer — you won't find a more usable terminal, color or black and white.

Which System Is Right For You?
The Intecolor 8001 CRT is a smart, inexpensive way to upgrade the CRT's in your present system from black and white to color. And color has definite sales advantages. Like more efficient man-machine interaction and significant error reductions in data entry and recognition.

Write Or Call For More Information
We know you're going to have some more questions, and we've got the answers. We think we've come up with a CRT and computer package that's hard to beat. And one thing for sure. The Intecolor 8001 is by far your best buy today in a color CRT micro computer or intelligent terminal. Make us prove it to you with a demonstration by one of our authorized representatives. Or call us direct and talk to an applications engineer.

Intelligent Systems Corp.
5965 Peachtree Corners East
Norcross, Georgia 30071
Telephone (404) 449-5961

*Quantity 100 Price.
Unit Price $2,495. Domestic USA Prices
Reliability

How do you measure it? We offer you hard cash numbers, not calculated MTBF claims and selected success stories. Our measure of Teleray Reliability is in terms of total life-cycle cost—not just price, but low acquisition cost plus low operating cost (including downtime & repair).

That comes out like this—
- Competitive pricing & low lease costs
- One year warranty—no-cost unlimited parts/assembly exchange
- Second-year warranty extension—$60 to $90 depending on model
- On-site maintenance—$7 to $12 per month (on lease) depending on model

Teleray has exceeded a conservative 6,000-hour MTBF rating based on a four-year field study. And we do have many success stories among our 600+ customers. But, we believe dollars measure Teleray Reliability better than words and calculated numbers. You can talk to us collect on (612) 941-3300. There’s a Reliable Teleray to match your need and budget, including APL.

**Teleray**
Division of
RESEARCH INC

Teleray Model 3541-TTY Replacement,
1920 Characters, Upper Case, TTY
Solid-State Keyboard, 50 to 9600
Baud, Backspace, Screen-Clear &
Space-over-Data standard. Small
Qty Price—$1125, Lease—$52/Mo.

A plug-in module for Tektronix’ 7D01 logic analyzer, the DF1 display formatter provides mapping displays in binary, octal, or hexadecimal configurations. Side-by-side comparison of stored reference data against new data in exclusive-OR mode provides an intensified display of new data that differ from those in the reference table.

In state table mode, standard display consists of a table of 16 lines of 16-bit words, in binary, octal, or hexadecimal. The interval between the cursor-selected word and the triggering word is displayed in alphanumeric characters at the top of the CRT screen. When the trigger word appears in the table it flashes intermittently for quick identification. Display is advanced line for line with fine cursor control, table by table with the coarse control.

Side by side comparisons of reference vs “new” data can be made. Data from the circuit under test are displayed on the left half of the screen (7D01 display); data transferred to the DF1 from an earlier 7D01 display are shown on the right hand side (reference display). An exclusive-or mode intensifies data on the 7D01 display which differ from that of the reference table to permit easy identification. Comparisons can be made table by table or column by column. Reference data in DF1 memory can be compared line by line or table by table with new data; the new data window can be advanced to provide comparison of two data sets offset by a specific number of words, or new memory can be searched for each occurrence of a key word in reference memory.

Circle 149 on Inquiry Card
From those wonderful folks who brought you the best high-priced testers.

The best low-priced tester.
Television Network Automated by Minicomputer-Controlled Channels

Viewers of televised musical spectaculars or dramatic extravaganzas regularly are awed by the extensive and complicated audio and video effects that often make the human talent on display seem of secondary importance. Yet these viewers rarely consider the even more awesome problems of getting those programs on the air—coordinating video and audio, inserting commercials, cuing special events, starting and stopping one program, and starting the next—without either blanks or overlaps.

The editors for a program may have days or weeks to cut and merge tapes before finalizing the program; the engineers putting that program over the network are working in real time. They can't back up and start over if they make a mistake.

Of course, the viewers—as the customers for the network's programs—should not be expected to consider those problems. They have every right to anticipate a perfect sequence of programming—and certainly the sponsors of the programs demand a smooth and uneventful continuance that will not detract from the impact of their commercials upon the viewers.

Commonly, the hub of all activity related to airing television programs is a television center or central. At NBC's New York City plant, for instance, the TV central coordinates several relatively independent areas such as production studios, telecine equipment, video tape machines, and audio/video master controls and circuits to assure proper release of audio and video signals to both the local NBC station (WNBC-TV) and the NBC television network.

Chief element of this coordination is “switching central,” which in turn depends on a master grid or audio/video routing switcher. Provisions are included for 10 simultaneous output channels, six of which have so far been implemented. Each of these six channels is controlled by a 16-bit General Automation, Inc SPC 16/45 minicomputer with 32K words of core memory, supplemented by 2.5M words of disc memory. In addition, two “keyboard” computers, substantially identical to the online “channel” computers, are included for addressing the channel computers to load or retrieve data. System design was conceived and executed by NBC Engineering. Portions of the system were then subcontracted for manufacture according to “black box” specifications. The routing switcher, for example, was built by General Dynamics, San Diego, Calif. Software was developed and executed by a 5-man team of programmers attached to RCA Laboratories, Princeton, NJ.

Most daily programming requirements are handled by one channel for the local station and one for the network. The remaining four active channels serve for special network services, to backup the local or network channels, to automatically preview programs for clients, or as automated pre-assembly facilities.

Master Grid

In its current organization, the master grid—an audio/video routing switcher—can switch 100 video inputs and 300 associated audio inputs into 320 possible users. Four different audio sources can complement each video source (although only three have so far been implemented).

Within the structure of each of the six channels, the respective minicomputer requires supporting equipment in order to perform its job. Since all station/network events are based on time, very precise time information must be input to the CPU. As shown in Fig. 1, in order to initiate computer procedures a time code is fed into a time code reader by a plant precision time generator. This code, originally intended...
The introduction of the affordable computer power center, the Hewlett-Packard 1000 Computer System, is one of those fortunate occasions where a number of computer advances arrive concurrently and are able to be utilized within a single new computer system. Significant contributions within the HP 1000 computer system include a fast new processor, and a fast and flexible new CRT terminal as the convenient machine/human interface to HP's new IMAGE/1000 data base management software. Plus, the system's contemporary and attractive desk styling is a welcome addition to office environments.

Beyond these new capabilities, the HP 1000 builds on previous contributions such as HP's complete computer network software, the Hewlett-Packard Interface Bus for control of automated instrument systems, HP's efficient and proven Real Time operating systems, and the fastest cartridge disc memory on the market.

The effect is an exceptionally fast and powerful small computer system that both OEM's and end users with computer experience can easily use as a tool to implement a wide range of applications. The HP 1000 is well suited to computation, instrumentation, and operations management applications that demand high performance. Because its increased performance is priced five to ten percent below previous HP small computer systems, the HP 1000 sets a new price/performance standard in its class.

From product design to customer delivery, the HP 1000 is your partner in productivity.
The combination of an HP 1000 and IMAGE/1000, Hewlett-Packard's new data base management software, provides a new entry level for data base management applications. For under $65,000 Hewlett-Packard provides a complete set of tools that allows better management of manufacturing and design information. IMAGE/1000 assists in organizing a company's individual data files into a single data base so that relevant information is available to those who need it, when they need it. IMAGE/1000 utilizes a logical and easy-to-understand structure that makes the construction of a data base a straight-forward task. IMAGE automatically links together related information and reduces redundant data. Users can have multi-terminal, multi-program access to the data base for concurrent and interactive retrieval and reporting of information.

Using IMAGE/1000 doesn't require programming skills. Non-technical people can access the data base with QUERY, a "free form" inquiry language. By merely typing simple, English-like commands on a terminal, an authorized operator can retrieve, enter, modify or delete data.

With QUERY, a user can quickly find any record in the data base by a "key value", such as a name, customer account or part number. There's no need to know the address of the data, or to search sequentially through records. QUERY is especially useful in generating impromptu reports and getting answers to one-time, "What if?" questions. For example, "What if there were a change in the styling of a product's design?" "How would material requirements and lead and delivery times be affected?" Access to an IMAGE data base can provide immediate answers to such questions. Special formatting features such as forms, titles, page and column headings, data sorting by categories, subtotals, totals and averages all contribute to readable, understandable reports.

You can receive more information on IMAGE, by circling A on the reply card.
A new sprint speed computer is the nucleus of each HP 1000 System. It provides the important performance necessary for multi-programming, multi-user application environments. The new processor executes most instructions 60% to 100% faster and performs floating point operations 250% faster than its predecessor.

**Processor growth power** is built into each HP 1000 in a number of ways. First, a variety of peripheral and software options enable users to upgrade from the smallest HP 1000 model to the largest as their requirements expand. Next, fast, low cost, semi-conductor, main memory capacity of up to 608k bytes is twice that of comparable systems. And last, the HP 1000's new processor uses a very high performance control processor, or "computer within a computer," that enables a user to increase computational horsepower almost at will. A simple terminal oriented language and editor can be created to write and load small routines, or entire application programs or operating systems into the control processor's large address space for faster execution. One HP implementation of this concept increases FORTRAN performance from 2 to 20 times over the non-micro-coded execution. The HP 1000 is a computer that strenuously resists being obsoleted by demands for more processing speed.

**Advanced interactive display.** The System 1000 also takes advantage of the innovations in the fast new 9600 baud, high resolution screened HP 2645 Display Station. Pocket sized mini-cartridges can be used for convenient storage of programs close to your heart, or for real time logging of data entry transactions on the dual cartridges.

The 2645's "Soft Keys" can be programmed to automatically enter multiple keystroke sequences. With a single stroke of a user defined "Soft Key," you can load or compile a program, query a data base, or monitor the status of multiple tasks.

**Multi-talented operating software.** The HP 1000 System has a voracious appetite for many different applications because its power can be applied in many ways. The HP 1000 operating system orchestrates interactive program development from multiple terminals concurrently with batch processing. Multi-lingual programming—in FORTRAN, ALGOL, HP Assembly and Multi-User Real-Time BASIC—allows users to communicate with the system in the language that best suits their requirements.

**Rapid access disc.** The performance demands of disc active applications, such as data base management and multi-terminal applications, are met with latest track-follower disc technology and the micro-processor based control unit of the System's HP 7905 Disc. The HP 1000's disc storage capacity of up to 120m bytes allows the construction of a data base large enough to serve most small to medium-sized organizations.

**Standard Instrument Connections.** Thanks to the Hewlett-Packard Interface Bus (HP-IB) the HP 1000 can be put to work in nearly any kind of automated electronic or electrical testing measurement and control application. With an HP-IB interface kit, the HP 1000 can control multiple clusters of instruments, each consisting of up to 14 HP-IB compatible instruments. More than one hundred HP-IB interfaceable measurement and test instruments are now available from Hewlett-Packard and other instrument manufacturers.

**And Network Connections.** If you use more than one computer within your organization, linking these "islands of automation" can give you more complete control of your operations and significantly greater flexibility in collecting and managing information.

This well-balanced combination of HP 1000 computer system power, and IMAGE/1000 make dynamic, user-oriented information handling a reality at an exceptionally low cost. An HP 1000 data base management system can be dedicated to a single department or to an entire company. Or several such systems can be linked in network, allowing each local data base to be shared by users throughout the network. Prices for complete data base management systems from Hewlett-Packard start at $61,200.*

Four basic HP 1000 system models priced from $33,500** to $62,200** make the HP 1000 the lowest cost member of the Hewlett-Packard family of major computer systems. HP 1000, an ideal starter system for experienced OEM's and end users, is followed by the HP 2000 Timesharing and the powerful multi-programming, multi-lingual HP 3000 Series II.

If you would like more information on how the affordable HP 1000 can be dedicated to a demanding application or distributed throughout an entire network to perform where the work is, circle B on the reply card.

*The Hewlett-Packard Interface Bus (HP-IB) is HP's implementation of IEEE Standard 488 and identical ANSI Standard MCl.1, "Digital Interface for Programmable Instrumentation".

**Domestic prices FOB California [ ]

The 2645's "Soft Keys" can be programmed to automatically enter multiple keystroke sequences. Circle C for more information on the HP 2645.
Unique HP 1000 Computer Systems can help turn design concepts into profitable products. Powerful yet affordable, HP 1000's can automate phases of the manufacturing cycle, shorten development schedules, optimize product design, increase productivity, and control manufacturing operations.

Optimize Product Design. For quick solutions to complex design problems, HP 1000 Systems include a new CPU 60% to 100% faster than its predecessors. It easily handles "computation heavy" tasks such as array manipulation, numerical integration and differentiation. Programming choices are FORTRAN, BASIC & ASSEMBLY.

Perform Simulations. Raw speed also makes HP 1000 Systems ideal for other computational tasks such as design simulation, modeling and life testing. Special purpose or frequently used routines can be microprogrammed for even faster execution—at cycle times as short as 175 nanoseconds.

Automate Materials Handling. Easy interface with sensors, transducers and electrical contacts makes the HP 1000 a logical choice for control of automated material handling equipment. Multiple terminals can be placed at strategic locations—receiving, incoming inspection, stockroom—to guide flow of material.

Automate QC Test Stations. Automating QC test stations is a simple procedure with HP 1000 Systems. Multiple clusters of up to 14 HP-IB instruments can be assembled for concurrent testing of component, subassembly, or finished-products. New test stations can be added concurrently with other system activities and test operations.

Computer-Aid Designs (CAD). With large main memory to 608 k bytes and fast disc swaps (average time: 100 milliseconds), the HP 1000 can handle the extremely long programs often found in CAD applications such as three-dimensional projections of mechanical parts and automated drafting systems.

Collect Factory Data. Each HP 1000 can support up to 56 low-cost data collection terminals. Dispersed terminals can collect up-to-date information about production status, material location, labor costs and machine utilization for a manufacturing data base maintained by IMAGE.

A MULTI-TALENTED TOOL THAT CAN PRODUCTIVITY & PROFITS.

Computerize Bill-of-Materials. Using an HP 1000 to build and modify bills-of-material makes it easy to compute material costs, respond to change orders and produce accurate kit-pull instructions. With IMAGE/1000, engineers can quickly locate part numbers for a particular component and determine which stocked parts meet design requirements.

Automate Prototype Testing. Full, automatic testing of design prototypes can spot design flaws before they become production fiascos. An HP 1000 with HP-IB* Interface Kits lets engineers set up specialized test stations quickly. Programming test procedures are simple with BASIC "PRINT" or FORTRAN "WRITE" statements.

Computer-Aid Manufacturing (CAM). HP's broad line of analog and digital subsystems gives HP 1000 users tools needed for control of production processes. RTE operating software's priority scheduled program execution, performs critical tasks immediately. Networking capability lets each HP 1000 direct satellite measurement/control computer systems.

Plan Material Requirements. IMAGE/1000 also provides the power for a full material requirement planning system. Once bill-of-material and inventory level have been stored in a database, the HP 1000 can compute net material requirements from a production schedule, interactively from an HP 2645 or in batch mode.

Process Customer Orders. An HP 1000 with IMAGE/1000 provides a common integrated database, making current information available to all departments for control of customer orders. Using QUERY, an English-like inquiry language, clerks can quickly locate open orders, input changes or add new information.

Generate Management Reports. QUERY also makes it easy to generate special management reports on customer order or production status. No special programming skills are needed to extract information from an interrelated IMAGE data base.

To find out more about how HP 1000 Computer Systems can improve products, productivity and profits, circle B on the attached reply card.
Hughes Aircraft Company's Industrial Products Division, Carlsbad, California, realizes, as production control expert George W. Plossl wrote, "manufacturing control is the last frontier for profits." Large dollar savings can result from small improvements in manufacturing control. For that reason Industrial Products Division installed a Hewlett-Packard 21MX minicomputer with IMAGE Data Base Management software to handle manufacturing information control.

Jack McNamee, data processing manager for the Division, says, "we confined our search for computerized control to on-line, interactive systems that are user oriented, and that require a minimal data processing staff and no programmers. To ensure that the information was timely and immediately available, we want CRT display terminals strategically placed throughout the plant. We wanted as few printed reports as possible."

McNamee says, "and found that the Hewlett-Packard 21MX minicomputer offered the advantages of low cost, short delivery time, reliability, prompt service and easy upgrading."

In the search for a company to provide the needed software, McNamee found ASK Computer Services, Inc., in Los Altos, California. ASK specializes in computerized manufacturing management systems and their MANMAN (MANufacturing MANagement) software runs on the HP 21MX with IMAGE. MANMAN is an on-line, interactive, multi-user program providing inventory control, bill of materials processing, purchasing and receiving, work in process, and material requirements planning.

According to Sandra Kurtzig, president of ASK, "The 21MX and IMAGE represent the latest technology in data base management at a price that allows a company to dedicate a computer resource to a specific application. Not many people are aware just how powerful a minicomputer is. The 21MX, with 64K to 68K bytes of memory, disc storage, and speed, is ideally suited for manufacturing management applications. A mini is not just a small 'big' computer, but a unique tool all by itself."

As the Hughes division put the MANMAN system on the line, McNamee found that it disciplined the manufacturing environment. The software system has built-in edits to automatically check for errors and to assist in maintaining data integrity. For example, these edits eliminate duplicate entries into the data base and immediately reject transactions against invalid parts, assemblies, purchase orders, etc. As a result, accurate entries must be made.

The system's user orientation simplifies data entry. For instance, when parts are withdrawn from stock for work orders, a clerk need only enter the work order number. The computer will automatically make the necessary on-hand inventory adjustments for all parts on the current bill of materials for that work order. The IMAGE/QUERY system can pull information not ordinarily compiled. For example, finding all vendors of a particular part or all customers for a piece of equipment.

When the system was first installed, the plan was to fully implement MANMAN for each of the Division's five product lines one at a time. The first task was to provide complete inventory control for the production equipment line. Because of the immediate visibility into the inventory of that line and the resulting financial control, management requested that inventory for all product lines be computerized before implementing the additional system functions. Currently, the entire MANMAN software package is in use.

The savings so far in manpower alone have been substantial. For instance, managers and supervisors used to spend two to three hours a day to enter stock transaction data. Now, the computer handles the manual tasks and frees up personnel to concentrate on other responsibilities.

Says McNamee, "we certainly have a more disciplined production system now, and tremendously more accurate records. I know that we have a better handle on expense control and we expect improvement in customer order delivery. The computer handles the manual tasks and frees up personnel to concentrate on their other responsibilities."

McNamee is pleased with both IMAGE on the 21MX and MANMAN. "ASK has integrated the latest in functional technology with the latest in systems technology. The combination of Hewlett-Packard and ASK software gave us immediate implementation and operational leverage without a long development cycle. We can concentrate on manufacturing, our specialty, rather than on computers and programming."

For more information on how diverse organizations are using HP's wide ranging computer products, circle D on the reply card.

Manfacturers of a broad line of automated Lasercutters designed for the apparel industry, Hughes Aircraft Co, saves time and cost since installing a Hewlett-Packard minicomputer and ASK manufacturing software.

HEWLETT PACKARD

Sales and service from 172 offices in 65 countries.
1501 Page Mill Road, Palo Alto, California 94304
for use in video tape editing, presents time signals in hours, minutes, seconds, and TV frames (approximately 30/s) and is used as a precision time standard throughout the plant.

Each of 320 outputs contains a data code which identifies the input connected to it. Certain outputs are tested by the channel computer to verify that the selected inputs are energized. If verification does not occur, the switching central operator is alerted.

Each channel computer is tied to the keyboard computers via the communications controller and intercomputer data links. These links provide access for the operator in switching central when he wants to make a programming change for a channel. All changes are fed in by the operator through the keyboard processors.

All of the daily program for an individual channel is on disc. Data loaded via the communications controller are stored on the disc (one per computer); and as the day progresses, a core-based operating system processes pieces of those data and manipulates them to make the proper sequences of events occur.

Actually, two days of events, including two alternate sequences, can be stored on disc. CPU core memory contains only a copy of the next 20 events. As each event goes on the air, a new event moves from disc to core. The channel computer can continue to operate, however, even if its disc fails. Its core-resident software system relays a take-over request to one of the keyboard computers which then automatically replenishes the core event file as events are transmitted.

Interfaces required for man-machine relationships between the switching central operator and the channel computers are illustrated briefly in Fig. 2. The data display terminal, a CRT, shows the operator what is being transmitted over a particular channel—the current program—and also what events are scheduled during the next time period.

If changes are required that are too time critical for routine channel access via the keyboard computer, the operator can access the channel computer through the manual function/tally (indicator light) panel to control the channel computer in real time. In addition, this panel can be used to perform routine checks of computer operation.

A separate panel allows the operator to input news bulletins and special events or for emergencies which require bypassing the computer system. When the operator assumes manual control he can select and switch onto the channel any of 100 sources that feed the master grid.

One monitor housing display shows exactly what is being transmitted over a channel as the current program. A second monitor can be used to view the back-up or "protection" tape or to preview the program that will be transmitted during the next time period.

Audio/video transition and effects are controlled by the channel computer: cross-fades and audio-over and audio-level selections, and video dissolves and inserts (Fig. 3). The channel computers constantly check five minutes in advance to gain control of the devices or facilities required for the next program segment. Channel computers have access to a large number of devices such as video cartridges or tape recorders, and any device can be accessed by any computer. However, once a device is acquired by a computer it remains totally under the control of that computer.
If you can find any other logic board tester on the market that has all these features, we'll buy it for you.

- Power-fail protection to safeguard software system.
- Automatic loader provides one-step bootstrap procedure for system initialization.
- Most complete service program available. One-year on-site warranty on entire system.
- Simulator generated test program on diskette for convenience of program distribution.
- LSI-II mini-computer with 16K words of memory and direct memory access.
- Wide range of UUT power supplies available.
- Single or dual 256K byte floppy disk drive for low-cost mass storage.
- Optional 5M byte dual moving head disk drive provides increased capacity for even the most complex boards.
- Analog capability for testing hybrid boards.
- Console with built-in digital voltmeter for operator convenience.
- Simulation capability can be added to test station or provided as stand-alone for fast, efficient test generation.
- Both hardware (TAPS) and software (Simulator) modeling available for fault verification of the test program.
- 16K Core Memory, expandable to 64K.
- Alphanumeric CRT for faster and quieter operation.
- UUT interface pins available in 3 types and expandable to 767 pins.
- Guided Fault Isolation for fast trouble-shooting by a low-skilled operator using a guided probe.
- Added GPI capability using our new Clever Clip which can handle IC's up to 24 pins.
Our family of CAPABLE logic board testers are in a class by themselves. That’s why we can make an offer like this and not worry for a minute that it’ll be put to the test.

Because the only way to match our features is to custom-build or custom-order. And even then you can’t match our pricing (starting under $22,000).

To begin with, all CAPABLE testers have our own powerful, ComputerAutomation LSI-II 16-bit computer with 16K words of memory and direct memory access for quick execution of the test program.

Next, there’s Guided Fault Isolation (GFI) with both a single point probe and our new Clever Clip™ which can handle IC’s up to 24 pins. This not only makes testing faster, but also minimizes the chance for error because the operator has less to do. There’s even a special readout that tells you if the clip isn’t making proper contact with the pins.

Both our probe and Clever Clip have individually-programmed threshold settings, which allow them to adjust automatically as different logic levels are probed.

CAPABLE testers are available with three types of pin electronics—TTL, CMOS, and programmable. So we can tailor a test system to your specific needs and minimize fixturing and adaptation costs when your needs change.

And since our entire system is modular, you can add pin electronics up to 767 pins as your boards become larger and more complex. You can add additional memory as your test routines become larger. You can add new logic families. Or you can convert your CAPABLE into a complete analog test system. All as you need it.

Here’s even more flexibility. An add-on simulation capability with a unique offer attached: We’ll buy it back at full price anytime your needs require that you upgrade to one of our larger simulators.


And CAPABLE testers carry the most complete support program available. Starting with a one-year, on-site warranty on the entire system—no exceptions. And including one week of technical training at start-up and on-going engineering assistance as you need it.

We’re uniquely able to help you solve your testing problems because we’ve gone to school on our own testing problems. Our sister division produces over 35,000 boards a year, as the industry’s second largest shipper of OEM mini-computers. And, using CAPABLE testers, they experience the industry’s lowest percentage rate of field failure.

So before you buy a logic board tester, compare CAPABLE’s features against the others. And if you find one (custom-builts don’t count) that out-features and out-performs us for the same price, we’ll buy it for you.

For details, write or call us. In the U.S.A., 18651 Von Karman, Irvine, CA 92713, Tel. (714) 833-8830 or in Europe, CAI Ltd., Hertford House, Denham Way, Maple Cross, Rickmansworth, WD3 2XD Hertfordshire, England, Tel. Rickmansworth 71211, Telex 922654.

This offer expires Dec. 31, 1976

CIRCLE 28 ON INQUIRY CARD
and cannot be accessed by one of the other computers until released.

Rolling devices start five seconds before they are switched on the air. Ten seconds prior to that a preset monitor switches on to permit an operator preview of what will be transmitted. The computer will automatically switch on a "protect" device if the originally specified device fails.

As more clearly shown in Fig. 4, an expanded presentation of the center column of Fig. 3, the master grid accepts inputs from 100 available audio and video devices and feeds items such as program, effects, and preset video and program and preset audio to the channel effects switcher along five buses. This switcher is supported by the channel effects controllers which in turn are controlled by the channel computer via the I/O bus. Outputs of the channel effects switcher are re-entered into the master grid for monitoring and then fed to the telephone line for distribution. As discussed previously, monitors show both on-the-air and preset (preview) video. A volume indicator, a specially designed voltmeter, reads both rms and peak values of audio signals.

Fig. 5, an expanded version of the right-hand column in Fig. 3, shows the interfaces involved in machine control. Both machine function/status and machine address controllers are multiplexed by the computer along their respective buses to the assignment decoders/interfaces. Each controllable device is assigned a unique address line that causes its decoder/interface to come under computer control when activated by a computer.

Four commands from the channel computer will be accepted by the interface system; the feedback
SSR UPDATE

We’ve got 87 answers to your AC solid state relay needs.

Teledyne Relays can handle virtually any AC solid state relay switching application. The reason? A family of AC SSRs with 87 models — and more on the way. We offer a broad range of voltage ratings up to 600V peak, with current ratings from 0.5 to 40 Amps. Add to that a variety of packages for pc board, chassis, or heat sink mounting and you have the industry’s most complete line of AC SSRs.

But hardware isn’t the only answer. You need assurance of the best available applications engineering support.

And we’ve got it — backed by seven years as a pioneer and leader in SSR technology to enable you to use our SSRs to their maximum advantage.

That know-how, for example, is reflected in Teledyne’s new 970 Series MOV transient suppressors designed specifically to protect our AC solid state relays against high voltage transients.

Contact your local Teledyne Relays people. You’ll find we have the experience, technical support and products to meet your SSR needs.

A. 601 Series* 5 and 10A (to 600V peak). Optically isolated, zero voltage turn-on. Screw terminals, quick disconnects, and pcb pin options.


C. 675 Series* Low profile (0.5" max.) pc board SSRs. Output rating 3A, up to 600V peak. Optically isolated, zero voltage turn-on.

D. 671 Series I/O Converter Modules. Special purpose SSRs for use in programmable controllers, machine tool controls, etc. Mounting panel available.

E. SerenDIP® Series* TO-116 DIP package. Output rating 1A/280VRMS. Logic compatible 3.8 to 10VDC input.

F. 970 Series MOVs High voltage transient suppressors designed specifically for use with all Teledyne AC SSRs.

*UL recognized/CSA certified.
If you think Mostek’s only memory is the industry standard 4K RAM, forget it!

We’ve got a whole bank of memories you can draw from—RAMs, ROMs, and PROMs. In fact, Mostek offers one of the broadest lines in the industry. All quality engineered for improved reliability over competition. And all rigidly tested. If our memories don’t measure up, they aren’t shipped out.

But once they meet Mostek standards, they set industry standards—like our 16-pin 4K RAM. Mostek’s MK 4096 is unsurpassed in performance and reliability. And the industry agrees—we’re shipping over half a million a month.

That’s a strong leader. But our other memories are keeping the pace.

The new MK 4027 is the industry’s fastest 16-pin 4K—150ns access time. At 550ns, the MK 3702-1 is the highest performing 2K EPROM. And the MK 34000 holds the world record for a 16K ROM—350ns.
## Random Access Memories

<table>
<thead>
<tr>
<th>Description</th>
<th>Part No.</th>
<th>Access Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>256-Bit Static</td>
<td>MK 4006P-6</td>
<td>400ns</td>
</tr>
<tr>
<td></td>
<td>MK 4008P-6</td>
<td>500ns</td>
</tr>
<tr>
<td></td>
<td>MK 4007P(N)</td>
<td>525ns</td>
</tr>
<tr>
<td></td>
<td>MK 4007P-4(N)</td>
<td>525ns</td>
</tr>
<tr>
<td>1K Static</td>
<td>MK 4102P</td>
<td>1µs</td>
</tr>
<tr>
<td></td>
<td>MK 4102P-1</td>
<td>450ns</td>
</tr>
<tr>
<td></td>
<td>MK 4102P-6</td>
<td>275ns</td>
</tr>
<tr>
<td></td>
<td>MK 4102P-8</td>
<td>250ns</td>
</tr>
<tr>
<td>4K Dynamic</td>
<td>MK 4096P-6(N)</td>
<td>250ns</td>
</tr>
<tr>
<td></td>
<td>MK 4096P-11(N)</td>
<td>350ns</td>
</tr>
<tr>
<td></td>
<td>MK 4096P-15(N)</td>
<td>350ns</td>
</tr>
<tr>
<td></td>
<td>MK 4096P-16(N)</td>
<td>350ns</td>
</tr>
<tr>
<td>1K Static</td>
<td>MK 4200P-11(N)</td>
<td>350ns</td>
</tr>
<tr>
<td></td>
<td>MK 4200P-16(N)</td>
<td>300ns</td>
</tr>
<tr>
<td></td>
<td>MK 4027P-2</td>
<td>150ns</td>
</tr>
<tr>
<td></td>
<td>MK 4027P-3</td>
<td>200ns</td>
</tr>
<tr>
<td></td>
<td>MK 4027P-4</td>
<td>250ns</td>
</tr>
<tr>
<td>4K Static</td>
<td>MK 4104P*</td>
<td>200ns</td>
</tr>
<tr>
<td>16K Dynamic</td>
<td>MK 4116P-2</td>
<td>150ns</td>
</tr>
<tr>
<td></td>
<td>MK 4116P-3</td>
<td>200ns</td>
</tr>
</tbody>
</table>

## Read Only Memories

<table>
<thead>
<tr>
<th>Description</th>
<th>Part No.</th>
<th>Access Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>2K ROM</td>
<td>MK 2400P</td>
<td>550ns</td>
</tr>
<tr>
<td>4K ROM</td>
<td>MK 24002600P</td>
<td>400ns</td>
</tr>
<tr>
<td>8K ROM</td>
<td>MK 3000P</td>
<td>450ns</td>
</tr>
<tr>
<td>16K ROM</td>
<td>MK 28000P(N)</td>
<td>600ns</td>
</tr>
<tr>
<td></td>
<td>MK 31000P</td>
<td>550ns</td>
</tr>
<tr>
<td></td>
<td>MK 34000P</td>
<td>350ns</td>
</tr>
</tbody>
</table>

## Programmable Read Only Memories

<table>
<thead>
<tr>
<th>Description</th>
<th>Part No.</th>
<th>Access Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>2K EPROM</td>
<td>MK 3702T-1</td>
<td>550ns</td>
</tr>
<tr>
<td></td>
<td>MK 3702T-2</td>
<td>750ns</td>
</tr>
<tr>
<td></td>
<td>MK 3702T-3</td>
<td>1µs</td>
</tr>
<tr>
<td>8K EPROM</td>
<td>MK 3708T*</td>
<td>450ns</td>
</tr>
</tbody>
</table>

*Available Soon

## MOSTEK

Setting Industry standards

1215 W. Crosby Rd., Carrollton, Texas 75006
214/242-0444

In Europe, contact:
MOSTEK GmbH, TALSTR. 172, 7024 Filderstadt-1, West Germany
Telephone (0711) 701096

CIRCLE 31 ON INQUIRY CARD
DIGITAL CONTROL AND AUTOMATION SYSTEMS

Fig. 6 Function/status switcher\(^6\) (expansion of assignment decoder/interface of Fig. 5). Three relays decode incoming addresses; fourth prevents accidental command from reaching system.

consists of three tallies plus a 1-bit address for video tape machines and a 2-bit address for telecine chains. The assignment decoder/interface, shown in more detail in Fig. 6, is made up of a 12-pole, 10-position stepping switch and associated control relays for homing, lockout (interlock logic), release of lockout, and manual stepping. Once a channel computer gains access to a device, its system locks out any other request for control until a release command is issued to indicate that the computer no longer needs the device.

Audio Multiplex

Each video channel is complemented by four audio channels which are encoded into 12-bit pulse-code modulation (PCM) digital signals and then biphase modulated on a 24-MHz subcarrier (Fig. 7). The resulting rf envelope is mixed with the baseband video signal and routed through the switching system as a multiplexed signal.\(^4\) Each video signal occupies a full 10-MHz bandwidth while combined audio signals are within a 12-MHz band that is centered at the 24-MHz subcarrier.

The four analog-to-digital converters (ADCs) shown in Fig. 7 sample and convert audio input signals to separate 12-bit PCM codes. Each code is then sequentially loaded into a parallel-to-serial shift register to make up the digital train which will modulate the biphase modulator. Sync, address, data, parity, and zero bits are added to each audio sample of 12 bits within the shift register to form one 20-bit audio word. The bit patterns for four successive audio words are shown in Fig. 8. In operation, these four audio words are formed 75,000 times a second (6 million bits/s).

An envelope of rf energy from 18 to 30 MHz is produced by a biphase modulator operating at the 24-MHz primary clock frequency. When this envelope is added to the video signal the combined signal is multiplied to supply 320 discrete crosspoints, one for each of the 320 switcher outputs.
For your pulse and digital timing measurements

The instrument shown includes a 7904 mainframe configured for pulse and digital measurements. Our \( \Delta \) time plug-ins, the 7B80 and 7B85 time bases, give you differential time measurements with sweep rates to 1 ns/div. The 7A19 provides one vertical channel with a rise time of 0.8 ns and the 7A26 provides dual channels with rise times of 1.8 ns.

**It's easy to use.** Your pulse train is displayed on a main sweep with two intensified zones that easily identify the time interval of interest. And our package digitally displays your time interval on the crt in the correct units of measure. A \( \Delta \) symbol precedes the time interval readout to indicate it is a differential time measurement. To make sure your answer is precise, you expand and adjust each intensified zone on separate delayed sweeps so each is positioned exactly where you want it on the pulse train.

Turn a switch and you are in the delay time mode; this mode lets you make propagation delay measurements using the beginning of the main sweep as a reference.

**It gives you confidence in your answer.** The \( \Delta \) time you see displayed digitally on the crt is accurate to within 1%, even when you’re measuring fast pulses.

And there is almost no chance for operator error. You view all three sweeps at the same time; that is, you observe the two intensified zones on the main sweeps while you expand those portions on two separate delayed sweeps.

**It's convenient.** Your pulse and digital timing measurements are easy to document photographically. The \( \Delta \) time is displayed along with the main and delayed sweep speeds and amplifier sensitivities—all in the appropriate units of measure. This gives you the information you need in one complete crt display.

**It's a flexible package.** This 7904 configuration gives you \( \Delta \) time capability—an easy and accurate way to make pulse and digital measurements. Because it's a plug-in scope, you can include other digital measurement capabilities—logic analysis, and digital and differential amplitude capability, to name a few.

To order the plug-in scope described here, call your local Tektronix Field Office.* For immediate assistance, call your Tektronix Field Engineer or circle 116 on your reader service card and we’ll have him call you. For a copy of our new application note on pulse and digital timing measurements, circle 115 or write us at Tektronix, Inc., P.O. Box 500, Beaverton, OR 97077. In Europe, write Tektronix Limited, P.O. Box 36, St. Peter Port, Guernsey, Channel Islands.

**The 7000-Series... more than an oscilloscope**

*Ordering information:
- 7904 Oscilloscope .................. $4300
- 7A26 Amplifier ..................... $1200
- Recommended probe; P6063A, 1X, 10X ........................................ $100
- 7A19 Amplifier ..................... $950
- Recommended Probe; P6056, 10X ........................................ $85
- 7B80 Time Base ..................... $745
- 7B85 Delaying Time Base .......... $895

U. S. Sales Prices FOB Beaverton, Oregon
Now you can get microcomputer based products out of the lab and into production faster than ever before. Intel® 8080 programmable LSI peripherals give you the competitive advantage by helping you reduce design time, component count and manufacturing and inventory costs. Most of all they'll help you get to market first.

Intel 8080 programmable peripherals are software controlled LSI replacements for hardwired SSI/MSI logic assemblies. You simply attach the appropriate peripherals to the system bus and the +5V supply. Then, with system software, you personalize device operating configurations to suit your applications. Reconfiguration and design changes are made with software. No expensive and time consuming hardware redesigns are necessary.

One peripheral, the 8253 Programmable Interval Timer, is the first LSI solution to system timing problems. It counts out I/O servicing delays, eliminating software timing loops and increasing CPU throughput. It also saves hardware when you need event counters, rate generators or real-time clocks. Each 8253 contains three 16-bit timer/counters.

Our 8257 Programmable DMA Controller is the lowest cost way to handle applications that require high speed data transfer such as disks, magnetic tape, analog interfaces and high speed communication controllers. The four channel 8257 contains all the logic necessary for bus acquisition, cycle counting and priority resolving of the channel requests.

The 8259 Priority Interrupt Controller replaces complex TTL arrays and minimizes component costs. The CPU can change interrupt structure "on the fly" to suit changes in the operating environment, such as time of day or process control parameters. The 8259 handles up to eight vectored priority interrupts. Multiple 8259's can control up to 64 interrupt levels.

Use the 8251 Programmable Communication Controller for "serial I/O." The first true USART in a single chip, the 8251 implements all popular com-
get you to market first.

Communication protocols, including IBM Bi-Sync. For "parallel I/O," each 8255 Programmable Peripheral Interface gives you 24 versatile I/O lines to interface relays, motor drives, printers, keyboard/display and other parallel equipment.

Once you've selected the peripherals to fit your application, use the Intellec® Microcomputer Development System for both software and hardware development. Using the Intellec CRT terminal, call up the resident text editor. Write the source program to initialize the peripheral and the subroutines for peripheral/system operation. Then you assemble or compile the source programs into an object file using resident macroassembler or resident PL/M compiler—and store the object file on the Intellec diskette. With the relocation and linkage capability of the Intellec ISIS II diskette operating system, these routines can be added to a system library and called from user programs as needed. Once the main system program is written, the new peripheral device routines are easily linked in. The entire program is now ready to be run on your prototype via the Intellec ICE-80™ in-circuit emulation module. ICE-80 lets you debug your software and hardware in your actual prototype environment. Move from system integration and debugging to production in a fraction of the time previously required.

Intel also provides applications assistance, training programs, the largest user's program library, and volume production support. Intel's 8080 programmable peripherals give you the competitive advantage from start to finish. Be first to market.

To order the new peripherals, contact our franchised distributors: Almac/Stroum, Components Specialties, Cramer, Elmar, Hamilton/Avnet, Industrial Components, Liberty, Pioneer, Sheridan or L.A. Varah. For your copy of our 8080 System brochure write: Intel Corporation, 3065 Bowers Avenue, Santa Clara, California 95051.

Inte® Microcomputers. First from the beginning.

CIRCLE 32 ON INQUIRY CARD
Filter circuits separate multiplexed components into two parts after switching and routing (Fig. 9). All energy below 10 MHz is routed through a low pass filter to the video output port, while a high pass filter allows the rf envelope from the biphase modulator to reach the 24-MHz phase lock loop. Digital-to-analog converters (DACs) return pulse-code modulated (PCM) digital signals to analog form.

Current and Future
When the switching central first went into automatic operation in October 1974, it was online for only four 70-hour periods each morning to determine what problems existed. Then the system was switched back to manual for the remainder of the day for debugging.

In January 1975, operation was extended to 1 pm, in March it ran to 4:30, and by August—less than one year after initiation—it was on a full 24-hour schedule. The early operating periods were chosen for the beginning of the day in order to fully debug the system before it was used in prime time periods.

Robert J. Butler, director of technical development, and Miguel A. Negri, manager of facilities engineering, of NBC Engineering concurred in the opinion that software development was particularly successful without major hitches—and basically within schedule—because "an excellent software team was given a firm foundation of technical operating procedures. The team was not asked to come up with a program and then start changing it."

A new project, currently in design, will involve control from New York City headquarters of film projection facilities in New Jersey. Control will be maintained by microcomputers over a communication link. Although not yet implemented, RCA COSMAC microprocessors will be the controlling elements.

References
1. F. L. Flemming, "NBC Television Central—An Overview," RCA Engineer, Apr/May 1976, pp 2-4
2. R. Edmondson and R. Post, "NBC Switching Central," RCA Engineer, Apr/May 1976, pp 7-17
4. R. J. Butler, "PCM-Multiplexed Audio In A Large Audio-Video Routing Switcher," RCA Engineer, Apr/May 1976, pp 42-45

Portable Programming Unit Extends Capabilities of Small Controllers

Because the unit used with the Simatic S3 controller was limited to small configurations, Siemens AG, Federal Republic of Germany developed a portable programming unit for use with larger, more complex control systems. The PG2 has a higher capacity than the earlier PG1 and incorporates integrated test functions permitting simple control of even extensive and complex equipment.

Program-dependent or -independent address searches can be alternated with program checks in any desired sequence. For data protection, the control program is recorded on magnetic tape and read back in when required. A printer can also be connected to log the programs following performance of routines.

In addition to standard programming functions, the unit includes test functions which simplify fault tracing. Status and control functions can display signal states of inputs, outputs, flip-flops, and timers or modify outputs and flip-flops independently of the control programs. The status display is continuously updated by an automatic cyclic scan.
Your Single Bored Computer can be the life of the party.

Just introduce it to these swinging iCOM Microperipherals™.

iCOM PP80 SBC/MDS PROM Programmer/Memory Expander—Programs 2704 and 2708 EPROMs. Has sockets for up to 8K additional PROM. Occupies one slot in SBC card cage. Works with Intellec MDS-800 too.

Intel’s SBC80/10 Single Board Computer and Card Cage

iCOM 360-56 SBC80/10 Interface card—Interfaces iCOM Frugal Floppy™ to the Intel SBC80/10. Includes software driver PROM and iCOM’s famous FDOS-II software with macro assembler and string oriented text editor. Occupies one slot in SBC card cage.

iCOM FF36-1 Frugal Floppy™ includes disk drive with daisy chain capability, proven IBM compatible controller, all cables and connectors. Also available as a completely packaged system. MDS version available, too.

So you have a computer on a board. Now what? iCOM has the answers with two essential Microperipherals.

First, our Frugal Floppy™ with disk drive, controller and SBC80/10 interface, for just $1495 complete. Includes our famous FDOS-II software with super features, such as named variable length files, autocopy create open and close, multiple merge and delete—and more.

Second, our PROM Programmer/ Memory Expander for 2704 and 2708 EPROMs. Just $395 including 1K ROM resident programming firmware. Room for 8K of additional PROM, too. So call iCOM today.
"Nervous Nellie" Nelson choosing his
Nelson “Nervous Nellie” Nelson.
To avoid undue confusion, had the same first and last names.
Always wore a belt and suspenders at the same time.
Owned several shares of Amalgamated Safety Pin.
Hated to make decisions. Especially when choosing minicomputer memories.
“Nervous” was sure he didn’t like the high prices of the mini manufacturers.
Yet he was afraid to buy from a lower-priced independent because he wasn’t sure what he would be getting.
One day, while shopping for a security blanket, “Nervous Nellie” spotted the following message monogrammed on the label:
“Plessey Microsystems is the largest independent supplier of minicomputer add-on memories there is, and they are part of an international billion dollar corporation. Plessey’s low prices are complemented by the high quality and reliability of their products and the comprehensiveness of their support services.
“Plessey Microsystems.
“P.S.: Do not remove this Plessey pitch under penalty of law”
He was certain he sort of liked that. With a newfound surge of self-confidence, he placed a person-to-Plessey call and reassured himself that Plessey Microsystems was everything the label said they were. And more.

From then on, Nelson Nelson bought all his mini peripherals from Plessey.
And threw away his suspenders.
You, too, can find out how add-on core memories, single and dual disc drives and punched tape readers from Plessey Microsystems can expand your mini at low prices without your having to sweat about the results.
Just call and we’ll be glad to tell you more about our products.

The Pacifiers

Plessey disc drive systems store up to four times the data in one quarter of the space at a much lower cost than drives from the mini manufacturers.
They are software, hardware, and media compatible with DEC and Data General minicomputers and they are available in a variety of types and sizes for doing your job your way.
To expand your mini systems even further, just plug the compatible Plessey disc controller into your mini mainframe. It will control up to eight Plessey disc drives, or any mix of Plessey and mini manufacturer drives with total capacities of 10, 20 and even 327 megabytes (depending on your mini model).
It all adds up to a great deal more capacity, performance and reliability for a great deal less than equivalent competitive drives.
You can count on it.

CIRCLE 34 ON INQUIRY CARD

Plessey Microsystems
(714) 540-9945
International Electron Devices Meeting

Emphasis will be placed on new and significant aspects of research, development, design, and manufacture of electron devices at the 1976 IEDM, which is sponsored by the IEEE Electron Devices Group. Particular subjects to be accentuated are principles, structures, materials, and technology of solid-state devices; characterization and developments of materials and devices involved in device technology; energy conversion devices and quantum electronics—specifically lasers and semiconductor light sources; radiation detectors, LCDs, LEDs, gas-discharge displays, and modulators involved with image transducers and optoelectronic devices; and devices and circuits—MOS, CCD, and magnetic bubbles, and digital circuits for logic and memory—concerned with integrated electronics.

The 3-day annual technical meeting will begin at 10 am on Monday with a General Session of invited papers to be chaired by the Technical Program Chairman, Dr. Josef Berger, Hewlett-Packard Company. This year’s General Chairman is Dr. C. Neil Bergl, Bell-Northern Research, Canada.

A luncheon will be held at noon on Tuesday, Dec 7, with guest speaker W. J. Sanders, president of Advanced Micro Devices, Sunnyvale, Calif, discussing the “Trends and Outlooks for the Semiconductor Industry.” Other scheduled special events are a cocktail party from 6 to 7 pm Monday, Dec 6 (open bar), and a tour of the National Bureau of Standards on Tuesday evening.

Registration fees at the Conference are $32 for IEEE members, $41 for nonmembers, and $16 for students or unemployed IEEE members. These fees include a copy of the Technical Digest. Additional copies will be available for $12 at the meeting; after the meeting, the price is $15 for members, and $20 for nonmembers. Tickets for the luncheon are $12; $5 for the cocktail hour; and $3 for the tour.

Only those sessions of particular interest to readers of Computer Design are covered in the following excerpts. Closing times listed for each session are approximate. Information is limited to that available at press time.

**TECHNICAL PROGRAM EXCERPTS**

**Monday Morning**

**General Session**

10 am Ballroom Ctr

**Invited Papers**

Organizer/Chairman: Josef Berger

"An Experimental Optical Fiber Communications System: Devices and Performance," M. DiDomenico, Jr, Bell Laboratories

"New Directions in Non-Planar Semiconductor Device Technology," H. C. Nathanson, Westinghouse Research Laboratories

"Progress in Low Cost Solar Cells," P. Rappaport, RCA, David Sarnoff Research Center

**Monday Afternoon**

**Session 2**

2-5 pm Ballroom Ctr

**Integrated Electronics—CCDs and Other Dynamic MOS**

Organizer: D. D. Buss

Chairman: J. F. Skalski

"A New Multiplexed Electrode-Per-Bit Structure for CCD Memory," S. Kohyama, H. Hatano, T. Tanaka, and N. Kubota, Tokyo Shibaura Electric Co, Japan

"Merged Charge Memory (MCM)—A New Random Access Cell," H. S. Lee and W. D. Price, IBM

"Charge Coupled Devices in Digital LSI," R. A. Allen, R. J. Handy, and J. F. Sandor, TRW Systems

"An Electrically Programmable Transversal Filter," Y. A. Haque and M. A. Copeland, Carleton University, Ottawa

"An Interlocking Inputs for Charge Coupled Devices," C. H. Sequin, Bell Laboratories

"Coplanar Al-Al₂O₃-Al Gate CCD," T. Ohzone, S. Horiuchi, H. Kadota, and K. Kazawa, Central Research Laboratories, Matsushita Electric Ind Co, Japan

**Session 3**

2-5 pm Ballroom W

**Device Technology—Bipolar Process Technology**

Organizer: R. K. Watts

Chairman: J. B. Kruger

"Bipolar Linear Integrated Circuit Reliability," G. F. Foxhall, Bell Laboratories


"High Performance ECL Gates Made by SEL Method," A. Hayasaka, T. Kaji, Y. Honma, and S. Harada, Hitachi, Japan

"Measurement of Minority-Carrier Lifetime and Surface Recombination Velocity with a High Spatial Resolution," M. Watanabe,

Ramtek's new RM9000 modular graphics and imagery system gives you expandability, economy and flexibility.

Select The Performance You Need.

The RM9000's total modularity lets you select the exact performance you need to fill your particular application. You pay only for the performance you need. Nothing more. And that's like money in the bank.

Add On As You Have To.

As your needs change and grow, the RM9000's capability will grow right along with them. A comprehensive list of options such as expansion from black and white to grey scale or color—even a complete range of interactive peripherals and additional independent channels.

Microprocessor-Controlled Raster Scan.

The RM9000 is the first raster scan graphics and imagery system to be totally microprocessor controlled. That means you can implement a higher-order user language to minimize programming costs without a sacrifice in system throughput.


High reliability is the direct result of intensive testing of components and systems prior to shipment. Solid state components and printed circuit construction are used exclusively. Result? No special preventive maintenance measures are required. In fact, the RM9000 can be pre-programmed with self-diagnostic capability.

You Need To Know More.

To fully appreciate the RM9000's capability, you need more details. Call or write Ramtek Corporation, 585 N. Mary Ave., Sunnyvale, CA 94086. (408) 735-8400.

Our Experience Shows
Now the line of AMP Coaxial Ribbon Cable Assemblies is wider than ever.

And so is your design range.
The introduction of AMP Coaxial Ribbon Cable assemblies represented a major breakthrough in interconnection technology. Lower costs with no compromise in performance. Now, AMP has broadened the line to give you an extremely wide range of high speed, low noise interconnections.

AMP ribbon coax is available in 50-, 75- and 93-ohm ratings, 6 to 26 positions, on .100-inch centers. Or in a 95-ohm rating on .125-inch centers.

Multi-position connectors mate with .025-inch posts, either 90° board-mount pin headers or I/O posts. Included are the new paddle-card and flanged types.

We can supply complete ribbon coaxial cable/connector assemblies of any length to fit your requirements. Or provide all the cable, connectors, and tooling you need to make your own.

Either way you get professional back-up by AMP field and home office engineers. They work with you from the prototype stage through production—and on to future design.

For more information on the design opportunities you get with AMP's extended range of Coaxial Ribbon Cable assemblies, call Customer Service at (717) 564-0100. Or write AMP Incorporated, Harrisburg, PA 17105.
Monday Afternoon
Session 5 2-5 pm  Alcove 8
Logics and Applications
Organizer: G. B. Stringfellow
Chairman: J. K. Butler
"(Al,Ga)As, GaAs Double Heterostructure Lasers Prepared by a New Liquid Phase Epitaxial Growth Technique," Y. Horikoshi, The Massashino Electrical Communication Laboratory, Japan
"Diode Sources for 1.0 to 1.2 µm Emission," C. J. Nuese, RCA Laboratories
"Visible CW (AlGa)As Heterojunction Laser Diodes," I. Ladany and H. Kressel, RCA Laboratories
"Modulation Characteristics of CW Laser Diodes," T. L. Paoli, Bell Laboratories

Tuesday Morning
Session 8 9-12 am Ballroom Ctr
Integrated Electronics—Static MOS Memory and Logic
Organizer: S. Rosenbaum
Chairman: M. Copeland
"Endurance of Thin-Oxide Nonvolatile MNOS Memory Transistors," M. H. White, J. W. Deimianski, and M. C. Peckerar, Westinghouse Electric Corp, Advanced Technology Labs
"A Cross-Point MNOS Capacitor Memory," A. S. Chawla and H. C. Lin, University of Maryland
"Back-Gate-Input MOS—A New Low-Power Logic Concept," S. Asai, T. Masuhara, and T. Nakamura, Central Research Laboratory, Hitachi, Ltd, Japan
"CL: A New High Speed, High Density Bulk CMOS Technology," A. Dingwall and R. Stricker, RCA Corp, Solid State Technology Center
"Frequency Dependent Propagation Delay in Silicon-On-Sapphire Digital Integrated Circuits," S. Sheffield Eaton, RCA; and B. Lalovic, Rutgers University
Introducing push-button microprocessor system debugging.

HP's 1611A Logic State Analyzer... Dedicated to all 8080 or 6800 based systems.*

View program flow in mnemonics. With CRT data and addresses selectable in either hexadecimal or octal formats and external lines in 1's and 0's.

Maintain testing control. LED indicators show status at all times. You can monitor system operation and give control to the 1611A for single or multiple keyed steps.

Enter data quickly and easily. The hexadecimal keyboard makes trigger and qualifier data entry as easy as operating calculator. And the CRT display gives you a quick visual check on your entries.

Choose your display. Either mnemonic or absolute (op codes). Roll the display to view any 16-line slice of the 64-byte memory.

Obtain program and timing data. Qualify the display with TRACE TRIGGER and see only those bytes that match your trigger inputs... all write instructions, for example. Press COUNT TRIGGERS and the 1611A displays the number of trigger occurrences between the TRIGGER ENABLE and TRIGGER DISABLE entries.

Obtain the display window. Delay up to 65,532 qualified clocks or memory transactions from the trigger word. Or, pre-trigger to see up to 63 bytes leading up to the trigger word (negative time).

Pinpoint virtually any specific event. Trigger on address, data, or external signals... or on any combination of the three. You can also qualify the trigger by bracketing the address and opting to trigger on the nth occurrence of the trigger word. TRIGGER ENABLE and DISABLE keys act as arm and disarm circuits providing unparalleled pinpointing flexibility.

Move the display window. Delay up to 65,532 qualified clocks or memory transactions from the trigger word. Or, pre-trigger to see up to 63 bytes leading up to the trigger word (negative time).

The 1611A should be on hand when you start up your microprocessor-based system. Imagine the time you'll save with push-button operation and an unparalleled view of your system's operation; viewing things dynamically that you never could see before. And there's more... self test; trigger outputs to drive external equipment; error messages to warn of improper operation or setup; and the choice of two initial "µP personality modules" that let you tailor the 1611A to either 8080 or 6800 based systems.

Let HP's 1611A, priced at $5,000**, help you speed development, production-line testing or service. Ask your local HP field engineer for all the details. Ask him about HP's digital seminars too. He can tell you when one will be held in your area and how you can attend.

*and more modules for other microprocessors to come.
**Domestic U.S.A. price only.

Managing the data domain.
QUESTIONABLE LOGIC:
Why go the long way around to get to 50 mB on disk?

Just how you tie a 50 megabyte capacity into your system depends on your capacity for punishment. You can do it the hard way, with disk drives that demand a technology change, with all the redevelopment risks and time required.

Or. Make it easy on yourself. And do 25 to 50 mB our way: build in Pertec's new extensions to our D3000 family. No mechanical packaging changes to your system. No special pre-recorded media. No major logistic support impact. How lucky can you get?

Home-grown out of proven product, D3400/D3600 disk drive extensions are simply enhancements within our established D3000 family. Expanded to put four platters into one compact unit: 3 fixed and 1 standard removable cartridge, each individually write-protectable. And you get parts commonality with the rest of the line...a big help in keeping operational and maintenance costs down.

With these extensions, Pertec's D3000 Series offers an OEM the super flexibility that real cost-effectiveness is based on. You can afford to get choosy, with a family now stretching from 3.0 to 50 mB, in front or top load models.

For fixed media applications—when more “byte for the buck” is critical, we build the same parts/technology commonality into our D1000 family. Makes non-removable-media drives still more economical. And our “easy-access” to electronics lowers operational/service costs.

Selecting a fixed disk drive to fit application specs precisely is a cinch with D1000 models, available from 3 to 24 mB. Pertec leads the field in capabilities—you don't compromise on capacity or transfer rates.

You name it, we've got it in disk. All the configuration-ranges, all the assistance you need, to simplify specification and design. Including in-depth specs, OEM application support, engineering manuals. Backed by solid sales follow-through in the field. Service depots are strategically located world-wide, and easily accessed through our toll-free 800 line—to provide parts and assistance around the clock.


PCC PERTEC
a division of Pertec Computer Corporation
CIRCLE 39 ON INQUIRY CARD
Graphic hardcopy output from IBM systems: the Plotmaster® makes it a reality, not a dream.

If you have an IBM System 360/370 computer operating under DOS, OS or VS, you know what a nightmare it is to get graphic hardcopy output.

That's why the Gould Plotmaster Systems are like a dream come true. They deliver crisp, high quality graphics output from the computer, with no intermediate processing steps. They also work at incomparably fast speeds, without demanding additional system resources. No hours or days of waiting as when you use a slow pen plotter attached to the computer. No waiting for post-processing film development and blow-up as when you use graphic microfilm units.

Plus, Plotmaster Systems are economical as well as efficient. Initial and recurring costs are surprisingly low. And fast turn-around and high capacity adds up to additional savings.

Plotmaster Systems have three major components. Efficient and flexible graphics software. A Gould electrostatic printer/plotter that you can tailor to your exact application. And hardware to link the two—an on-line controller, or a tape drive for off-line operation.

In addition to this basic package, specialized software is available for business, scientific and engineering applications. Full printing capability is optional.

Let us tell you more about the fast, powerful, versatile Plotmaster Systems. They can be purchased or leased and are supported by Gould's specially trained service force.

For a free brochure, write Gould Inc., Instrument Systems Division, 3631 Perkins Ave., Cleveland, Ohio 44114. Or Gould Advance Ltd., Raynham Road, Bishop Stortford, Herts, United Kingdom. Or call Gould toll-free at (800) 325-6400, Ext. 77. In Missouri: (800) 342-6600.
Session 12 9 am-12:30 pm  Lincoln Room W

**Solid-State Devices—Novel Devices, and Techniques**

Organizer/Chairman: D. Hendricks

“Gallium Antimonide Planar Tunnel Diode,” S. Kang and W. Ko, Case Western Reserve University

“A Silicon Bipolar-Carrier-Domain Magneto-Current-Generator,” Jim Smith, Tektronix Labs

“Schottky Diode Magnetic Sensor of High Sensitive,” G. Kamarinos and P. Viktorovitch, Institut National Poly Technique, France


“Metal-Oxide Devices for Rapid High Current Switching,” G. Gaule, P. La Plante, S. Levy, and S. Schneider, U.S. Army Electronics Technology and Devices Laboratory

“Investigation of the Sapphire-Silicon Interface by Transient Current Analysis,” K. Lehovec and R. Miller, University of Southern California

“The Utilization of Charge Pumping Techniques to Evaluate the Energy and Spatial Distribution of Surface States of an MOS Transistor,” W. V. Backensto, Hughes Aircraft Co.; and C. R. Viswanathan, University of California, Los Angeles

Tuesday Afternoon

Session 13 2:30-5:30 pm  Ballroom Ctr

**Integrated Electronics—VLSI Technology and Modeling**

Organizer: J. G. Fossum

Chairman: J. Saltich

“Physics of and Models for PL,” F. M. Klaassen, Philips Research Laboratories, The Netherlands

“Solid-Stat Devices—Novel Devices, and Techniques

The Schottky PL Technology and its Application in a 24 x 9 Sequential Access Memory,” F. W. Hewlett, Jr and W. D. Ryden, Bell Laboratories

“A New High Speed PL Technology—Up-Diffused,” B. B. Roesner and D. J. McGreivy, Hughes Aircraft Co

“Modular Bipolar Analysis,” J. L. Dunkley, Tektronix, Inc; S. D. Kang, Texas Instruments Inc; and P. A. Nygaard, Hughes Aircraft Co


Session 14 2:30-5:30 pm  Ballroom E

**Device Technology—MOS Reliability, Performance, and Characterization**

Organizer/Chairman: D. Farrington

“Failure Modes and Reliability of Dynamic RAMs,” C. R. Barrett and R. C. Smith, Intel Corp

“Anomalous Electrical Gate Conduction in Self-Aligned MOS Structures,” W. E. Ham, RCA Laboratories; and S. Eaton, RCA Solid State Division

“The Relative Performance and Merits of CMOS Technologies,” A. Aitken, A. P. T. MacArthur, R. Abbott, and J. D. Morris, Bell-Northern Research, Canada

“CMOS Process for High-Performance Analog LSI,” W. C. Black, Jr, R. H. McCharles, and D. A. Hodges, University of California, Berkeley

“Relationships of Residual Defects and Excess Noise in Ion-Implanted MOSFETs,” K. L. Wang, General Electric Co

“Surface Characterization of Ion-Implanted Si-SiO2 Structures,” K. L. Wang and P. V. Gray, General Electric Co

 Wouldn’t it be great if the PDP-11 could operate in his environment.

Norden is making it happen.
New snap-in rockers with Cutler-Hammer reliability.

Here's a completely new line of snap-ins, each engineered with the kind of solid dependability you expect in Cutler-Hammer Rockette® switches. Bright metal bezels, illuminated and non-illuminated, A-c and D-c capabilities up to 20 amps.

Switches snap in and stay in permanently. Speed up assembly time, cut costs.

Flush-mounted rockers in the same wide range of designer-oriented colors and styles. One- and two-pole models.

Illuminated single-pole rockers. Choice of red, green, amber, white, or clear. Hot-stamped legends indicate switch functions.

For more information, call your Cutler-Hammer Sales Office or Switch Distributor.
Session 15  2:30-5:30 pm  Georgetown Room
Solid-State Devices—Microwave Transistors and Integrated Circuits
Organizer: C. P. Snapp
Chairman: W. R. Wiseman
“Developments in GaAs FETs and ICs,” R. Zuleeg, McDonnell Douglas Astronautics Co
“Gunn Domain Formation in the Saturated Current Region of GaAs MESFETs,” R. W. H. Englemann and C. A. Liechti, Hewlett-Packard Laboratories
“Noise in Un gated GaAs FETs,” J. Graffeuil, J. C. Martin, and G. Blasquez, Laboratoire D’Automatique et D’Analyse des Systemes du Centre National de la Recherche Scientifique, France
“The Effects of Neutral Capacitance on the Frequency Response of Microwave Transistors,” A. Wang, Hewlett-Packard Laboratories
“Interface State Density in Au and Al nGaAs Schottky Diodes,” J. M. Borrego, R. J. Gutmann, and S. Ashok, Rensselaer Polytechnic Institute

Wednesday Morning
Session 22  9-12 am  Lincoln Room W
Electro-Optical Devices—Infrared Detectors
Organizer/Chairman: M. Y. Pines
“On-Chip Signal Processing to Overcome IR Detector Nonuniformities,” R. E. Eck, Santa Barbara Research Center
“Advances in 2.5 Micrometer (Hg,Cd)Te Photodiodes,” T. J. Tredwell, Honeywell Radiation Center
“Epitaxial Heterojunction InAs:Sb, InSb Photodiodes,” D. H. Pommerrenig, M. Kinoshita, A. Mantzouranis, and T. Oishi, Hamamatsu Corp
“InSb CID Infrared Imaging Devices,” J. C. Kim, W. E. Davern, and D. Colangelo, General Electric Co
“TGFB and DTGFB Pyroelectric Vidicons,” E. H. Stupp and B. Singer, Philips Laboratories; and T. Conklin, Amperex Electronic Corp

Wouldn’t it be great if the PDP-11 could operate in his environment.
Norden is making it happen.
our 2-piece pc connectors use just 1 contact.

Elco has a habit of coming up with innovations in connector design. And Varicon™ contacts prove the point once more. This unique, spring-action mutually embracing, hermaphroditic contact has logged millions of operating hours and continues to be the most reliable and trusted contact available, bar none.

Used in both the receptacle and the plug, Varicon's mating surfaces are gas-tight for protection against corrosion. The design itself, provides low contact resistance which provides high current capacity. And the Varicon contact's interlocking design makes it highly resistant to shock and vibration.

You just can't find 2-piece connectors more reliable than Elco's single-contact Varicon designs. You won't find a greater selection either.

Elco makes 2-piece connectors for 1/16" and 3/32" thick P.C. cards with from 18 to 165 contacts or more, all using a single Varicon contact. They're priced competitively and available off-the-shelf.

We'll fill your order fast. So get your 2-piece connector with just 1 contact, now.

"GREAT CONNECTIONS ... WORLDWIDE"

Elco Corporation
2250 Park Place, El Segundo, Ca. 90245
213-675-3311 / TWX 910-325-6602

Elco Corporation
A GULF + WESTERN MANUFACTURING COMPANY

CIRCLE 44 ON INQUIRY CARD

COMPUTER DESIGN/NOVEMBER 1976
Wednesday Afternoon

Session 23  2-5:30 pm  Ballroom W

Solid-State Devices—Short Channel FETs and MOS Type Devices
Organizer: P. J. Salsbury
Chairman: H. C. Nathanson

"Minimization of Gate-Drain Overlap Capacitance in VMOS Structures," I. S. Bhatti, T. J. Rodgers, and J. R. Edwards, American Microsystems, Inc


"Modeling of V-Channel MOS Transistors," B. K. Ahuja and A. R. Boothroyd, Carleton University, Ottawa

"Double-Implanted V-MOS," P. Ou-Yang, State University of New York at Stony Brook

"Hot Electron Emission from a Semiconductor Under Low-Level Avalanche Conditions," R. R. Troutman, IBM Corp

"Narrow Channel Effects in Insulated Gate Field Effect Transistors," W. P. Noble and P. E. Cottrell, IBM Corp


Session 24  2-5 pm  Ballroom E

Device Technology—Process Technology II
Organizer/Chairman: R. Edwards

"MOSFETs with Polysilicon Gates Self-Adjusted to the Field Isolation and to the Source/Drain Regions," V. L. Rideout and V. J. Silvestri, IBM Watson Research Center

"A Metallization Providing Two Levels of Interconnect for Beam Lead Silicon Integrated Circuits," W. D. Ryden, E. F. Labuda, and W. van Gelder, Bell Laboratories

"Dielectric Isolation Using Shallow Oxide and Polycrystalline Silicon," J. I. Raffel and S. E. Bernacki, Massachusetts Institute of Technology Lincoln Laboratory

"Preparation of Semiconductor Devices by Ionized-Cluster Beam Deposition and Epitaxy," T. Takagi, I. Yamada, and A. Sasaki, Kyoto University, Japan


"Laser Vaporization of Metal Films—Effect of Optical Interference in Underlying Dielectric Layers," J. C. North, Bell Laboratories

Session 25  2-5:30 pm  Georgetown Room

Electro-Optical Devices—Displays and LEDs
Organizer: H. Kressel
Chairman: G. B. Stringfellow

"Phenomena Useful for Displays," J. I. Pankove, RCA Laboratories


"A Photoconductivity Controlled Liquid Crystal Light Valve," M. H. Wu and N. H. Farhat, The Moore School of Electrical Engineering

"Matrix Display Using Twisted Nematic Liquid Crystal Dynamically Addressed," M. Goscianski and J. Donjon, Laboratoire d'Electronique et de Physique Appliquée, France

"The Fabrication and Performance of LEDs and Detectors from the Ga/In/As Alloy System," A. W. Mabbitt and K. Ahmad, The Plessey Co Ltd, England


"Increase in Luminous Efficiency With Thinned LEDs," F. Porrett, Centre Electronique Horloger S.A., Switzerland

Wouldn’t it be great if the PDP-11 could operate in his environment.

Norden is making it happen.

Norden Division of United Technologies
Five tough questions
to ask our
8080A competitors.

1. Do you have an 8K Electrically Erasable PROM? You know, like NEC Microcomputer’s µPD458 that’s compatible with 2708’s but can be erased in 1 minute, programmed in 80 seconds, only needs two voltages for reading and programming, has conventional packaging, a guaranteed data retention time of 10 years, and an access time of 450/650ns, making it the first practical non-volatile RAM storage.

2. Do you have a Universal Synchronous Receiver/Transmitter Data Communications Controller? You know, like NEC’s µPD379 with SDLC capacity up to 50K baud.

3. Do you have a 450ns 16K ROM? You know, like NEC’s µPD2316A that’s pin compatible with other 2316A's but has the speed to match the 8080A.

4. Do you have a Floppy Disk Controller? You know, like NEC’s µPD372 that can control up to four IBM 3740-compatible drives.

5. Do you have a Tape Cassette Controller? You know, like NEC’s µPD371 that can control up to four cassette drives with International Standard Data Format.

Go ahead, ask any competitor you like. What you’ll find is that if you want these super 8080A peripherals, you’ll simply have to come to NEC.

And when you do, you’ll also be dealing with an 8080A supplier with complete applications support plus the full range of 8080A products listed.

Any more tough questions?

Your NEC rep or distributor is waiting to put you at ease.

NEC Microcomputers, Inc.,
Five Militia Drive, Lexington, MA
02173. 617-862-6410.

µPD8080A
µPD8080A-E
µPD8080A-1
µPD8080A-2
µPD411
µPD5101-E
µPD2010AL
µPD20102AL
µPD454
µPD2308
µPD369
µPD758
µPB8212
µPB8214
µPB8216
µPB8224
µPB8228
µPB8251
µPB8255

2.0 MHz MPU
1.25 MHz MPU
2.5 MHz MPU
3.0 MHz MPU
4K DYN-RAM
1K STATIC RAM
1K STATIC RAM
1K STATIC RAM
2K EE PROM
8K Mask ROM
UART
Seiko Printer
Controller
I/O Port
Priority Interrupt
Controller
Bus Driver
Clock
Generator/Driver
System Controller
Prog. Comm.
Interface
Peripheral Interface

NEC microcomputers, inc.
The new Silent 700® Model 743 KSR data terminal is the lowest priced 30-cps printer terminal available today. And, true to its heritage, it combines all the popular Silent 700 performance features — speed, reliability and quietness.

In fact, its speed and reliability are enhanced. Now there's true 30-cps throughput, because incoming data is buffered. Reliability is improved because its microprocessor logic means fewer circuit boards and components. This application of the latest design technology not only adds up to enhanced reliability but reduces size and weight as well.

As for quietness, the 743 KSR is virtually silent, as its name implies. Its non-impact electronic printing eliminates the disturbing noise associated with conventional impact printers.

At $1395* quantity one, the 743 KSR is another TI price/performance value leader... whatever your application: console I/O for software development, keyboard terminal for inquiry response, data entry, interactive remote computing, or a message network terminal.

OEM prices go below $1000* in large quantities; and attractive lease rates also are available. All Silent 700 terminals are backed by TI's comprehensive worldwide maintenance and support services.

For more information on the 743 KSR and other Silent 700 terminals, contact the nearest TI office listed below or contact Texas Instruments Incorporated, Digital Systems Division, P.O. Box 1444, Houston, Texas 77001. Or, phone Terminal Marketing at (713) 494-5115, extension 2126.

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorporated

Texas Instruments Incorpora...
It is often difficult to estimate quantitatively in advance which computer or compiler would be adequate or cost-effective to solve scientific and engineering research and development problems. This technique simplifies such estimations.

Procedure Evaluates Computers For Scientific Applications

Louis Wolin

U. S. Army Materiel Development and Readiness Command
Alexandria, Virginia

To the research scientist and engineer, comparing the performance of various computers is of the highest priority. While he usually does not care about the capability or cleverness of the processing system, he does need to know if a given computer or compiler can solve the problem in a reasonable time and meet mission requirements within cost constraints. From the point-of-view of management, number of runs and cost per run per unit time are significant when new equipment is procured or existing equipment is replaced or augmented. Once management has purchased a particular system, the scientist is limited by maximum capabilities of both the hardware and software operating systems.

In developing a technique for making such comparisons, the U.S. Army Materiel Development and Readiness Command (DARCOM) focused its attention on problems in which the heavy workload is performed by the central processor, while the peripheral workload and input/output (I/O) processing are relatively low. These conditions are typical of real problems in radar, signal processing, missiles, energy, medicine, and other fields, where the high processing workload results from the requirement for computation in real-time, or the extreme complexity of the simulation. In developing this model or applying the technique, design criteria were:

1. Job or application dependence rather than computer dependence
2. Present and future scientific computation capabilities to be represented in quantitative terms

Basic Relationships

A processor that satisfies the requirements for a particular line of scientific computation must operate within these guidelines:

\[ R_p = O \times P \times S \]
\[ B = \frac{O_{\text{max}}}{R_p} \]
\[ T = \frac{N}{B} \]

where

- \( R_p \) = Problem requirements in operations per cycle at the highest problem frequency
- \( O \) = Number of operations per pass through the equations
- \( P \) = Number of passes per sample
- \( S \) = Number of samples per problem cycle
- \( B \) = Processor-limited problem bandwidth
- \( O_{\text{max}} \) = Maximum operations per second of processor
- \( T \) = Computation time in seconds
- \( N \) = Problem length in number of cycles of highest frequency
(3) No system to be favored over another
(4) Realism
(5) Testing capability against existing computing systems, as a function of cost per run per unit time
(6) The technique should be tailored to user requirements.

A survey of various Army laboratories showed that problems with over 50 nonlinear simultaneous differential equations were considered overly expensive to solve by digital techniques because of excessive computation time. Reasonable computation for research and development required the solution of no more than 30 to 50 of these equations, with frequency requirements from 1 to 500 Hz.

**General Theoretical Considerations**

To meet real-time needs and make simulation problems cost-effective under large computational loads, computation speed is an important parameter—particularly in semiphysical simulations, or when system hardware is included in the simulation. The fastest digital machines available today do not meet the frequency requirements of many scientific applications. When the bandwidth of the application problem to be solved is very high, the number of operations per unit time required for each state variable increases as a function of the highest frequency. Since the maximum speed of any processor is limited, computation time must increase to meet the problem's dynamic accuracy requirements. Thus problem bandwidth is very important in the solution of scientific problems, both in real-time and non-real-time simulation; however, it has been neglected by many users and computer manufacturers.

For purposes of this article, problem bandwidth is defined as the highest frequency in hertz present in the problem dynamics, which are represented by a set of differential equations. In nature, these equations are usually nonlinear, but for purposes of analysis, they can usually be approximated by a set of linear differential equations, by considering small perturbations about a reference or equilibrium solution. Roots of these linear equations at any instant, if real, represent exponential dynamic behavior; if complex, they represent oscillations. Both types of roots have units of frequency—that of the corresponding transient oscillation, or of the reciprocal time constant of the corresponding exponential transient. The root with the largest magnitude defines the highest problem frequency, and therefore the bandwidth.

For example, in an aircraft problem with six degrees of freedom, the highest problem frequency typically is approximately 1 Hz, the frequency of the short-period motion. If control-surface dynamics are included in the equations, frequency increases to about 10 Hz, taking into account, for example, helicopter blade dynamics. For a process control plant, the highest frequency may correspond to a time constant of 0.1 s, so that the highest problem frequency (and hence the problem bandwidth) is

\[
\frac{1}{0.1} = 10 \text{ radians/s or } \frac{10}{2\pi} = 1.59 \text{ Hz}
\]

In digital simulation, where nonlinear differential equations representing the problem dynamics are integrated numerically, accuracy of the result is very sensitive to integration step size. If the latter is too large, accuracy deteriorates and the solution may show instability when the simulated system is actually very stable; if it is too small, the computer word length may impose dynamic range problems (round off errors). If the same integration step size is used throughout the problem (as is usually the case), typically the number of integration steps per cycle of the highest problem frequency lies between 10 and 100, depending on the integration algorithm used.

At each integration step, all algebraic, transcendental, and logical operations needed to evaluate the rate-of-change of each state variable over that step must be computed at least once. Thus, every time the problem bandwidth is doubled, the number of required digital operations per second is doubled if the computation must proceed in real-time; or, if the digital computer was already operating at maximum speed, overall problem solution time is doubled, and real-time operation is lost. Thus problem bandwidth, as defined, can set speed requirements for real-time digital simulation. Conversely, for a given digital computer in non-real-time, bandwidth determines time required for the simulation run and hence the cost per run.

However, for some types of simulation, problem bandwidth alone may not set speed requirements. One or more time-varying input variable to the simulation may have significant power content at frequencies above the problem bandwidth. For example, if the simulation consists of low pass filtering of input data, filter cutoff is the highest problem frequency. If integrator step size is based on this frequency, resulting sample frequency for the input data may be inadequate for certain power frequencies. According to a well-known theorem, sampling frequency must be at least twice the highest problem frequency; otherwise, frequencies in the input signal that are more than one-half the input sample frequency are converted erroneously into frequencies less than one-half the sample frequency. This effect, known as "aliasing," can cause large errors if not recognized and corrected. Correction requires either a higher input sample rate or prefiltering the input signals; the higher rate requires either higher digital processor speeds or more processor time.

Despite these considerations, the proposed technique is based strictly on the problem bandwidth. The quantitative method of comparing computer systems described here does not assume that one system is superior to the other. It shows how to predict in advance which computer is more cost-effective or more likely to solve the required application according to design specifications. In comparing computers, the physics of the problem and the input and output signals must be considered.
### TABLE 1
Typical Scientific Problems

<table>
<thead>
<tr>
<th>Organization</th>
<th>Applications</th>
<th>Millions of Operations/s</th>
<th>Number of Differential Equations</th>
<th>Bandwidth (Hz)</th>
<th>Computer Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEC</td>
<td>Reactor core dynamics</td>
<td>80</td>
<td>200</td>
<td>50</td>
<td>10 min. (EAI 8900)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>200 min. (IBM 360/75)</td>
</tr>
<tr>
<td>Army</td>
<td>Gun stabilization/ control (500 runs/vehicle)</td>
<td>10</td>
<td>50</td>
<td>200</td>
<td>0.83 min. (EAI 231R)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20 min. (IBM 360/44)</td>
</tr>
<tr>
<td>Army</td>
<td>Cross country vehicle (20 runs/vehicle)</td>
<td>4</td>
<td>30</td>
<td>500</td>
<td>1 min. (EAI 231R)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15 min. (IBM 360/44)</td>
</tr>
<tr>
<td>Army</td>
<td>Helicopter flight simulation (500 runs/aircraft)</td>
<td>43</td>
<td>250</td>
<td>50</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 hr (IBM 360/65)</td>
</tr>
<tr>
<td>Hughes Aircraft</td>
<td>Air-to-air homing missiles (400 runs/day)</td>
<td>36</td>
<td>60</td>
<td>1000</td>
<td>20 s (EAI 680)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>600 s (Sigma 8)</td>
</tr>
<tr>
<td>Navy</td>
<td>Real-time torpedo launch simulation</td>
<td>1</td>
<td>10</td>
<td>10</td>
<td>1 min. (EAI 8800)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12 min. (Cyber 72)</td>
</tr>
<tr>
<td>Beech Aircraft</td>
<td>Missile dynamics</td>
<td>1</td>
<td>35</td>
<td>20</td>
<td>1 min. (EAI 600)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1012 min. (IBM 1130)</td>
</tr>
<tr>
<td>U of Michigan</td>
<td>Electrohydraulic control system</td>
<td>10</td>
<td>8</td>
<td>60</td>
<td>1.5 min. (AD/1130)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1012 min. (IBM 1130)</td>
</tr>
<tr>
<td>Army/Martin-Marieetta</td>
<td>Missile trajectory (100,000 runs/missile)</td>
<td>8</td>
<td>53</td>
<td>50</td>
<td>100 s (EAI 8800)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>334 s (IBM 370/168)</td>
</tr>
<tr>
<td>Air Force/Martin-Marieetta</td>
<td>Missile trajectory (4000 runs/missile)</td>
<td>8</td>
<td>—</td>
<td>50</td>
<td>5 min. (EAI 8800)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>200 min. (EAI 8400)</td>
</tr>
<tr>
<td>Army/Martin-Marieetta</td>
<td>Missile stability and control (90,000 runs/missile)</td>
<td>2</td>
<td>31</td>
<td>60</td>
<td>10 s (EAI 8800)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100 s (EAI 8400)</td>
</tr>
<tr>
<td>DCA/Martin-Marieetta</td>
<td>Communication receiver simulation (10,000 runs)</td>
<td>150</td>
<td>32</td>
<td>45</td>
<td>5 min. (EAI 8800)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>246 min. (U 1108)</td>
</tr>
<tr>
<td>Martin-Marieetta</td>
<td>Voice intelligibility study (900 runs)</td>
<td>64</td>
<td>46</td>
<td>35</td>
<td>22 min. (EAI 8800)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>702 min. (Xerox)</td>
</tr>
<tr>
<td>Martin-Marieetta</td>
<td>Economic system model (100 runs)</td>
<td>230</td>
<td>14</td>
<td>5</td>
<td>0.02 s (EAI 8800)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2 s (IBM 370/168)</td>
</tr>
<tr>
<td>Martin-Marieetta</td>
<td>Autovon model (18 runs)</td>
<td>10</td>
<td>—</td>
<td>50</td>
<td>1.1 min. (EAI 8800(3))</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>360 min. (IBM 370/165)</td>
</tr>
<tr>
<td>Toyota</td>
<td>Automobile dynamics (1000 runs/design)</td>
<td>7</td>
<td>29</td>
<td>10</td>
<td>5 s (EAI 600)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5400 s (IBM 360/65)</td>
</tr>
</tbody>
</table>

### Scientific Mix to Compare Computers

One technique for comparing computer performance is the use of a scientific mix of instructions. It is based on the assumption that a quantitative measure may be derived from the mathematical representation of the system to be simulated and the performance characteristics of the computer, and used as an estimate of computation time to perform the simulation. It assumes that mathematical equations for the simulation are known and will be evaluated by a digital computer that operates in accordance with advertised or measured performance specifications. These mathematical equations are translated into a total count of digital computer operations per second, which is then used to obtain total computation time. To reflect the experi-
mental nature of the simulations conducted by the U.S. Army Laboratories, arbitrary and fixed function generators were included in the mix. Finally, all or part of the estimate was validated by actually running the problem on the computer system and comparing estimated and actual times.

The method is problem-dependent rather than computer-dependent since the engineer or scientist reduces the equations directly to operations per second. For example, the equation \( w = \frac{xy}{z} \) requires one multiplication, three stores, and one load to be evaluated on a digital computer. Although various computers may solve the problem differently, the mix serves as a baseline for comparing them, because it depends upon basic mathematical operations and the computer characteristics in performing these operations. The mix is intended to be used both in applications that tax present large computers, and in systems of minicomputers.

This measure of performance is useful when new computer systems are selected and evaluated, or when existing systems are replaced or augmented. It can also project future requirements by predicting which problems require too much time to be solved effectively on present-day large digital computers. For example, the U.S. Army Air Mobility Research and Development Laboratories encounter very large problems in the simulation of helicopters, while analyzing competitive designs. Simulation of these applications requires approximately 250 first-order simultaneous nonlinear differential equations and requires up to four hours on an IBM 360/65 to evaluate a few minutes of real-time performance. Other large problems are equally time-consuming (Table 1).

The technique is best explained by a specific example (Table 2), which is based on a representative simulation of a large missile. Developed by DARCOM, it is called the Wolin-Saucier-Peak (WSP) Scientific Mix. It includes 102 simultaneous nonlinear first-order differential equations. Evaluation of these equations requires summation, multiplication, Boolean comparison, arbitrary function generation, and single fixed function generation in terms of a power series. These five operations, along with the fourth-order Runge-Kutta integration algorithm by which each first-order equation is integrated over one time step, are listed in the first column of Table 2. In the next column, these mathematical operations are reduced to equivalent
lent digital operations. For example, the summation function \( A_1 X_1 + A_2 X_2 + A_3 X_3 \) requires a minimum of two additions, three multiplications, three loads, and three stores to evaluate. Each of these operations has a weighting factor, normalized with respect to the execution time of an add operation for the specified computer. With these weighting factors, differences in digital computers can be adjusted. In this example, weighting factors are all 1 except for multiplication, which is assumed to require the equivalent of three additions to execute. Sum of the digital operations, each multiplied by its weighting factor, is the number of static digital operations for the corresponding mathematical operation; this number, for a summation, is 17 (third column). Missile simulation requires 136 of these summations (fourth column), so that the total count of normalized operations is the product of the number of digital operations per function and the number of times the function occurs in the simulation. This is 17 x 136 for the summation, or 2312 (fifth column).

Similarly, total normalized digital operations are calculated for the other functions in the simulation. The result in column 5 is the total number of digital operations required to evaluate the corresponding mathematical function in column 1 at a single value of the independent variable—that is, for a single sample representing a brief interval of time. However, for the Runge-Kutta integration, the table entry is the previously mentioned product divided by four, because four passes are necessary at each sample point. These passes represent, in effect, a partial evaluation at the next three sample points as well as the present one, because the algorithm is recursive. Taking this into account, the total of all entries in column 5 is 8568, the number of digital operations required to run the whole simulation for a single value of the independent variable—that is, for a single sample.

Because four passes are made per sample, and because 20 samples are made for each cycle of the problem frequency, which is 1 kHz, the number of equivalent digital operations per second of missile time (not necessarily per second of real-time) is \( 4 \times 8568 \times 20 \times 1000 = 685,440,000 \). However, if the mix assumes a problem frequency of 10 Hz, the simulation is slowed down by a factor of 100 from this rate, or 6,854,400 operations/s. Thus the simulation runs at 1/100 real-time.

Empirical relationships can be developed from experience relating the number of operations per second to number of simultaneous differential equations and bandwidth of the highest frequency. If all other parameters are fixed, and only the frequency varies, number of operations per second is proportional to bandwidth. Such an estimate does not take into consideration software efficiency or computer overhead; however, as a figure of merit it estimates the best performance possible.

**Validation of the Technique**

The technique can optimize the selection of a computer for any given computation requirements, either to choose new computing systems to meet present or future needs, or to predict in advance the most cost-effective technique or fastest computation time for large and small scientific problems.

Martin-Marietta Corp verified the technique by utilizing experience gained over many years in simulating missiles. In applying the technique with debugged production programs repeated many times, Martin-Marietta was requested to answer two questions without imposing an additional workload on its facility.

(1) Given two computers, the IBM 370/168 and the EAI 8400, can the computation time of each be predicted in advance? Predicted execution times on both computers were within 10% of actual computation time.

(2) Given a large computer, such as the IBM 370/168, and a choice of several compilers written to run in various memory capacities, which compiler is best suited for a program to solve the equation of motion of a rigid body in a single plane? Although these
Fig. 3 Comparison based on problem size. Time required to solve a problem is proportional to problem complexity measured in the number of operations per second that would be required to solve it in real-time. Relationship applies even to parallel-processor systems, but is clearly impractical for small computers. Proposed hybrid design, standard for the comparison, would be represented by a horizontal line just above the axis; increasing complexity calls for more hybrid modules that keep the solution time constant.

Another representative missile simulation like the one used earlier required roughly 30,000 digital operations per integration step. Assuming, as before, 20 steps/cycle of the highest problem frequency, this comes out to 600,000 digital operations/cycle of the highest problem frequency. A proposed large hybrid system could handle problem frequencies of up to 1 kHz without significant accuracy deterioration. This is its bandwidth, corresponding to 1000 x 600,000 = 600M operations/s.

Another way of comparing computers is to constrain them to real-time operations. This approach assumes that they run at the maximum possible speed consistent with acceptable accuracy, since this yields the lowest cost per solution. For various digital computers (Fig. 2) the range of problem bandwidths varies from

results were less definitive than the first, because all compilers ran in about the same time, within 4%, predicted compilation time was reasonably close to the time actually required.

Further validation of the method was provided by the University of Massachusetts, in predicting the computation time to solve linear simultaneous differential equations on a Control Data Corp CYBER 74 computer using CSSL/ISSL software. In this test, the highest frequency was 1 kHz, and the Runge-Kutta algorithm was used with each equation over one time step. Eight simultaneous differential equations were solved in 1 s, and 40 equations in approximately 7 s (Fig. 1). Observed computation times were slightly longer than predicted because of inefficiencies in the ISSL software.

Various government and industrial laboratories have further verified the technique on digital and hybrid computers.

**Applying the Technique**

Another representative missile simulation like the one used earlier required roughly 30,000 digital operations per integration step. Assuming, as before, 20 steps/cycle of the highest problem frequency, this comes out to 600,000 digital operations/cycle of the highest problem frequency. A proposed large hybrid system could handle problem frequencies of up to 1 kHz without significant accuracy deterioration. This is its bandwidth, corresponding to 1000 x 600,000 = 600M operations/s.

Another way of comparing computers is to constrain them to real-time operations. This approach assumes that they run at the maximum possible speed consistent with acceptable accuracy, since this yields the lowest cost per solution. For various digital computers (Fig. 2) the range of problem bandwidths varies from
less than 1 Hz for some minicomputers to roughly 170 Hz for today's largest computers when applied to simulations that require 600M operations/s. For the proposed hybrid system just mentioned, maximum problem frequency content may fall anywhere between 10 Hz and 1 kHz. For digital computers the maximum practical interval of numerical integration corresponds, as in the example cited, to about 20 steps/cycle of the highest problem frequency.

Maximum number of operations per second for a number of scientific digital computers was estimated and verified by consulting with various laboratories and computer manufacturers throughout the country. In each case dividing this number by 600,000 gives the actual maximum problem frequency which the given computer can handle and still solve the missile simulation problem. This is defined as the computer bandwidth.

Since digital computers operate serially, problem solution time grows linearly with problem size (Fig. 3). Even in the case of digital computers using a number of parallel processors, such as ILLIAC IV, maximum number of operations per second is achieved when all processors operate simultaneously at full speed, so that the linear relationship holds.

**Computer Selection**

The technique is based essentially on two nomographs (Figs. 4 and 5). Using the first, the computer with the required maximum operations per second can be selected from the problem requirement in operations per problem cycle (abscissa) and problem bandwidth (ordinate). Since operations per second equals operations per cycle multiplied by cycles per second, the curves in Fig. 4 are hyperbolas of the form \( xy = k \); they appear as straight lines because the scales on

---

**Fig. 4** Nomograph 1. Operations per problem cycle (horizontal axis) and number of problem cycles per second (vertical axis) determine the number of operations per second (curve and figures in color) required of the processor that will solve the problem.

**Fig. 5** Nomograph 2. Number determined in Fig. 4, divided by problem requirements in operations per cycle, gives the processor-limited problem bandwidth, shown along the horizontal axis. This number, and the actual problem bandwidth (curves and figures in color) provide an estimate of the length of time required to solve the problem.
TABLE 3
Typical Computer Speeds

<table>
<thead>
<tr>
<th>Computer</th>
<th>Max Operations/s (x 10^6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ILLIAC IV</td>
<td>100</td>
</tr>
<tr>
<td>Texas Instruments (ASC 4³)</td>
<td>75</td>
</tr>
<tr>
<td>CDC STAR-100</td>
<td>15</td>
</tr>
<tr>
<td>IBM 370/195</td>
<td>15</td>
</tr>
<tr>
<td>CDC 7600</td>
<td>80</td>
</tr>
<tr>
<td>CRAY</td>
<td>3</td>
</tr>
<tr>
<td>CDC 6600</td>
<td>1.85</td>
</tr>
<tr>
<td>UNIVAC 1110</td>
<td>0.8</td>
</tr>
<tr>
<td>Interdata 8/32</td>
<td>0.55</td>
</tr>
<tr>
<td>DEC PDP-11/70</td>
<td></td>
</tr>
</tbody>
</table>

both axes are logarithmic. The second nomograph (Fig. 5) relates computation time in seconds to the number of problem cycles at the highest problem frequency and the processor bandwidth in hertz. These curves are also hyperbolas, generated from a different basis but the same relationship as those in Fig. 4. This technique is particularly useful and has a high probability of success when problems or simulations can be expressed quantitatively by equations or number of equivalent computer operations. Its validity depends upon problem definition, accuracy required, and problem bandwidth. Corrections to the predicted results can be made easily by running a scaled-down version of the problem on various computers.

Illustration of Technique

A practical problem illustrates the method. Assume that a simulation requires 10⁶ operations/problem cycle as determined by the maximum number of equations or operations required. For this problem, the best computer can be found from Fig. 4, assuming that the problem bandwidth is 10 Hz. At the point 10⁶ (problem requirement) on the abscissa draw a vertical line. At the point 10 Hz (problem bandwidth) on the ordinate draw a horizontal line. The two lines meet on the diagonal line labeled 10⁶. This means that a computer capable of 10⁶ operations/s is required. At least two computers meet this requirement (Table 3) and are therefore candidates for the job; they are a CDC 6600 or a UNIVAC 1110.

When a computer has been selected, computation time for solving the problem can be predicted from Fig. 5. It depends on the processor-limited problem bandwidth—that is, the highest problem frequency that a given processor can handle in real-time, which may not be the same as the actual problem bandwidth. This processor-limited problem bandwidth is the quotient of the maximum processor operations per second, as determined from Fig. 4, divided by the problem requirements in operations per cycle. For example, from the nomograph, a machine with a processor-limited problem bandwidth of 10 Hz requires 1 s to run a program with an actual problem bandwidth of 10 Hz. Similarly, if another machine with a processor-limited problem bandwidth of 1 Hz were selected, computation time for the same problem would be 10 s. Since maximum capability of most computers can be expressed in operations per second, a family of curves like those in Fig. 4 but with different slopes and intercepts can be developed for new computers when theoretical and measured data become available. From such curves, a processor can be selected to give the optimum computation time and the minimum cost—keeping in mind the assumptions that the computer is not saturated when processing the problem and that architecture, software, operating system, and compiler are performing in accordance with known specifications.

Conclusions

For problems requiring 600,000 operations/cycle of the highest frequency, effective bandwidth of present-day large-scale digital computers is less than 170 Hz. However, from a survey of the scientific applications of various laboratories, there are real-time requirements for computers which can process problem bandwidths of at least 10 kHz and approach a performance capability of 600 x 10⁶ operations/s—three orders of magnitude faster than available computers. The technique described here is useful in predicting the optimum computer system and an approximate required solution time for a given problem, and in selecting a computer system to meet present or future computational needs for scientific applications.

Bibliography

R. M. Howe, "A Performance Comparison of All-Digital Computation and the Advanced Hybrid Computer System," University of Michigan, Apr 1975

Louis Wolin, currently an operational research analyst, has worked in digital communications, digital and analog computers, and simulation. He holds a BS in mathematics and physics and an MS in education from the College of the City of New York, a BS in electrical engineering from Ohio State University, and an MS in electrical engineering from the University of Pennsylvania.
With a line of minis and micros like ours, we don’t have to push any one of them.

With other companies, you might set out to buy a microprocessor chip and end up with the whole chassis. Or get a box when all you need is a board.

But Data General doesn’t work that way. We don’t have to push you into buying something you weren’t really looking for. Because we can let you choose from microprocessor chip sets, microcomputer boards, completely packaged MOS minis and full-blown NOVA 3 systems. All four are compatible. And they give you a range of performance with a range of prices.

So, if you’re a component user, there are both high-performance microNOVA chip sets and microcomputer boards that feature Data General’s mN601 microprocessor. The mN601 is a full 16-bit NOVA-on-a-chip. And the microcomputer is a full 4K-word computer-on-a-board. You package them yourself, for greatest economy. (Speaking of economy, the board costs only $589 in OEM quantities of 100.)

And if you’re not ready for components yet, there’s our fully-packaged microNOVA MOS minicomputer. It’s available with up to 32K words of MOS memory and peripherals like our diskette subsystem. And it’s supported by our Real-Time Operating System and diskette-based Disc Operating System. You can get our mini with 4K words of MOS memory for only $1995. Or as a complete development system with the diskette.

If you need bigger systems capabilities, take a look at our NOVA 3 computer. It’s compatible with our microNOVA family. And it runs with high-performance peripherals, sophisticated software like Real-Time Disc Operating System, high-level languages like FORTRAN 5 and BASIC, and memory expansion to a full 128K words.

We’ve got it all. But we won’t try to sell it all. Unless it’s what you really need. If you don’t believe that line, call us. Dial 800-225-9497 (in Massachusetts, 1-617-485-9100, extension 2509) and ask for information on microNOVA and the free half-day microNOVA seminars that happen this fall all over the country.

Or write for our microNOVA and NOVA 3 brochures. And see for yourself.
The introduction of the first Raycorder in 1970 marked the end of the struggle to use basically audio-type cassette transports in digital systems. Designed solely for digital data, the Raycorder established new standards of accuracy and reliability.

Today thousands of Raycorders are in daily use around the world, having been specified for virtually every major data processing application by Original Equipment Manufacturers.

It continues to be the finest transport for standard Philips cassettes. Our free brochure tells the full story.

Size: 5.5" x 5.8" x 3.9"
Weight: Under 4 pounds
Data Transfer Rate: Up to 24,000 BPS
Data Capacity: 700K bytes

Complete specifications are available for the asking. Contact "Bud" Gould.

Raycorder

Raymond Engineering Inc.
A Subsidiary of Raymond Precision Industries Inc.
217 Smith Street, Middletown, Connecticut 06457
Phone: (203) 632-1000 Telex 9-8394

Mini-Raycorder

With the advent of the microprocessor has come the need for even smaller tape transports—in test equipment, in desk-top calculators, in portable battery-operated terminals and in scores of other applications. Once again, Raymond is ready.

The new Mini-Raycorder, completely compatible with the Information Terminals MI-50 MiniData Cassette and the proposed ANSI standard, brings to subminiature recording the same standards of reliability and performance which have long been the hallmarks of the original Raycorder.

Size: 3.0" x 3.0" x 1.8"
Weight: 16 ounces, including electronics
Data Transfer Rate: 2,400 BPS
Data Capacity: (single-track) 128K bytes

Complete specifications are available for the asking. Contact "Bud" Gould.
As large-scale integrated circuits add more and more capability, their usefulness to terminal designers increases, resulting in more articulate or cheaper terminals or both.

Impact of LSI On Terminal Architecture

Peter G. Cook and Thomas B. Cheek
Tektronix, Incorporated
Beaverton, Oregon

Designers have a responsibility to assess the value of arising technologies and to propose revolutionary products which satisfy user needs rather than user desires. This obligation contrasts sharply with the way most terminal designs are created—winding up at the engineer’s bench after a series of customer inputs have been filtered by the marketing department. Marketeers usually want evolutionary products that are extensions of the existing product line: a little faster, cheaper, and with a few new functions.

Large-scale integrated (LSI) circuit technology offers promise of a breakthrough in product design, and deserves careful consideration in planning its introduction into terminal designs. It offers some universal advantages, independent of the details of its use. One of these is reduced lifetime cost, resulting largely from reduced downtime and faster maintenance. A lower component count and accompanying reduction in circuit boards, connectors, and cables present less opportunity for failure.

Another advantage is the opportunity for built-in reliability. Lower cost per function permits redundancy and error correction, reducing failure incidence. Addition of diagnostic facilities also promises lower cost to repair. Fewer failures and faster repairs increase the system’s availability to the user throughout its life. LSI also reduces power dissipation. Smaller power supplies, less heat, and fewer fans promise smaller, quieter, and lighter terminals.

Unfortunately, LSI does not have much effect on purchase price reductions, which are more limited by packaging, mechanical considerations, software, and marketing costs than by semiconductor devices.

LSI Functions and User Needs

LSI also has advantages in specific terminal functions, which include data input from keyboard or digitizer; display on cathode-ray tube (CRT) or printer; secondary storage on cassette or diskette; communication with mainframes or other terminals; and data manipulation. Onto this set of terminal functions must be mapped a series of requirements that represents the set of user needs, which includes data entry, data retrieval, editing, display, and computation. The degree of fit between these two sets determines the effectiveness of the terminal in a particular application.

Prime concern of the design engineer is how to implement the functions most effectively; however, for the user terminal functions are but a means to an end. He is relatively indifferent to their implementation. The designer must not lose sight of the user forest as he looks at the functional trees.

When implementing the desired feature set, the designer must choose between the flexibility of a general-purpose device and the performance of a specialized device. LSI microprocessors offer the advantage of changing the feature set without modifying the hardware. This permits a terminal to be designed for usefulness in more than one application by changing the control program. The result amortizes hardware engineering expense over a larger volume and achieves economy of scale in manufacturing. For example, a single alphanumeric CRT and associated hardware might be applied both to a data retrieval application and to another application utilizing “fill-in” from displays.
Unfortunately, circuits as complex as a microprocessor are most easily implemented in metal-oxide semiconductor (MOS) and related technologies, which are relatively slow. Some terminal functions, such as error checking of high speed communication lines, may exceed the capability of many processors. To stay with the general-purpose approach requires use of a faster but more expensive microprocessor, perhaps a bipolar implementation. Use of multiple microprocessors is an alternative, but brings problems of multiprocessor architecture. On the other hand, the special-purpose approach requires random logic to implement the precise function set required. If properly done, this last approach optimizes performance.

A feasible intermediate approach uses a microprocessor at the heart of the system, and surrounds it with specialized medium-scale integrated (MSI) or LSI circuits for repetitive functions or those working with special signal levels. As needs have been defined, a number of special-purpose devices have appeared. Semiconductor distributors stock many of the common terminal functions. These include: universal asynchronous receiver-transmitters (UARTs), keyboard scanners, character generators, power supply regulators, and digital-to-analog converters. Some special functions may be implemented with standard microprocessors dedicated to one task. This avoids the problems of generalized multiprocessor systems.

**Networking**

The most far-reaching consequence of LSI's effect on terminals is in how they will be used in networks. The typical computer network consists of a large central computer, a variety of local high performance peripherals, such as printers and mass storage units, and a large number of remote terminals connected by telephone lines. The network exists primarily to allow remote terminal users to access the computer's processing power, and to share the central data base and the system peripheral devices. However, such networks, in attempting to provide "real-time" response, incur a high system overhead that raises costs and lowers performance. They are also subject to relatively high communications costs, which do not appear to be falling as fast as other system costs.

If present trends continue, future terminal processing power and memory capacity will be adequate for many processing tasks now being imposed on the host
computer. This is particularly true of input and editing tasks. As a result, the host computer system can be optimized to run larger programs with less concern for real-time response, and will, therefore, suffer less from overhead. At the same time, the terminal user will have improved response, since much processing will be local; and communication costs will be lower, as fewer messages are transmitted back and forth.

However, since the need for shared data bases, shared specialized peripherals, and backup computation power will continue, networks will continue to exist. Paradoxically, instead of terminals supplying data and programs to the host computer, it may be more common for the host to feed data and programs to be run on the terminal.

This process will not occur overnight, but the trend should be steady.

**LSI and Computation**

Microprocessors are falling even faster in price than memory chips, while architectures, speeds, and instruction sets are becoming more powerful. Machines, which began modestly as 4-bit "number gummers," are now available with 8-, 12-, or 16-bit words, and some are real "number crunchers." Introduction of bipolar processor chip sets has opened yet another dimension of speed and flexibility.

At first thought, it would appear that terminal computation would not require very high performance. This would be true if LSI were used merely to implement the traditional terminal functions. However, between designers' imagination and customer wishes, terminal processing requirements can be demanding. Even now, many applications require 8K, 16K, or even 32K bytes of control memory. Although the typical data word is a 7- or 8-bit character, any operation requiring much data translation on the display screen will require manipulation of 16-bit address pointers and, therefore, 16-bit arithmetic. Meanwhile, graphic terminals have almost unbounded needs for computation. While simple 2-dimensional images require little processing, such tasks as clipping a picture to fit on the screen, or performing real-time 3D rotation, can put severe demands on a system.

Some important issues have not yet been resolved. For example, how much programming power will the individual user want? and what will be the division of responsibilities between vendor and customer?
Data Input

The standard typewriter keyboard is likely to remain the most common data entry device for some time. LSI has its impact here by allowing keyboards to be configured in unlimited ways. Traditionally, each key on a keyboard is assigned a specific code, which is transmitted to the computer when the key is depressed. With LSI, these key codes can initiate separate control routines, which, for example, might alter key codes according to some algorithm. By this means, key-cap positions could be moved freely; changing the “mapping table” would make the proper key codes follow the keys.

Similarly, normal and shifted key codes can be freely paired rather than restricted by coding conventions. Individual keys can be tagged to repeat their codes as long as they are held down, while others are non-repeating. LSI scanning techniques also make protection against “N-key roll-over” easy—that is, avoiding incorrect signals when two or more keys are depressed simultaneously. Finally, special function keys can be programmed to perform whole sequences of operations and even reprogrammed by different users for different functions. This flexibility means that the keyboard can be more readily tailored to the user’s needs and thus should allow faster and more accurate data entry.

As has been well recognized, errors are most effectively corrected at the source. Local software can apply a variety of tests to data input, verifying consistency, range, and so on. When the terminal itself performs these checks, it avoids burdening the host computer and communication lines.
Data Display

Certainly during the next five years the CRT will be the dominant display component for terminals. LSI will help improve performance and lower costs of CRT-based terminals by taking over or aiding timing generation, picture geometry correction, digital-to-analog signal conversion, and other functions. Generally, these functions will be implemented using analog and combined analog/digital LSI devices. Although the term LSI often implies a monolithic structure, some of these combined devices will be hybrids built with thin-film technology. In some terminals LSI will be used to build units with larger CRTs of higher resolution, which therefore can show larger numbers of characters that are more legible and more attractive.

With low cost semiconductor memory, inexpensive graphic terminals using refreshed CRTs will be feasible. However, technology improvements will also make storage CRTs and plasma panels cheaper, and these devices will compete extensively in some applications.

For several important segments of the graphic terminal market—such as computer aided design, which requires large and complex displays—the storage CRT will reign supreme. For screens more than 30 cm across and images with over 20,000 vectors, the storage CRT has not only a very large equivalent memory space, but also image addressability, small spot size, and resolution much higher than all but the most expensive refresh CRTs.

LSI will eventually solve addressing, memory, and driving problems in emerging display technologies, such as liquid crystals, by incorporating the LSI circuits directly into the display unit. However, much work remains to make such devices economically practical. In particular, in the short run magnetic bubble memories, charge-coupled devices (CCD), and electron-beam-addressable memories appear to be inferior to MOS random-access memory (RAM) both in performance characteristics and potential low system cost for general-purpose terminal usage. In terminal applications, the organizational flexibility of MOS RAM makes it much more attractive than serial memory approaches or techniques requiring complex support circuits.

LSI and Communications

One of the major reasons for incorporating intelligence in terminals is to reduce communication cost. The word “intelligence” implies more complete message correction and verification before transmission, which reduces the need for repeated data transfers and improves transmission accuracy. The term also includes methods of polling, delayed data transmission, and elaborate networking techniques, permitting more efficient allocation of communication resources.

Special-purpose LSI is especially important in communication because the signal levels of some channels differ from standard logic levels. Also, because some communications tasks require very specialized processing, optimized circuit architecture is needed for efficient performance.

LSI and Peripherals

The impact of LSI on peripheral equipment for terminals has been pronounced. One of the characteristics of the market is that terminals are usually bought to match the terminal as closely as possible to the job. This means that the typical user buys units without much excess capability. As the need arises for peripheral devices, such as magnetic memories or printers, the original system can be very difficult to expand. However, by building LSI processors and memory into each peripheral device, the control burden imposed on the terminal is much lighter. Transferring data in blocks can reduce timing constraints. In addition, some specialized data manipulation tasks such as format conversion and signal amplification can be assigned to LSI chips specifically designed for them.

Summary

LSI technology offers an opportunity to reduce cost and increase reliability in terminals. The engineer will have to trade-off the flexibility of a general-purpose approach against the performance of special-purpose modules. Sales volume and application needs weigh heavily in the decision. Designers must also watch for opportunities for a real breakthrough. A reduction of terminal selling price by a factor of 10 would benefit the entire computer industry.

Presently engineering manager for the Information Display Systems Div of Tektronix, Peter G. Cook has been involved in data processing management, software development, and terminal design. He received a BA degree in physics from Williams College, and has done graduate work at Syracuse University and North Carolina State University.

Thomas B. Cheek is a senior engineer with the Information Display Group of Tektronix. His experience in design of low cost, high performance graphic display systems includes early work on direct-view storage, raster-scan, and calligraphic-refreshed CRTs. He holds BSEE and MSEE degrees from Massachusetts Institute of Technology.
Trigac VI digital-to-synchro converter gives you accuracy and power without raising your temperature.

The closest thing yet to a Solid State Synchro, Kearfott's Trigac VI Modular Digital-to-Synchro/Resolver Converters provide the accuracy and power you need, with a bonus. In addition to standard 4 arc minutes of accuracy at 1 volt ampere, the transformation ratio remains constant within ±.25%. We also have units constant within ±0.1%. That can make the difference between delivering power or just throwing it away.

Let us help you be cost effective. Standard options range from industrial grades thru hi-reliability units, from accuracies of ±20 arc minutes to ±1 arc minute and, in addition, special designs and packaging as you require.

Need more power? Try our line of compatible synchro amplifiers.

Our 3185 Series is designed to perform the synchro power buffering or resolver to synchro (Scott-T) function. They provide matched power amplifier channels and transformer coupled outputs capable of driving torque repeaters or multiple control transformers up to 5 va. These fully potted units feature overload protection, low-quiescent currents and transformer-isolated outputs. Models available range from industrial to full MIL-SPEC high-reliability grades.

NEED ADDITIONAL POWER? We have units available with power outputs to 50 va, 60 or 400 Hz operation, and options of built in digital converters and/or power supplies.

For details on our converters and amplifiers, contact The Singer Company, Kearfott Division, 1150 McBride Avenue, Little Falls, New Jersey 07424.
Getting the most out of microprocessors in any application requires the system to be designed for a broad range of applications, with flexibility and versatility built in.

Challenges in Microprocessor System Design

Tom Jones and Peter Thomas
Intel Corporation
Memory Systems Division
Sunnyvale, California

Today’s electronics industry enjoys a sense of freedom and growth unimaginable only a few years ago. The advent of the microprocessor has enabled manufacturers in the industry to use relatively simple, but powerful, microprocessor cards containing no more than 10 to 20 large-scale integrated circuits, not only for one particular product, but for entire lines of products. Product design has thus become largely a matter of system reconfiguration, which has, in turn, become a matter of redesigning system software and shuffling peripheral subsystems, much the same as with minicomputers.

Although these generalized microprocessor cards could well revolutionize product design, because of the ease with which the resulting product can be modified, designing microcomputer systems that allow flexibility and versatility is subject to numerous considerations. Design of generalized microcomputer systems involves many facets of microcomputer hardware design, and poses numerous questions that should be faced by any designer embarking on such a design.

Equipment manufacturers have discovered the impressive cost-effectiveness of microcomputers. Today, manufacturers are finding that the utilization of generalized microcomputers, rather than specialized logic controllers, can have a direct bearing on their profitability. These boards bring about reduced costs of development, production control, manufacturing, and field maintenance for diverse end-products.

Microcomputer Development

Two previous difficulties in adapting microcomputer systems have been generation of microcomputer software and integration and debugging of this software with the microcomputer hardware. However, modern microcomputer development systems, especially adapted to perform these tasks, have essentially removed those difficulties. They are effective because they can control multiple development resources and allow users to simultaneously develop and debug software and hardware from the beginning of the design cycle.

These development systems support numerous peripheral devices, which make system software generation quick and efficient, and allow software and hardware system testing and debugging to be carried out. Because of their architecture, most modern microcomputer development systems check out integrated software and hardware with either complete hardware emulation or selective in-circuit emulation.

Today’s microcomputer designers are at the confluence of two traditionally separate technologies. Neither hardware nor software design can be carried out without full knowledge of the capabilities and constraints of the other discipline. Using currently available development tools, digital designers can do most of their design tasks in software. Thus, reconfiguring a microcomputer system is totally a matter
of reprogramming, as long as the microcomputer hardware has been designed to allow for the required changes.

**Hardware Considerations**

Now that the microprocessor has made the transition from laboratory novelty to production line workhorse, microcomputer system design techniques are known and widely used. Slight variations to these techniques can improve versatility of the microprocessor unit (MPU) hardware and thereby increase the hardware's utilization.

First step in "designing out" obsolescence of a new microcomputer system is not merely to concentrate on the primary system, but also to consider any possible options to be offered with it. In addition to these primary and secondary considerations, designers should keep in mind potential uses for their MPU in future products. Knowing future requirements in general, the design team will know in which areas the microcomputer hardware will probably change. This information also will serve as an important constraint when selecting the microprocessor family.

The list of parameters on which the selection of a microprocessor family is based may be quite lengthy, and may differ for each application. However, one of the most important characteristics on which the selection should be based is the ease of expansion of memory and input/output (I/O) ports. Another important factor is that the components making up the microprocessor family should be reconfigurable on the board with only software modifications.

Regardless of which microprocessor family is chosen, the design team will want to develop a prototype quickly. They have two choices: to develop a prototype that approximates the final system, or to procure a standard microcomputer board that uses the selected microprocessor family. Either way, they can use a microcomputer development system to refine both software and hardware systems. For both they must determine required memory size, number of I/O ports, need for handling interrupts, number of interrupt levels, and amount of special circuitry to be incorporated on the MPU card.

Determining the memory size is of foremost importance. While an exact size can be determined only after extensive software development, in the majority of microprocessor applications a reasonable approximation of memory requirements is obtainable from a cursory analysis of the control, numerical, I/O, and data manipulation tasks to be performed by the microcomputer.

I/O requirements are determined by the number of peripheral devices to be used and the various control and data signals associated with each device. Specifications should include number of I/O lines, type of communication on each (eg, synchronous or asynchronous communication, parallel or serial data words), number of status flags, and data rates on each I/O line.

An adjunct of I/O requirements is the processor interrupt system. Interrupts, of course, are closely linked to the communication environment of the processor, and in most applications, the answer is fairly obvious. Not so obvious, however, is the required number of interrupt levels and the arbitration of interrupt priorities. Here again, a number of microprocessor families include a peripheral circuit which provides priority arbitration and vector generation. These flexible components allow the details of interrupt handling to be performed in software, instead of hardware.

Prototype specification is completed with the definition of any special circuitry required on a microprocessor card, which may include analog-to-digital converters, voltage translators, current buffers, and other equipment.

Once the prototype has been specified and built, and with the aid of a modern microcomputer development system, the software development team has all the diagnostic tools required to completely check out the microcomputer software and hardware system simultaneously. While this checkout is in progress, designers can begin detailed definition of the system hardware. At this point they must decide whether to use a generalized microcomputer card or a special-purpose logic module. Close attention must be given to future system expansion, production testing, field maintenance, final system partitioning, packaging techniques, board size, bus structure, and system voltage. A number of hardware trade-offs must be made at this time, each directly affecting the future usefulness and flexibility of the MPU card.

**Generalized MPU Design Example**

Trade-offs to be made in a microprocessor design can be illustrated through an example. The task is to develop a controller. Immediate design requirements comprise one serial asynchronous interface of 110, 300, or 1200 baud; input for seven status lines; output for 21 lines to an impact printer; output to 37 other control lines; enough read/write memory to satisfy the requirements of operating system software, plus a buffer for about 4K 8-bit words of data; read-only memory (ROM) for program storage, the actual size of which is to be determined during development; and service requirements for six interrupts. In addition, marketing requirements call for several future expansion options, including field-replaceable programs, field expansion of read/write memory, portable nonvolatile storage (probably either cartridge tape or flexible disc, but possibly a newer technology), and one additional communication interface for 9600-baud synchronous data transmission.

Analysis of the major present and future system requirements indicates that system controller and processor cycle time will be challenged primarily when the 9600-baud interface is attached. However, since 1-ms intervals are available between transfers of parallel 8-bit words into the interface, a high speed microprocessor is not required. Future field upgrade of the system calls for a modular system, a characteristic that is present in various microprocessor families.

Analysis also shows that a standard universal synchronous/asynchronous receiver/transmitter (USART) in the communication interface is desirable, because it eliminates the need for software-generated timing loops—not to mention word formatting and deformat-
System Component Examples

<table>
<thead>
<tr>
<th>Card Type</th>
<th>Quantity</th>
<th>Components</th>
<th>I/O Lines*</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>1</td>
<td>8080A microprocessor</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>8224 clock generator</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>8228 data bus driver, bidirectional</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>8214 priority interrupt control</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>8216 quad bus driver</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>8212 8-bit 3-state latch</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>8205 1-of-8 binary decoder</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 or 2</td>
<td>8316A 16K-bit masked ROM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 or 4</td>
<td>8708 erasable 8K p/ROM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>8111-1 static memory 256 x 4</td>
<td></td>
</tr>
<tr>
<td>Memory Control</td>
<td>1</td>
<td>8222 refresh control</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>8205 1-of-8 binary decoder</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>various logic ICs (TTL)</td>
<td></td>
</tr>
<tr>
<td>Memory Module</td>
<td>16</td>
<td>2107B dynamic 4K x 1 RAM</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>8212 8-bit 3-state latch</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>8216 quad bus driver</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>8245 quad MOS clock driver</td>
<td></td>
</tr>
<tr>
<td>General-Purpose</td>
<td>2</td>
<td>8255 programmable I/O device</td>
<td>70</td>
</tr>
<tr>
<td>Input/Output</td>
<td>12</td>
<td>8216 quad bus driver</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>8205 1-of-8 binary decoder</td>
<td></td>
</tr>
<tr>
<td>Impact Printer</td>
<td>2</td>
<td>8255 programmable I/O device</td>
<td>60</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>solenoid drivers</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>various logic ICs (TTL)</td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>2</td>
<td>8251 USART</td>
<td>40</td>
</tr>
<tr>
<td>Interface</td>
<td>1</td>
<td>8205 1-of-8 binary decoder</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>various logic ICs (TTL)</td>
<td></td>
</tr>
<tr>
<td>Mass Storage</td>
<td>20 to 30</td>
<td>small and medium ICs</td>
<td>40</td>
</tr>
<tr>
<td>Controller</td>
<td>1</td>
<td>8255 programmable I/O device</td>
<td></td>
</tr>
</tbody>
</table>

*Not including power

Regarding the 9600 baud under software control, I/O flexibility can be improved with the use of reprogrammable I/O circuits such as the MCS-80 8255. A number of I/O lines are provided from each IC package with simple interface to the system central processor unit (CPU) bus. Program control of the I/O configuration is important in a modular/expansible system.

Other Considerations

Another consideration at this time is whether to concentrate on the use of static or dynamic random access memory (RAM). Trade-offs include packaging density, power requirements during active and standby modes, reliability, ease of interface, and cost. Static memory is generally more expensive (cost per bit) than dynamic memory, and also tends to lag behind dynamic memory in packaging density. Interface design of the memory to the processor is generally easier with static memory.

Additional analysis of system requirements and how they fit various microprocessor families, leads to a decision to use a specific type or family of microprocessor. However, before beginning the detailed system design, other decisions must be made to determine the best long-term design approach. These include establishing present and future packaging constraints for the system, determining how many customers will eventually upgrade their systems—especially in preference to buying additional new systems, defining the company's field repair policy to fit multi-board and/or single-board designs, deciding whether various customers' requirements are different enough for modularity to increase sales, or similar enough for single-board design to pay off, and, finally, planning additional controller designs that might use the same CPU board, but different I/O and memory configurations.

For the present example, modularity was considered very important. Requirements for read/write memory vary in 8K-byte increments between different customers. I/O options vary from a minimum of 16 to a maximum of 96 lines. A field repair organization is already established to handle either the single- or multi-board configuration.

The decision to direct the design toward a multi-board modular system is followed by definition of system modules. Trade-offs for packaging are critical, and must be coordinated between the mechanical and electrical design teams, requiring a series of decisions.
Fig. 1 CPU card. CPU clock and buffer requirements are included along with vectored interrupt and program memory. CPU mode control and system sync control as well as data, control, and address buses are available at the edge connector.

Fig. 2 Memory control card. With use of a dynamic read/write memory, refresh cycle control and priority are placed on this card, which also carries timing for read and write cycles for all dynamic memory cards.
First, mechanical engineers tentatively define the envelope available for mounting printed circuit (PC) boards. Electronic engineers then decide on tentative module configurations and the amount of board space they will need. Contributing to this decision are the total list of options, perhaps grouping the options as specific packages, and determining whether the options require similar amounts of board space. An important consideration is allowing for future field installation of options—deciding, for example, whether field installation of options requires wiring as well as adding components, which complicates the installation, or whether it should require only new components in prewired spaces. Options should be set up to minimize the number of PC boards in the system, while keeping the configuration on each board as unspecialized as possible.

Then, with module configurations and board space in mind, mechanical and electrical design engineers agree on definite board size and connector types for the system. Finally, design engineers start designing the board. All engineers must agree on the backplane connections prior to actual board layout.

**Organizing the System**

For the generalized example, the card configurations described in the Table are one approach to the system. Block diagrams of the card designs (Figs. 1 through 6) show the function of each in the system.

Each card has specific features that are important to the design flexibility and modularity. For example, on the CPU card (Fig. 1) all control, data, and address buses are accessible at the connector, allowing...
full use of the CPU in other designs. All memory ICs are mounted in IC sockets, for easy expansion or removal. The optional 256 or 512 words of static read/write memory on the CPU card could replace the main memory and its controls in some system designs. Also, if the CPU card were used as a built-in diagnostic subsystem to test other system cards, static memory could store control and status information.

Memory modularity allows up to eight 8K-byte modules to be used in a system. To minimize total active system power and attain lowest costs, a dynamic memory using 4K RAMs was selected. Centralization of all control and timing for the memory modules is on the memory control card (Fig. 2). The control card provides an interface between processor and memory cards, centralizing refresh priority logic and generating timing for all memory cycles. Control signals and least significant address lines from the control card are on a separate bus, permitting ease of future modification of the memory system. The single control card makes it easier to use the memory cards with a different processor; only the control card interface to the processor needs to be redefined.

All memory cards (Fig. 3) are identical. They use 13 address lines to locate the specific word out of 8K words; the lower 12 of these are divided into two groups of six with the lower six multiplexed with the refresh addresses on the control module. The other line specifies one of the half-arrays of each module. Card selects are decoded on each memory
with the use of small dual inline packaged (DIP) switches and address-compare logic.

The I/O card (Fig. 4), using programmable large-scale integration (LSI) with program- or jumper-selectable drivers, has many different configurations. Output drivers are mounted in sockets. If the system requires buffered I/O ports, type 8216 bidirectional drivers are plugged in as shown in the diagram, and the appropriate input or output buffer drive direction is selected with wire jumpers. If system I/O requires strobed I/O ports or controlled bidirectional ports, the 8216 bidirectional buffers are replaced as necessary by headers that connect the I/O signals directly to the programmable logic. This design approach provides maximum flexibility of the I/O module in any system environment.

The impact printer control module (Fig. 5) puts most of its control in software, reducing hardware requirements and giving more flexibility to use the same interface with different printers.

The communication interface (Fig. 6) has sockets for the two USARTs, thereby allowing easy field expansion of the system. Selection of transmission speed and synchronous or asynchronous mode for each USART is made through system software. One USART is permanently wired to an RS-232 interface; the other can be connected to either an RS-232 or a current-loop interface, selected by jumper.

The system also has room for a mass storage card, undefined until later, which would have access to the common data address and control buses from the CPU.

Fig. 5 Impact printer control card. Printer control is primarily through software. However, solenoid drivers for some functions, and timing and control interface conversion, require logic circuits.
SELECTABLE TIMING CHAIN

ADDRESS AND CONTROL BUS

PORT DECODE LOGIC

DATA BUS

Fig. 6 Communication interface card. Both USART chips are socket-mounted to reduce cost in applications requiring only one interface. One of them can be connected by jumper to either a current loop or RS-232 interface.

and would use programmable I/O logic in LSI and discrete form.

**Buses Are the Key**

After the design has progressed to a block diagram level, the approach to testing the modules and servicing the controller should be determined. Test capability of circuit cards or modules is strongly enhanced by the common data, address, and control buses linking all modules (Fig. 7). Through the buses, any CPU card or controller has access to any other card in the system. Thus, for production testing, cards can be individually checked for performance, using a special test control CPU or automated test equipment. Common bus organization also simplifies field testing and repair of the processor and its modules. Since all internal board communication is carried over these buses, controlling and monitoring the internal functions of the various system modules is easy. This, in turn, provides a simple technique for exercising submodules and detecting component level discrepancies.

Final system tests that put all of the logic together for a performance check are important. However, they should be made only after each individual module has been fully checked, including temperature burn-in and worst-case voltage margin testing, and a mechanical check. Pretested modules assembled as a system greatly reduce the number of failures when power is applied to the total system.

There are two approaches to field maintenance of the system (Fig. 8). One approach includes diagnostics as part of the system program and allows the end user to check his own system. The other uses an external program and test equipment attached to the controller buses, for checking by service personnel. The latter approach allows the field serviceman to reconfigure the system ROM card for a different ad-
address space or even remove the ROMs from the controller and plug in diagnostic programmable ROMs (p/ROMs) to analyze the system.

Physical attachment of the test equipment to the buses can be made at a connection on the CPU card or through a system bus connector. All power and control for the diagnostic tester would come from the controller chassis through this connection.

System analysis can proceed without any address reconfiguration if system software includes a means of sensing the remote test interface. For example, via power-on or a fixed interrupt, the software could check for the presence of a test program at a fixed address. If present, the test program would take control of the system. One advantage of this approach is that the diagnostic can use system subroutines in ROM to exercise various peripheral devices.

The printer and any other external display device could ordinarily be used as a diagnostic tool. Since a system failure could prevent use of these peripherals, one additional diagnostic display is required—for example, display of the diagnostic program address. After detecting a system failure, the diagnostic routine would display its current address on the tester control panel indicators and jump to a specific HALT instruction in the program. The address at which the machine halts would correlate to a specific failure.

**Summary**

Microcomputer design is a complex process that requires concentrated, directed effort on the part of software and hardware design engineers, project management, and marketing personnel. Careful thought and consideration must be given to all aspects of future product utilization. Decisions are made throughout the development program that affect production costs, pack-
aging, customer options, modularity, field maintainability, performance, and future system expansion. With complete and detailed planning, a manufacturer can design hardware obsolescence out of his products. By treating a microcomputer system as though it were a small minicomputer, specifically designed for an entire line of products, equipment manufacturers can take full advantage of today’s microprocessor technology.

**Bibliography**


---

Tom Jones is product manager for the Microcomputer Div of Intel Corp. He received a BSEE degree from the University of Rochester and an MSEE degree from New York University.

Manager of custom systems engineering, Peter Thomas holds a BSEE from Utah State University and an MSCS from the University of Santa Clara. At Intel’s Memory Systems Div his experience includes product development of custom memory boards, memory systems, and custom microprocessor systems.
See things your way

Elite 1500A
- Conversational
- Roll up
- 64 character ASCII
- Modular display (32 x 8 to 80 x 24)

Elite 1520A
- Conversational
- X-Y addressable cursor
- 64/128 character ASCII
- Display 80 x 24

Elite 1520APL/ASCII
- Conversational
- 128 character APL/ASCII
- Bit-paired or typewriter-paired
- Display 80 x 24

Elite 2500A
- Page/line or conversational
- 128 character ASCII
- Dual intensity and blink
- NEW—Protect Line feature significantly reduces form preparation time

with Datamedia Elite Video Terminals

A family of video terminals that offers a wide range of features to perform an even wider range of data entry and display tasks.

If you're with an OEM firm or a system house, and look at peripherals with one eye on cost and the other on performance, you'll want to take a long look at these proven products from Datamedia.

Their modular design makes troubleshooting a breeze and facilitates conformance to your system needs, and their quality workmanship assures that those needs will be met longer than you thought possible.

And if you believe in service after the sale the way Datamedia does, you'll appreciate the new dimension we've given to the word "responsive."

Datamedia. We've been seeing things the right way for users in industry, business services, government, education, medicine and research around the world. Why don't you see what we can do for you.

Datamedia Corporation

7300 N. Crescent Boulevard • Pennsauken, NJ 08110 • TEL: 609-665-2382 • TWX: 710-892-1693
18311 Lost Knife Circle • Gaithersburg, MD 20760 • 301-948-1670
5456 McConnell Avenue • Suite 180 • Los Angeles, CA 90066 • 213-397-3556

NEW!

Elite Video Terminals available in compact, portable versions.

CIRCLE 106 ON INQUIRY CARD
Low Power Computers: A Make or Buy Decision

Jerry Washburn

Computer Automation, Incorporated
Irvine, California

Although microprocessors are justifiably an increasingly popular type of component for use in many systems, many reasons for using a standard low power minicomputer of traditional design are discussed from the viewpoint of a minicomputer manufacturer.

Engineers who work for companies in the OEM market* often must decide whether to build or buy low power computers—sometimes called microcomputers, minicomputers, or minicomputers—for the systems they design. Should they solve the dilemma by building computers with microprocessor chips and other integrated circuits, or should they buy standard low power computers?

Building low power computers always seems attractive; it’s easy now, with over 25 microprocessor chip sets on the market. Semiconductor manufacturers claim that users can satisfy their computer requirements at the lowest possible price by selecting, configuring, and assembling microprocessor chip sets.

In many applications, the do-it-yourself microprocessor chip set or kit approach does indeed provide a workable low power computer for the system. However, when all the factors that affect a rational decision are examined, computers implemented from do-it-yourself microprocessor chip kits often turn out to cost more than mass-produced computers from bona fide minicomputer OEMs. Unless the application calls for a very large number of computers with minimum performance to work with equipment, the requirements of which are unlikely to evolve, microprocessor chips do not usually offer the better way to go. Designing the system to use microprocessors may be more fun for the engineer, but not for the general manager (Fig. 1).

Microprocessor chips generally are suitable for high volume applications requiring small physical size, for which limited performance is adequate. They provide excellent solutions to design problems posed by auto fuel systems, clocks, calculators, cash registers, small test equipment, and many other consumer-related products.

Although the cost of microprocessor chips is attractive, other costs must be considered, too. These expenses include such items as software development, supporting system hardware components (Table 1), testing, sustaining costs, and associated risks. In building a low power computer, what the system designer may not know at the start of the project can hurt him, because the price of the hardware is just the starting point for the total cost.

Before building a computer, the system designer must first determine

*Ed. Note—Mr Washburn’s discussion of an important design decision principally concerns OEMs—an abbreviation that most readers recognize as standing for Original Equipment Manufacturer. The term correctly describes the seller of an item traded in large quantities for incorporation in a customer’s product. It does not describe the buyer of such an item—even though the abbreviation is often used incorrectly in that sense. Thus, Mr Washburn’s employer is an OEM to many of its customers, such as process-control system houses, makers of data acquisition systems, and builders of communication networks. This article has been edited with this definition in mind.—WBR
how much computer power is needed. Once that decision is made, the design team usually must acquire specialists in software, firmware, CPU, memory, and interfacing. Extra personnel for drafting, testing, documentation, maintenance, diagnostics, inspection, and supervision for the computer portion of the system are also required. These requirements invariably get bigger as the product functions and capabilities evolve or change.

**The Processor**

Microprocessor architecture usually limits do-it-yourself computers to a basic repertoire of 50 to 75 primitive instructions. Since microprocessors generally are not I/O-oriented, they provide I/O only through registers. On the other hand, computers from minicomputer manufacturers provide programmed I/O through both registers and memory, plus automatic I/O instructions and a standard direct memory access port.

Microprocessor chip interrupt capabilities are minimal; most minicomputers provide system-oriented interrupt structures. (Interrupts are signals generated by internal and external sources, such as peripherals, to take the processor away from the task it is performing and direct it to handle other systems events.) Minicomputers usually offer a wide variety of interrupts, enables, disables, and a nesting capability for processing several sequential interrupts. This multiplicity of fully implemented, vectored priority interrupts is hardly comparable to the one partially implemented interrupt level that micros typically furnish.

Instruction cycle time is the typical rule-of-thumb measurement of a processor's macroinstruction speed. Microprocessor cycle times are longer and the chips use many cycles to perform useful operations, because semiconductor manufacturers have had to make compromises in chip geometry, number of pins, and cost versus performance. Fewer of these limitations constrain minicomputer makers, who thus can make trade-offs that shorten instruction executing times by factors of two to eight relative to the microprocessor.

Minis often have very powerful macroinstructions that would require implementing with many subroutines in microprocessor chip sets, whereas 4- and 8-bit microprocessors generally perform arithmetic instructions slowly because of limited word size. These microprocessors make up the majority of available types; only a few have 16 bits. Word size also affects instruction power and speed, because shorter words can call up fewer operations than longer words. A substantial proportion of operations by micros therefore requires multiple-word instructions.

Minicomputers not only offer higher processing speed than microprocessor chip sets, but also use memory more efficiently. For example, minicomputers have powerful user-level instructions that get more done in a single instruction cycle than a microcomputer can hope to achieve. In many cases these macroinstructions are possible because the minicomputer's control store has long words with which to specify many steps in a complex sequence—whereas most microcomputers, if they have control stores at all, have control words no longer than the data words. These are two ways to achieve high memory efficiency, which is very advantageous, because memory often costs many times more than the CPU itself.

Occasionally, the potential chip user selects a microprocessor that does not work in his system, because of incomplete evaluation or increased performance requirements. This realization may come too late for him to recoup his development costs. The minicomputer manufacturer minimizes this risk by providing a complete line of mutually compatible processors, arranged in steps of increasing capability or power; few micro makers have this capability.

**Software**

Minicomputer manufacturers offer a complete line of time-tested, high level language software packages that generally include several assemblers, loaders, various subroutines and utilities, editors, and diagnostic programs. They also supply a user's manual and documentation.
Most micro users, on the other hand, are obliged to develop programs in assembly language with the help of a read-only memory assembler card or on a large computer. Their programs can be tested on the microprocessor itself or simulated on larger computers. However, the testing of programs on micros themselves is often difficult because some of them are unable to operate in single steps and do not offer access to internal registers.

Simulating microprocessor software operation on large computers does not necessarily offer the best solution, either. Large, very expensive-to-use computers or timesharing computer networks cannot effectively simulate the input and output required to debug the real-time parts of a microprocessor application program. In many cases, the system designer must develop his own prototyping aids or purchase expensive development equipment. In fact, many designers are beginning to use minicomputers for microprocessor simulation. If a designer has to use another computer to support his macroinstructions, he might as well use that computer to complete the total job.

OEMs offer batch operating systems with real-time operating systems and BASIC and FORTRAN languages, whereas chip manufacturers usually offer nothing comparable. In some cases, modified subsets of high level languages are available for micros, but most of these are limited and inefficient. The comprehensive library of software available from minicomputer houses greatly reduces the time required to develop the programming for a product. At the same time, superior programmability of minicomputers makes software generation faster and easier.

### System Hardware

Semiconductor manufacturers do not offer the potential low end computer user a full line of off-the-shelf system components. Of 25 suppliers of mini, milli, and micro equipment and configurations (Table 2), less than 50% sell their microprocessor assembled on a printed circuit board and only 25% offer supporting system components, such as memory and teleprinter interfaces, to support their chip sets.

Only OEM minicomputer companies market a full line of selectable supporting system components, including chassis, power supplies, panels, core and semiconductor memories, peripherals, and interfaces. Computer Automation, for example, offers off-the-shelf interfaces for numerous specific devices and many types of general purpose interfaces. Just recently, the company introduced a universal distributed I/O system for interfacing peripherals at a price of well under $200 in quantities of 100. That price includes peripheral cables and connectors.

By contrast, the chip manufacturer generally markets only a teleprinter interface. Consequently, the

### TABLE 2

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model #</th>
<th>Chip</th>
<th>Chip Set</th>
<th>PC Card</th>
<th>Partial System</th>
<th>Complete System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Micro Devices</td>
<td>9080</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>American Micro-Systems</td>
<td>9209</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Automation</td>
<td>LSI-3/05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital Equipment Corp</td>
<td>MPS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LSI-11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronic Arrays</td>
<td>MP-12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fairchild Semiconductor</td>
<td>F-8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Automation</td>
<td>Solution 16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Instruments</td>
<td>CP1600</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intel</td>
<td>3000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8008</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8080</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intersil</td>
<td>IM6100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monolithic Memories</td>
<td>6701</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mostek</td>
<td>5065</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motorola</td>
<td>M6800</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National Semiconductor</td>
<td>IMP 8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IMP 16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RCA</td>
<td>COSMAC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rockwell International</td>
<td>PPS-8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signetics</td>
<td>2650</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teledyne Systems</td>
<td>TDY52</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texas Instruments</td>
<td>9900 Series</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western Digital</td>
<td>MPS1600</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
WE’LL READ, TYPE, RECORD, PRINT, PUNCH, SPOOL AND REPRODUCE FOR JUST ABOUT ANYBODY.

We believe everybody has the right to choose the best computer system to fit specific business needs.
That’s why we make the best peripheral equipment for just about any configuration.
And that’s why behind that claim we’ve put over 100 years of experience in precision engineering and gaining electronic capabilities to meet the demands of almost any system.
So, today, we have the equipment for whatever media is best for you.

PRINTERS
We have a whole group of matrix printers to pick from, in various speed ranges and all with superb accuracy and neatness.
For instance, there’s our new 4540 matrix, with a revolutionary printing head, high speed printing, and economical cost.

PAPER TAPE
If paper tape meets your needs, we’ve got high quality readers, spoolers, or punches for your choosing.
Take our Facit 4020 Paper Tape Reader or Facit 4070 Tape Punch, for example. They’re already seen with some of the best computers in the world.

FLEXIBLE DISKS
And, if you’re looking for flexible disk drive, we can work together, too.

Our single floppy disks are expertly designed for easy installation, safe disk handling, and one of the fastest access times around.
Even better, our dual floppy disks give you all the same precision and accuracy, plus twice the data capacity of the single machine for only a fraction more investment.
And the special box-in-a-box construction, with its ability to reduce the problems created by heat and increase reliability, is something you won’t find in any other flexible disk drive.
So, whatever Facit peripheral you choose for your needs, you’ve selected our choice piece. Because they’re all made to work hard, work long, and require a minimum amount of maintenance.
In fact, we honestly feel that no other OEM manufacturer offers a better performance to price ratio. It’s just part of the Facit belief that all our equipment should make work easier and more efficient for everybody.
If you’d like more information about our equal opportunities in peripheral equipment, send us the coupon below. We think you’ll find Facit has the right idea about all your business needs.
user must design, build, test, and manufacture interfaces to mate other I/O equipment to a special I/O chip, and incorporate it into the computer.

Alternatively, the user can invent his own interface to the microprocessor. However, because this approach requires completing the CPU interface definition before the peripheral device interface design is started, attaching gadgets to the microprocessor chip set can take a distressingly long time. With a general-purpose minicomputer interface, on the other hand, hooking up an I/O device often consists of merely wiring up an interconnecting cable.

**Product Development**

Development of a product generally occurs in two phases: assembling and testing a prototype, and manufacturing the finished design. During both of these phases, development costs of kit machines can skyrocket, because of the things that the semiconductor manufacturer can't pack into the kit—such as documentation and testing. The hidden cost of software, documentation, and development far outweighs the savings accrued from the low microprocessor price.

The premanufactured minicomputer frees the designer from tasks that can erode his budget. Such tasks as interfacing a memory to the processor or designing battery-back-up for the memory can be nightmarish. The minicomputer OEM solves these problems for the user by making available a large selection of memories in a variety of types, speeds, and sizes.

**Continuing Costs**

When using microprocessor chips, the designer must also add product continuation costs to the total. These added costs include testing, sustaining, engineering, and the inevitable repair of failed products. Unlike many minicomputer manufacturers, some chip suppliers do not provide warranties on components.

Microprocessor chip testing is difficult and expensive. Since the chip manufacturer must minimize test time to sell his product for a profit, he must avoid exhaustive, time-consuming tests; otherwise no one could afford to use a microprocessor. Cost of exhaustive testing is very high, because a typical microprocessor chip set contains 12,000 to 15,000 active elements. This complexity can allow microprocessors to run perfectly on many possible programs, only to malfunction when run on another program. Therefore, the potential user must be prepared to test microprocessor chips.

**Risks**

Developing a specific product with a microprocessor chip set can be risky business for reasons other than those already noted. For example, the chip or chips selected may be available from only one source, placing the user at the mercy of the supplier and of his good fortune. Although probably few, if any, honest semiconductor makers would deliberately cut off a customer except under dire economic circumstances, all of them are subject to fires, floods, or other catastrophes that could leave a user in a very embarrassing position. Currently only one or two microprocessor chips have multiple sources, but cross-licensing is beginning to appear. Generally, where quantities are involved the best policy is not to gamble, but to stay with a microprocessor chip or chip set that has alternative suppliers. On the other hand, remember that even though two manufacturers offer identically specified parts, their microprocessors may contain idiosyncrasies that can be incompatible in some applications.

Time is one risk that the project manager or system designer must carefully consider. Overrun development schedules can be costly in development charges and potential loss of profit caused by amortizing the extra development expense. Product development with microprocessor chips can take as much as six months to a year longer than it would with standard minicomputer products from an OEM. Manufacturers who use small OEM computers in their systems usually get to market faster than those who use microchips and can beat their competitors, thus increasing their chances for product success (Fig. 2).

Generally, the user does better by buying from a minicomputer OEM, even if cost trade-offs show little or no benefits. A minicomputer that is easy to work with gives the designer a benefit that means much more than money. It gives the system manufacturer peace of mind, because the software tools, CPUs, and system hardware are all reliable, field proven, and readily available. All it takes is smart buying.
The new generation of Diskette Drives is here and under control.

PerSci has it—a family of diskette drives "design-years" ahead of competitive drives—now available in complete low cost subsystems for interface to 8080, 6800 and other major microprocessors.

The Highest Performance Diskette Drives:
PerSci diskette drives, both single and dual head units, offer a combination of performance features unique in the marketplace while still maintaining compatibility in existing systems:

- Voice coil positioning for access speeds seven times faster than competitive drives (76 tracks in 100 ms)
- A low power all DC system reduces cost and assures high reliability
- Automatic electric loading simplifies operation and protects media
- Small size permits 5 single drives or 4 dual drives to be mounted vertically in a 19 in. rack

The Most Powerful Diskette Drive Controller
The PerSci Model 1070 Diskette Drive Controller puts the advanced performance of PerSci drives to work in microprocessor based systems. An IBM format compatible, "intelligent" controller, the Model 1070 will handle from 1-4 drives with minimum demand on the host system.

In fact, with addition of a power supply and keyboard to the PerSci subsystem, the user can perform many floppy disk routines without additional hardware or software. Controller features include:

- Interface to most microprocessors including 8080, 6800 & Z80
- Internal disk operating software including IBM formatting
- RS232 interface option
- Rom options allowing copy data transfer between diskettes and data transfer between RS232 interface and diskette

An Economical Diskette Drive Subsystem
A complete subsystem including a single diskette drive (Model 70), the Model 1070 controller with interface and a controller-to-disk-drive cable is available in single units for $1,195. For double capacity, a dual diskette drive (Model 270) subsystem is available for $1,495. OEM discounts available.

Don't settle for yesterday's diskette drive. Get the new generation under control from PerSci, 4087 Glencoe Avenue, Marina Del Rey, CA 90291 (213) 822-7545.

CIRCLE 125 ON INQUIRY CARD
When Ball Computer Products introduced the BD-50 disk drive earlier this year, we set a new standard of reliability and maintainability for 3330-type disk drives.

But a high-performance disk drive needs a high-performance formatter/controller before it can deliver optimum access speed, data reliability, error correction, and maintenance and configuration flexibility.

**Introducing the 3300 Disk Formatter/Controller.** The 3300 is a comprehensive microprocessor-based interface for disk drives employing 3330/3340 technology. Such as our model BD-50, our forthcoming BD-80, and drives marketed by Ampex, Control Data, Calcomp, and Memorex. With the 3300, minicomputer users obtain functions formerly available only in large mainframe disk systems. Such as IBM error correction codes. Variable record formats. Error recovery (including read strobe offset and track offset). And high speed drive support.

Other 3300 features include multiple drive capability (up to 8), seek overlap operation, multi-record transfers, internal data encoding and decoding, alternate track sparing, and FIFO buffering. Plus additional performance characteristics to facilitate maintenance and configuration flexibility.

Many optional features are available. Including dual port con-
better disk drive. \textit{ter/controller to match.}

configuration. (The 3300 automatically resolves disk contention and file reservation from multiple CPUs.) And a multiple-drive power sequence module.

Best of all, Ball's new 3300 can be combined with our 50 megabyte BD-50 disk drive to provide you with a one-vendor disk subsystem for minicomputers that matches large mainframe performance. At a price that's surprisingly low.

Fill out the coupon, or circle the reader service number below. And find out more about the better disk subsystem. From Ball Computer Products.

---

Ball Computer Products
860 East Arques Avenue
Sunnyvale, California 94086

Tell me about the better disk subsystem. I use the following drives:

- Ball
- Ampex
- CDC
- Calcomp
- Memorex
- Other

I need a complete disk subsystem for the \underline{ } minicomputer.

Name

Company/Title

Address

City/State/Zip

Regional Offices
Los Angeles, (213) 822-1419
New York, (201) 224-2332
Minneapolis, (612) 854-1211
Atlanta, (404) 289-0101
Dallas, (214) 241-1861
Tampa, (813) 381-2177
San Francisco, (415) 733-6700
There is only one reason to buy the Wangco/Orbis Floppy Disk Drive

1. IBM-type ceramic heads with low pad force give 15,000 hours head life and extended media life.

Double density electronics and head design permit expanded data capacity to 6.4M bits as well as single density encoding in the same drive. A variety of sector options include IBM and expanded soft sectoring, 32 hole hard sectoring and sector generation.

There are many more No. 1 reasons to buy the Wangco/Orbis Model 76 Floppy Disk Drive—like low 45 watt power consumption, self-centering clutch and wide mouth door with open and close interlock for gentle media handling, and choice of optical or mechanical write protect circuitry.

Write for full information to: Wangco, Inc., 5404 Jandy Place, Los Angeles, CA 90066.
(213) 390-8081

WANGCO

CIRCLE 101 ON INQUIRY CARD

1. High reliability design makes possible 5000 hour MTBF with no recommended maintenance. Die cast mainframe and carrier maintain precise tolerances.

1. Fast access positioner and electronics facilitate 6 ms track to track seek with 164 ms average seek. Low friction uniball positioning assures data reliability of $1 \times 10^{-10}$. 
36" PLOTTER WITH COST-PERFORMANCE PLUS

THE NEW SERIES OF

DP-8 DIGITAL PLOTTERS

PICK THE ONE YOU NEED TODAY

• Three low-cost, high-performance models
• Nine switch-selectable step sizes
• One or three pens
• 3 or 4.5 ips
• Quiet operation
• Positive paper feed
• Can be driven by existing interfaces
• Priced from $7600
• Options:
  12" paper handling drum — $900
  36" paper take-up spool — $300
  Plexiglass cover — $450
  Paper tear-off bar — $125
  Plot timer clock — (contact factory for price)

USE IT ONLINE, OFFLINE
OR WITH OUR NEW 734
BATCH TERMINAL CONTROLLER

houston
instruments

THE
RECORDE
COMPAN

DIVISION OF BAUSCH & LOMO

ONE HOUSTON SQUARE (at 8500 Cameron Road) AUSTIN, TEXAS 78753
(512) 837–2820
TWX 910–874–2022
cable HOINCO
Pachterbaan 6 1240 Gistel Belgium
Phone 059/277445 Tele: Bausch 19399

CIRCLE 51 ON INQUIRY CARD
Now you can offer your customers a "receive only" Thermal Printer that contains its own power source. No extra box. No extra cable. Just one handsome cabinet.

With the new EM-T33 (parallel) or the EM-T44 (serial) unit from NCR you can provide distinct advantages over other terminals.

Quiet . . . almost completely electronic; the only sound comes from the movement of paper and a non-impact printing head.

Fast . . . Up to 30 characters per second is the printing speed — 2 to 3 times faster than terminals with conventional impact printers.

Accurate . . . Hard copies of every message means no slips of memory; no mistakes in transcribing which are possible with some units.

Compact . . . One single, light, easy-to-carry unit contains both the thermal printer and the power source in a single attractive cabinet.

Here's a way for you to increase the benefits you offer in the communications system you sell . . . and increase your sales and profits by doing so.

For more information on this and other components for your communication systems, please contact us today.

NCR
Terminal Systems Division — Ithaca
Director of Marketing
P. O. Box 490, Ithaca, N. Y. 14850 607-273-5310

CIRCLE 91 ON INQUIRY CARD
**problem:** Find the 267th bit  
**solution:** Programmed digital delay

Finding the 267th bit takes quite a while, and then you're not sure you have the right one. The solution is programmed digital delay. On the Philips PM3261 you can program the delayed timebase to start on the nth bit. By means of an internal variable-speed clock, the events counter can be preset from 1 to 99,999 events, with complete trigger level setting control.

Another addition to the Philips family of HF portable oscilloscopes, the 120 MHz PM3261 adds easily programmable digital delay to the already completely separate delayed timebase control section found on its predecessors.

Special TTL triggering selection allows the PM3261 to react just as logic does - a TTL level window prevents false triggering on rising or falling edges.

For further information, contact Philips Test & Measuring Instruments, Inc.

Utilize our toll-free HOT LINE number 800 645-3043  
New York State residents call (516) 921-8880 collect

For information, circle 52 on Inquiry Card.  
For a demonstration, circle 53 on Inquiry Card.
DOCUMATION'S DOC 5120 DISPLAYS A FULL 6144 CHARACTER PAGE AT FIVE TIMES THE BRIGHTNESS AND RESOLUTION OF ORDINARY CRT'S.

Documation just introduced the ideal display system for your word-processing and text-editing customers—a CRT that's big enough to display an entire 8½ by 11 inch typewritten page at actual size (80 or 96 characters per line by 64 lines) at one time, and with sufficient brightness and resolution to make every part of that page highly readable.

The DOC 5120 Display System displays characters and symbols using cursive stroke character generation techniques and offers about five times more resolution and brightness than a typical dot-matrix CRT. The page refresh rate of 60 times per second eliminates annoying flicker.

Available with Refresh Memory and Memory Controller option, a 16-bit, two-way I/O interface allows asynchronous execution of a powerful, yet simple, instruction set. Other options include: Keyboard Interface and Control; Proportional Character Spacing; additional displayable symbols.

Like all Documation equipment, the DOC 5120 Display System exhibits Documation's state-of-the-art technology and unique quality control. The entire system is constructed in-house from high-quality, computer-grade components and does not employ the entertainment-grade TV-type components typical of other CRT display systems. The 5120 also features plug-in modularity for ease of maintenance and expandability.

For more information or to place your order for Documation's new, better and brighter display system, contact Roy Ostrander, Box 1240, Melbourne, Florida 32901. Phone (305) 724-1111. It could be the brightest CRT decision you'll ever make.
If you recognize optimum price/performance value when you see it, you should see our new SLASH 6. It outperforms most 32-bit minis, at a price that’s better than many 16-bit minis.

The Harris Slash 6 costs only $14,500*. You get 600 nanosecond cycle time; 48KB of MOS memory with error correction; hardware multiply, divide, and square root; 8 priority interrupts; and a turnkey control panel.

You get building-block architecture that lets you expand your systems as your needs expand. And sophisticated real-time software that no other machines offer in this price/performance range.


*Volume discounts available.
The Changing World of Advanced LSI

Technological growth has rarely been as dramatic as in the development of semiconductors, and particularly of integrated circuits. Even the introduction and acceptance of the transistor itself seem minor compared to the impact of small-, medium-, and now large-scale integration.

Since the early 1960s, developments in semiconductor design and manufacturing technology have resulted in a doubling of the number of components per chip every year as well as spectacular increases in speed, concurrent with increasing chip densities and reduced power requirements. Per-chip prices, however, have remained relatively uniform, resulting in the equivalent reduction of per-component, or per-bit, prices by a factor of two per year.

This dramatic technological growth is particularly significant to the designers of digital equipment. In the present and near future it means major equipment simplification as well as increased sophistication. Possibly even more important, it means substantially lower per-function costs. Products that were previously technically impractical or commercially unsound are now being introduced or are rumored. Even if the past trend of rapid development were to slow, the technological impact will remain. For instance, one forecast calls for the mid-1980s debut of a desk-size computer, equivalent in power to a mid-range System/370, with 1M byte of semiconductor memory—priced at $2500 to $5000.

As spectacular as this may seem, the effects over the somewhat longer term may be even more important. In addition to expected miniaturization, digital equipment will come to depend less and less on electro-mechanical mass storage. Disc and tape storage, although not fully replaced, will be secondary to such devices as high density read-only memory, charge-coupled devices, and bubble memory.

Miniaturization and cost advantages of electronic portions of a system may in some cases be offset by the bulk and expense of mechanical and electro-mechanical components. For instance, evolution of the computer has been characterized by a tendency to maintain size and cost balance among the system’s three elements: processor, memory, and power supply—technological effort necessarily focused on the element that lagged the others and therefore “didn’t fit.” Therefore, recent major cost and size reductions in central processing unit and memory which brought about the microcomputer caused emphasis to be placed on the power supply. Solutions, in such forms as switching regulated supplies, have been provided—as in the past—by new developments in semiconductors. Similarly, other advances brought about by advanced semiconductor technology and use of large-scale integration should bring at least some of the input/output devices into line with the rest of the computer system.

Impact of large-scale integration has been evidenced in such areas as information sensing, where “real-world” data enter the digital system through analog-to-digital converters, which are now available as inexpensive yet fast monolithic integrated circuits. As the next step in the integration process, these converters and associated devices are being designed directly into the processor chips, substantially reducing the complexity and cost of the interface.

Impact of Large-Scale Integration

To a large degree, the continuing interest in further development of large-scale integration (LSI) techniques is a direct consequence of successes thus far. Clearly, the microprocessor with its wide potential in

Recent and Near Future Developments in LSI Devices

Programmable digital frequency synthesizer using IIL and Schottky technology to replace discrete component telecommunications equipment
Ion implantation bipolar chip containing most of the components of an integrated switching regulator
Bipolar microprogram sequencer with highly versatile control features
A-D converter combining digital and linear CMOS, minimizing external circuitry, interfacing directly with TTL or CMOS logic, and especially suited for microprocessor controlled bus-oriented systems
4-decade IIL LSI programmable counter using one-third the power of a competitive CMOS counter and operating at more than 60% higher frequency
Interrupt controller with eight levels of requests, and expandable to configurations of up to 64 levels
8-bit I/O port
1-of-8 decoder
Priority interrupt control unit
4-bit bidirectional bus driver
Programmable interval timer
DMA controller
General-purpose software programmable I/O chip
General-purpose keyboard/display, floppy disc controllers
Solid-state crossbar switch
Digital dialer chips for telephone application
LSI multiply/divide unit
Synchronous data link controller
Programmable communications interface
Programmable I/O port
present and new applications cannot be fully exploited if large numbers of additional integrated circuits (ICs) are required, for example in system interfaces. Thus, the trend is toward increasing microprocessor sophistication, adding to the central processor unit (CPU) chip many functions which in earlier units had been relegated to external ICs.

The substantial increase in the variety of LSI devices used with microprocessors has enhanced the system simplification made possible by the microprocessor itself. Markets for microprocessors have provided the economic motivation for the development of many of these chips; high volume applications that were not feasible prior to the advent of microprocessors are stimulating LSI developments which would have been uneconomical only a year or two ago.

Microprocessors as generally available components are only about two or three years old, and much of their supporting LSI has been developed even more recently. However, a survey conducted early in 1976 showed that LSI devices-in addition to expected read-only memory (ROM), random-access memory (RAM), and programmable ROM (p/ROM)—were already in extensive use. In addition, a number of LSI devices have since become available or are soon to be introduced (see "Recent and Near Future Developments in LSI Devices").

Developments in LSI Technology

Inventiveness of semiconductor design and manufacturing engineers has continually extended technological performance beyond that predicted by even the most knowledgeable forecasters—basically because no allowance can be made for "breakthroughs." As an example, after two to three years of evaluation, bipolar integrated injection logic (IIL) is emerging as a serious and exciting entry in the LSI race. It is presently regarded as a competitor of complementary metal-oxide semiconductor (CMOS) but not to MOS in general. Although many of IIL's performance advantages have been diluted by continuing spectacular improvements in the speed and power consumption of CMOS, the special ability of IIL to combine low cost digital and linear functions on the same chip is a major asset in meeting increasingly complex LSI interface requirements. Among the linear functions that have been combined in this way are operational amplifiers, sample-and-hold circuits, and A-D and D-A converters.

Other IIL advantages are exceptionally low power dissipation for its propagation delay, compatibility with other bipolar devices, and suitability over the wide temperature ranges of military applications.

Currently, IC manufacturers are developing families of IIL digital products, including high speed 4K-bit memories and microprocessors for use where high performance is desired, even at a modest cost premium. A large variety of specialized IIL devices is expected to become available during the next year, and a fast 64K-bit memory may eventually be developed.

There is also encouraging progress in other exciting technologies. For example, the V-MOS fabrication technique, recently applied in high power junction transistors, offers the possibility of a low nanosecond cycle time memory. Both V-MOS and (double diffused) D-MOS with their high density potential have important implications for the future, such as in 64K-bit memories. Recent developments increase densities by factors of two to four, as well as provide performance advantages, by using 2-level memory structures.

Low Cost Applications

While advanced LSI devices have extended the achievable levels of complexity and sophistication as well as the performance of practical digital systems, parallel developments have occurred in simpler application areas. Manufacturers are now developing and offering basic microprocessor devices in which computer power is traded off against low cost and ease of application. Such devices are ideal for the many uses where quantities are large and unit cost savings are therefore important, and where most microprocessor offerings have substantial excess capability.

Interfacing and control represent typical generic areas for such bottom-of-the-line devices. A typical device might be a single chip standalone controller including CPU, p/ROM, RAM, and I/O, thus greatly reducing the need for additional ICs, simplifying interconnection, increasing reliability, and lowering cost. Combining analog with digital electronics on the chip will further extend this trend.

Future developments may permit use of smaller chips for these less sophisticated applications, improving production yields, and further lowering costs. Plastic packages will accelerate cost reduction, expanding LSI usage to extremely high volume and relatively unsophisticated and highly competitive consumer applications.

Where production requirements exceed many tens of thousands, and delays and expenses of development and tooling can be justified, special LSI devices can optimize chip characteristics for the application. Standard chips are now available incorporating basic semiconductor components, with specific interconnects added to order. Mask programmable "universal" chips are often a fast and satisfactory route to an optimum design. Some manufacturers are increasing the use of computer-aided design to reduce the cost and delivery time of special LSI ICs.

Conclusions

That IC devices have been accepted is indisputable. WEMA recently released figures which showed that U.S.-based semiconductor manufacturers shipped $156 million worth of IC devices worldwide during July 1976. U.S.-industry IC shipments for the first seven months of the year totaled more than $1 billion.

Continuing advances in LSI technology and chip design are so spectacular that the revolution in digital system design brought about by the microprocessor may be said to be barely under way. "Keeping up" must necessarily be a major continuing effort of the digital equipment designer.

*As part of a survey on the impact of microprocessors, conducted jointly by Computer Design Publishing Corp and International Data Corp, respondents were asked what LSI devices they were using other than microprocessors and semiconductor memories. The largest single category mentioned was universal asynchronous receiver/transmitters (21%). Other predominant interfaces included programmable interface adapters, I/O chips and ports, A-D and D-A converters, multiplexers, and encoder/decoders. Memories other than RAMs, ROMs, and p/ROMs included FIFO/LIFO, programmable and field programmable logic arrays, character generators, and shift registers.
Bipolar LSI Circuit Eases System Interrupt Control

Prioritized control on interrupt inputs to a microprocessor system can be attained by the priority interrupt controller (PIC), a bipolar LSI circuit optimized for the M6800 microprocessor system. Basically, the MC8507/MC6828, from Motorola Semiconductor Products Inc, PO Box 20294, Phoenix, AZ 85036, eliminates the software interrupt polling routine in systems containing multiples of eight I/O devices. Functionally, it can change the interrupt vector, reserved in memory for hardware interrupts, into one-of-eight alternate vectors assigned to the I/O service routines.

The PIC modifies low order bytes of the reserved interrupt address. Second, third, fourth, and fifth least significant bits (LSBs) of the system address bus are used as inputs; a bit pattern of 1100 (fifth through second LSBs, respectively) will be put on the address bus. This allows the PIC to begin substituting the alternate vector, assigned to that PIC interrupt input, for the original vector.

Inhibited interrupts to the PIC will generate IRQs when the mask is reprogrammed to an inhibit level that is lower than the priority level of the unserviced interrupt.

An output from the PIC, called the STRETCH signal, is available to lengthen a system clock cycle (Δt2 in an M6800 system) when accessing slow memories. When unused, the PIC is transparent on the address bus and will not affect the reserved interrupt vector.

PIC is currently offered from stock in a plastic 24-pin DIP at $7.50 in quantities of 100 to 999. A ceramic version will be offered in the near future.

Circle 351 on Inquiry Card

3-Digit CMOS DVM IC Competes Economically With Analog Panel Meters

Self-contained construction of the LD130, claimed to be the first 3-digit monolithic digital voltmeter integrated circuit, reduces the cost of building meters into products to approximately $15 to $20, making the device economically competitive with analog meters. Whereas, in the past, complex circuitry and precision components had to be added to such DVM ICs to attain accuracies of 1 to 3%, a built-in temperature drift correction function in this IC maintains a typical accuracy of ±0.1% ±1 count.

The single-chip CMOS device operates as a self-contained analog-to-BCD converter, with its digit-strobed BCD outputs directly driving standard CMOS display decoder/driver units. It avoids the usual maximum 200 count limitation of 2½-digit monolithic DVMs by using the same three elements for a maximum count of 999. An autopolarity function increases the range to ±999 and automatically switches the ± sign. Auto-

CMOS Circuits Offer Improved Design and Utility

Additions to its Isoplanar family of CMOS circuits have been announced by Fairchild Camera and Instrument Corp’s Digital Products Div, 464 Ellis St, Mountain View, CA 94042. One, the 4528 dual retriggerable, resettable monostable multivibrator, offers a typical device-to-device output pulse width variation of ±3% at VDD = 15 V; and ±1% typical output pulse width variation over the commercial temperature range with VDD = 15 V. Propagation delays are independent of the timing capacitor, and the device will not retrigger while the timing capacitor is discharging in response to an initial trigger input.

A second device, the 4511, is a BCD-to-7-segment latch/decoder/driver which is claimed to offer significant improvement in ac performance for additional multiplexing flexibility, and improved output drive capabilities for added application utility. Both devices meet or exceed all limits of the industry standard "B" series CMOS specifications, and are available from stock in plastic or ceramic packages in both military and commercial temperature ranges.

Other added devices, which also meet or exceed the "B" series specifications, are the 4066 18-stage shift register, 4041 quad true/complement buffer, 4043 quad nor R/S 3-state latch, 4044 quad NAND R/S 3-state latch, 4510 BCD up/down counter, and 4516 binary up/down counter.

Circle 351 on Inquiry Card
The REMEX RFD 1000 – Because It’s Versatile. Double or single density with capacity up to 6.4 Mbits ... IBM standard or 32 hole hard sectored media without drive modification ... IBM compatible or expanded hard and soft sectored formats for application flexibility ... Unit select daisy chain capability for maximum controller efficiency ... Selectable DC negative voltage for system compatibility ... Individual drive housing or two drives horizontally side by side in a 19 inch rack configuration.

The REMEX RFD 1000 – Because It’s Reliable. Ceramic head for extended life ... Precision machined, die-cast construction ... Operator interlock and expandable clutch for media protection ... Front panel “head in contact” indicator and optional “head in contact” door lock ... Optical write protect to assure data security ... Stylus ball lead screw positioning system for long-lived accuracy ... Optical track 00 sensing for drive carriage protection.

The Remex RFD 1000 is the RIGHT peripheral from Remex.

This Is The Only Flexible Disk Drive You Will Ever Need

Ex-Cell-O Corporation
1733 E. Alton Street, P.O. Box C19533, Irvine, California 92713

CIRCLE 55 ON INQUIRY CARD
range functions provide six decades of operation and the control can be used to switch range-scaling components and display decimal point.

Power dissipation is 26 mW typ. Since separate active analog requirements are not needed, a single or split 10-V power supply can be used; eg, a ±5-V supply is adequate for battery powered instruments. Type of voltage reference is optional: a standard zener diode fixed reference or a low power current source driving a potentiometer.

Fabrication is in an 18-pin DIP. Pricing in quantities of 100 to 999 is $8.75 each from Siliconix, 2201 Laurelwood Rd, Santa Clara, CA 95054. Delivery is from stock. Circle 352 on Inquiry Card

Analog MUX Have Input Overvoltage Protection

Single-ended 8-channel and 4-channel differential I/O CMOS analog multiplexers, respectively, the MPC88 and MPC4D feature self-contained binary channel address decoding and are compatible with DTL, TTL, or CMOS input levels. Transfer accuracies of better than 0.01% can be achieved at sampling rates up to 200 kHz from signal sources of up to ±10-V amplitude. The user can individually enable an 8- or 4-channel group to ease channel expansion in either single-mode or multi-tiered matrix configurations.

Digital and analog inputs are failure protected by channel interaction during overvoltage conditions as well as in the event of power loss. Operating power dissipation at 100 kHz is 15 mW (7.5 mW standby).

Both units are accuracy-compatible with 12-bit systems and have typical access times of 500 ns. Break-before-make switching protects input sources. Off-channel isolation is typically 65 dB. Supply range is ±5 to ±20 V; I/O range is equal to supply voltage.

They are specified for operation over the 0 to 75°C range and are housed in 16-pin DIPs (pin- and package-compatible with the 508/509 series). Available from stock from Burr-Brown, PO Box 11400, Tucson, AZ 85734, the devices are priced at $14.00 for 1 to 24, $12.20 for 25 to 99, and $10.00 for 100 or more. Circle 353 on Inquiry Card

Mil-Range FPLAs Offer Improved I/O Abilities

Full military temperature range versions of field programmable logic arrays (FPLAs), from Signetics, 811 E Arques Ave, Sunnyvale, CA 94086, are claimed to offer the best performance now available over the −55 to 125°C range. Key specifications include 600-mW typical power dissipation and 90-ns maximum access time. S82S101 has a 3-state output and S82S101 is an open collector version.

The Schottky-TTL arrays, based on niche fuse technology, are collections of AND and OR logic gates whose internal and external input connections can be arbitrarily programmed by the user. They feature a single 5-V supply operation, and differ in organization from any other FPLAs now on the market.

They are organized with 16 inputs and eight outputs, whereas other devices typically have 14 inputs. This I/O configuration allows direct manipulations of two data bytes and provides the capability to scan an address field 65,536 words deep.

Although the organization also includes 48 product terms, the number used or shared among the outputs does not affect speed or power dissipation. By contrast, competitive FPLAs typically dissipate 4 mW more power for each product term used. In addition, a chip-enable input eases the expansion of inputs and product terms and permits application of the 3-state device to bus-organized systems.

Both devices are available from stock as full military temperature and MIL-STD-883B processed units in 28-pin ceramic DIPs. In quantities of 100 up, prices are $48 for the S82S101 and $54.25 for the S82S101. Circle 354 on Inquiry Card

Linear ICs Meet Interface Requirements

Five interface circuits—four dual memory drivers (55/75326 and 55/75327) and a dual line driver (75150)—have been announced by the Linear Integrated Circuits Div of Fairchild Camera and Instrument Corp, 484 Ellis St, Mountain View, CA 94042. Several packaging or temperature-range versions of each are available.

All of the dual memory devices can sink up to 600 mA. 55/75326 versions operate from single 5-V supplies. Output-transistor base current can be increased by connecting an external resistor. Each output collector is protected from voltage surges during inductive switching by

64-Bit Multiplier IC Meets Requirements of High Speed Processing

Complete 8- by 8-bit parallel multiplication can typically be performed in 130 ns by the MPY-8, a monolithic LSI circuit developed by the Electronic Systems Div of TRW Inc, 1 Space Park, Redondo Beach, CA 90278. The monolithic multiplier cir-
Your 1K ECL RAM struggle is over.

$15.60
MCM10146L
MECL RAM

Now Fairchild’s begins.

It’s no effort to get 1K ECL RAMs anymore.

Now that you can get them from a production house that thinks like a production house, Motorola.

Many of you waited for us to introduce this part so you could have ensured deliverability and producibility. Well, you’ve got ‘em.

Together with an unbelievably low price... neck-and-neck even with pricing for F-troop’s fastest T²L RAM. Look it up. That’s gonna surprise a lot of people. Including the former first source.

Our producibility is so good we can sell it for less. And we knew once you saw our unit you’d choose it over theirs. For obvious reasons.

It’s what you’ve been battling for all along.

Send for complete data from Motorola Semiconductor Products, Inc., Box 20912, Phoenix, AZ 85036. Or check with your in-plant data center or your authorized distributor.

Maybe we took longer. But we fought to make it available and cheaper, and that’s what counts in the real world.

Doesn’t it Fairchild?

MOTOROLA Semiconductors — still the production house

CIRCLE 99 ON INQUIRY CARD
a clamp diode in parallel with an internal pull-up resistor.

55/75327 memory switches can function as either sink or source drivers at up to 600 mA, and operate from two supplies: one 5 V and the other 4.5 to 24 V. An internal base-drive resistor on the chip can be used by connecting two pins externally.

Devices are available in either ceramic DIP or military flatpack for

Bipolar RAMs Meet High Speed/Low Power Scratchpad Requirements

Low power 64-bit bipolar memories with full military capabilities, the DM-74LS289 and DM74LS189 random-access memories, with open collector and Tri-State\textsuperscript{a} outputs, respectively, are replacements for the older DM5489D and DM7599D. Although they require only 25-mA max input power, they maintain the 35-ns speed of the older devices. Available from National Semiconductor, 2900 Semiconductor Dr, Santa Clara, CA 95051, these devices can be applied to scratchpad applications which require the high speed of TTL plus the low power of Schottky technology.

Both RAMs are fully decoded and feature a chip-enable input to simplify the decoding needed to achieve the desired system organization. They are available from stock, priced at $3.73 each (in lots of 100) for commercial parts, and $8.00 each for the military temperature range.

Custom MSI Circuits Ease Design Problems For Low Volume Needs

Two-week delivery (after receipt of customer's masks) is promised for low volume supplies of custom medium scale integrated CMOS circuits by Mosfet*Micro*Labs of Penn Centre Plaza, Quakertown, PA 18951. Using company supplied layout rules and test circuits, the customer designs standard elements on one chip such that the metal pattern can be interconnected in different circuit configurations by changing only the metal mask. The company then fabricates CMOS wafers to meet test transistor requirements from the mask sets. Circuit testing is performed by matching electrical results of probed chips with breadboarded ICs.

An oxide/nitride gate dielectric is claimed to provide much improved stability. Allowing a maximum change in flat band voltage of 0.5 V at conditions of 250°C at ±30 V (cooled to room temperature) the devices nominally change less than one-tenth this value. A planar oxide process virtually eliminates metal discontinuity over stepped oxides.

After field testing of the custom part, the layout can be improved to optimize yield if high volume needs develop.

Circle 356 on Inquiry Card
Our commitment to the tape drive market can be summed up this way:

We make four basic tape drives. One of them is just the one you want.

Because the options we’ve engineered for our basic four effectively give you a choice of over 400 configurations.

Speeds from 12.5 to 125 ips. Tension arm or vacuum column. A variety of electronics options. And more.

Yet with all the differences from drive to drive, there are a number of things the same in every drive.

Simple one-hand loading, dynamic braking, linear sensors and servos, and other engineering advantages.

A near 80% parts commonality. Which makes your spares stocking, training, and servicing a lot easier. An industry-unsurpassed commitment to quality—given meaning by our industry-unsurpassed 13 month warranty. And backed by 24 hour a day, 7 days a week field service.

AMCOMP Tape Drives.
Giving you exactly what you want rather than selling you just what we have.

To find out more about the tape drives, or other products and services we have, please contact your nearest AMCOMP office, or AMCOMP, INC., 686 West Maude Avenue, Sunnyvale, CA 94086, phone (408) 732-7330.

AMCOMP. Our strength is our commitment. And our commitment is strong.
This month's column is the first of several that will focus upon the concept of an interrupt. When used in the context of a computer, an interrupt can be defined as the suspension of normal program execution in order to handle a sudden request for service, i.e., assistance, by the computer. At the completion of interrupt service, the computer resumes the program from the point where it was interrupted. This specific use of interrupt is consistent with the general meaning of the term: to stop a process in such a way that it can be resumed.

A given computer typically will communicate with a variety of external I/O "devices." If it is a minicomputer, it may communicate with a teletypewriter or alphanumeric keyboard, CRT display, printer, floppy disc, and perhaps one or more laboratory instruments. If it is a microcomputer, it may communicate with smaller devices—motors, solid-state relays, pushbutton switches, display lights—within a larger machine or instrument. When used as a replacement for discrete logic devices in a complex digital circuit, a microcomputer may communicate with other TTL integrated circuit (IC) chips such as latches, flip-flops, and 3-state buffers.

When communicating with external I/O devices, microcomputers can operate in two general modes, polled and interrupt. Polling is the periodic interrogation of each I/O device that shares a communications link to a microcomputer to determine whether it requires servicing. A microcomputer sends a poll that has the effect of asking the selected device, "Do you have anything to transmit?" "Are you ready to receive data?" and similar questions. When a microcomputer services a polled device, it simply exchanges digital information with the device in a manner that is prescribed by software in a subprogram or subroutine called a software driver.

In polled operation, the microcomputer sequences through the devices tied to the microcomputer looking for individual devices that need servicing. When it finds a device that requires service, it stops sequencing, calls a software driver, and services the device. Once it is finished, the microcomputer continues checking the devices. Polled operation is most useful with relatively slow devices that do not require frequent service, do not need attention from the microcomputer for excessive periods of time, and can wait to be serviced. Advantage is taken of the difference in operating speeds between the microcomputer and the I/O device. Most common I/O devices are much slower than microcomputers. For example, in 100 ms (teletypewriter response
time) an 8080A-based microcomputer can execute approximately 20,000 instructions when operated at a clock rate of 2 MHz. Although a microcomputer may appear to be doing several things simultaneously, this is only an illusion since it can manipulate data much faster than most I/O devices can respond to changes in data. A single computer can perform only one task at a time.

In interrupt operation, the microcomputer juggles the demands of the external I/O devices. There is a distinction between slow devices that require frequent servicing and high speed devices that demand almost constant attention from the microcomputer. The most appropriate description for interrupt operated systems is that they are asynchronous, i.e., they lack a common synchronizing signal and therefore give rise to generally unexpected or unpredictable program execution within the microcomputer. In an asynchronous device the speed of operation is not related to any frequency in the system to which it is connected. Use of asynchronous devices is the rule rather than the exception.

Priority can exist in interrupt operation; all I/O devices can be ordered in importance so that some devices take precedence over others. In contrast, there is usually no priority in polled operation; once a device is serviced, it waits its turn until all others are sequenced and, if necessary, also serviced. Time between the interrupt request by a device and the first instruction byte of the software that services it is known as the interrupt response time. For a high speed device that has high priority, the response time can be very short, less than a millisecond. For a low speed device that has low priority, the response time is variable, since it depends upon the demands placed upon the microcomputer by all higher priority devices.

Three commonly used microcomputer interrupt techniques are the single-line interrupt, multilevel interrupt, and vectored interrupt (see Figure). In the single-line interrupt technique, multiple devices must be connected to a single interrupt line to the microcomputer. Once an interrupt signal is received, all interrupt devices are polled to determine which one caused the interrupt. Software priorities may be assigned to the various interrupting devices, so that the first device polled that needs service is the one that receives the attention of the microcomputer. A common term used for the part of a program that polls interrupt devices is flag checking routine. (The concept of a flag will be discussed in a future column.) At the moment, consider a flag to be a single-bit memory that indicates when an operation has been completed or when a condition has been attained.

In the multilevel interrupt technique, there exist several interrupt lines to the microcomputer, each line being tied to a separate I/O device flag. The microcomputer need not poll the devices to determine which one caused the interrupt. This is done internally within the microprocessor chip. Depending upon the nature of the microprocessor chip, this can be a very fast interrupt technique, but it is somewhat difficult to expand. A vectored interrupt causes a direct branch by the microcomputer to the part of the program that services the interrupt. This interrupt technique requires external IC service chips to supply the memory address of the interrupt service routine as well as to set the priority. With the 8080A microprocessor chip, eight different service routine addresses can be readily specified, although one of these addresses coincides with the reset address for the microprocessor, location zero. The Intel 8259 programmable interrupt controller, which became available commercially in July 1976, should be considered by those who are interested in vectored interrupts.

Use of interrupts should be considered very carefully. More complicated software is invariably required. For example, the status of the microprocessor chip generally has to be saved at the time that the interrupt occurs. This means that contents of the accumulator, flags, and registers must be placed in a specified region of memory from which they can be retrieved at a later time, after the interrupting device has been serviced. Pay attention to priorities: devices that require high priority and need immediate servicing should be given the highest priority; other devices, such as teletypewriters, should be low priority. Also, if too much is attempted with an interrupt system, the microcomputer may become "interrupt bound," which means that it is working only on interrupt tasks and not on the main task. It should be working on the main task and only infrequently servicing interrupt requests.

Finally, we would like to provide an example of an interrupt system. Assume that the microcomputer is performing mathematical computations on 7-bit ASCII numbers that are entered via a UART chip connected to a teletypewriter operated at 110 baud, or 10 ASCII numbers per second. Data exchange between the microcomputer and the UART can be performed in 20 to 30 µs, which leaves 99.97 ms for the microcomputer to do other things. With the Intel floating point package, for example, each floating point multiplication or division can be performed in 2 to 5 ms with an 8080A-based microcomputer operating at 2 MHz. Sixteen-bit binary multiplications and divisions can be performed even faster. Therefore, it is appropriate to consider that the main task of the microcomputer is to perform such computations, and that it can devote 0.05 to 0.10% of the time to servicing the interrupting teletypewriter. Less attractive alternatives are for the microcomputer either to poll the UART or to wait for a change of state of the UART data ready or transmitter buffer empty flags.

Interrupts also are effective for use with devices that provide data to a microcomputer but which have no buffer of their own to store it. Existing data must be removed from the device and stored in the microcomputer quickly before a new data word can be generated by the device. One example of such a device is an analog-to-digital converter in which conversions are locked by an external clock at repetitive time intervals.

References
1. Microprocessor Buzz Words, Schweber Electronics Marketing Services, Westbury, NY
4. D. G. Larsen and P. R. Rony, "Computer interfacing: The universal asynchronous receiver/transmitter (UART)," American Laboratory, Feb 1975, p 113

This article is based, with permission, on a column appearing in American Laboratory magazine.
Single Board Computer Features Full Multiprocessor Capability

SBC 80/20 is a second generation complete OEM single-board computer containing CPU, memory, and programmable parallel and serial I/O. The system includes a variety of high performance circuits—multimaster control logic, programmable interval timer, and programmable priority interrupt controller. It can operate as a stand-alone, 8-bit general-purpose computer, or in a multiprocessor system containing up to 16 master subsystems.

Basic subsystems similar to those of the SBC 80/10 (see Computer Design, Mar 1976, pp 116, 118) are included in addition to major enhancements. The resident multimaster bus control logic allows four 80/20s to share the system bus. An optional priority network extends the number to 16. Bus controller has its own clock, allowing controllers of different speeds to operate as bus masters; asynchronous data transfers permit masters to operate at their own speeds. Master-slave capabilities can be used for DMA as well as multiprocessing.

Maximum design flexibility is provided by the use of programmable LSI devices for I/O interfacing and peripherals control, which allow system operating configurations to be customized with software. The addition of LSI peripherals increases the onboard intelligence to handle system tasks and to control external peripherals, thereby reducing CPU real-time loading and increasing throughput and real-time responses.

Since each system contains its own local memory and I/O, much of the processing occurs onboard without reference to the system bus. Several computers together can simultaneously execute programs without speed reductions due to heavy bus loading. Interprocessor communication, when necessary, occurs via global memory and the system bus.

Measuring 6.75 x 12", the board has a CPU with system clock, controller, and bus expansion drivers; 2K bytes of read/write data memory in static RAMs; sockets for up to 4K bytes of EPROM or ROM; 48 programmable parallel I/O lines with sockets for interchangeable quad line drivers and line terminators; programmable synchronous/asynchronous serial data I/O with

RS-232-C compatible interface and fully software-selectable baud rate generation; 8-level programmable interrupt control; two programmable interval timers/event counters based in 16-bit binary/BCD counters; auxiliary power bus and memory protect control logic for battery backup data memory; and compatibility with the full line of optional memory and I/O expansion boards.

The 8080A 8-bit parallel n-channel MOS CPU has 8-bit general-purpose registers, accumulator, 16-bit program counter for up to 64K bytes of memory, and 16-bit stack point and manipulation instructions. Instruction execution time is 1.86 µs.

A programmable interval timer eliminates most problems associated with monitoring and managing I/O servicing and external events and
The Only Bipolar Microprogram Controller

The 67110 Handles every control application from discs to CPUs. And replaces 26 or more MSI devices.

Applications

CPU
Process Control
Disc Control
High Speed Printer Control
CRT Controller
Signal Processing Control

Features

- Works with any bit slice microprocessor such as MMI 6701, 2901, 3002.
- Works as a stand alone non-arithmetic controller
- Directly addresses 512 words of microprogram storage
- On-chip five bit loop counter for program looping routines
- Data shift linkage for arithmetic and logic shifting with 4 bit slices
- Microsubroutine and four way branch capabilities
- Very High Speed — 33 MHz

Information

For more information about this revolutionary microprogram controller and about other members of our growing family of LSI logic devices that will eventually replace all MSI logic, call, TWX or write:

In the United States, Ed Barnett or John Birkner.
In Europe, Bernd Kruse

Monolithic Memories

CIRCLE 57 ON INQUIRY CARD
rates. One of the three 16-bit timer/counters within the timer operates as a programmable baud rate generator; the other two can function independently. Timing range is approximately 2 µs to over 60 ms, which can be extended to 1.1 h by cascading the two timers.

A programmable interrupt controller handles vectoring control of up to eight priority interrupt levels for the CPU. It generates interrupt vectors and resolves priorities, changing them as needed. Four modes which can also be changed dynamically are the fully nested, autorotating, polled mode, and software assigned priority levels with masking of individual levels.

Manufactured by Intel Corp, Microcomputer Div, 3065 Bowers Ave, Santa Clara, CA 95051, the SBC 80/20 and associated products are available from stock. Price ranges from $895 for a single unit to $520 in quantities of 100; OEM discounts apply to quantities over 10.

System programming, which is the only development task associated with using the computer, can be done directly with the Intellec Microcomputer Development, ICE-80 In-Circuit Emulator, and resident software. An Intellec resident software package, which uses the company’s PL/M high level language or assembly language, is also being introduced. It includes PL/M resident compiler, and ISIS-II diskette operating system containing DOS system, text editor, macroassembler, and linker, loader, and library manager.

Circle 170 on Inquiry Card

n-MOS Technology Combines 2-Chip F8 Into 1-Chip Version

Fabricating what is claimed to be the first true computer-on-a-chip, Fairchild Camera and Instrument Co, Systems Technology Div, 1725 Technology Dr, San Jose, CA 95110, has announced a 1-chip version of the F8. Describing the device in a paper presented at the IEEE Computer Conference (Compcon) in September, Thomas A. Longo, the company’s vice president and technical director, points out that this device, as well as the 2-chip F8, is different from the majority of microprocessors. Other units consist of a computer system’s CPU, reduced to fit on one or a few ICs, and require numerous external circuits to function.

In its most elementary form, the original F8 family consisted of a processing unit (part number 3850) and a program storage unit (part number 3851). The 2-chip F8, however, did not fit many applications in which space was at a premium. Many of the 40 pins on each of the two packages were devoted to signals between chips, not to or from the outside. Furthermore, due to partitioning of functions between chips, some functions had to be duplicated. In order to meet these conditions, the company decided to merge the two chips into one, which resulted in the type 3859. In the original F8, one chip had an ALU, two I/O
Worldwide increases in both material and labor costs within the electro-mechanical industry have fostered a dangerous trend toward buying OEM components on the basis of price alone. But the fact is that the need for quality components has never been more critical. Loss of your product reliability for the sake of lower component costs can only result in substantially higher life cycle costs due to premature field failure. And that's a sure-fire way of increasing your product cost! That's why most cost-conscious manufacturers SPECIFY escap® miniature dc servomotors. They know that the escap® line reflects the highest level of engineering skills and Swiss precision manufacturing... and the best performance-to-cost ratio available.

escap® motors feature a permanent magnet stator and a self-supporting skew wound ironless rotor. This unique low inertia construction results in: fast response, no cogging, smooth torque, high efficiency, and high power-to-volume ratio. The use of a unique combination of precious metals in our commutator and brushes ensures high reliability and trouble-free operation.

So, if reduced life cycle costs, optimum performance efficiency, and reliability are what you expect from a miniature dc servomotor, buy escap® micromotors.

Insure quality and long life for your product - SPECIFY escap® motors.

Portescap U.S.
Member of the Portescap Group
730 Fifth Avenue
New York, New York 10019

Call for additional information and applications assistance:
In New York: (212) 245-7715
In San Francisco: (415) 886-1618
ports, a 64-byte R/W memory, and clock, and the other had two more I/O ports, a 1K-byte ROM, timer, and interrupt circuitry. The new version puts all of these on one chip. Due to limited space, there are three registers of 10 bits each—a program counter, data counter, and stack register—rather than 16 bits as in the 2-chip version. At 16 bits, the program and data counters can identify items stored in up to 65K of memory; at 10 bits, they are limited to 1K, which is adequate for the unit’s intended applications. The elimination of unnecessary and duplicated functions reduces the logic transistor count by about 7.5%; the area of the transistors on the chip is reduced about one-quarter. Power dissipation and cycle time have also been reduced.

The key to achieving this capability on a single chip is the n-MOS Isoplanar fabrication process which was also used in the 2-chip F8. In the process, the active area of each transistor is slightly higher than the surrounding chip surface, reducing the height of the “steps” over which the upper metallization layer must make contact with the semiconductor substrate; in addition, these steps are given rounded edges by a refining technique, reducing the probability of metal cracking, and therefore device failure during subsequent fabrication steps or in the field. By this means, the number of transistors per chip increased from about 9500 in the 2-chip F8 to over 18,000 in the 1-chip version.

Shipments of the 1-chip F8 will begin shortly after the first of the year; the 2-chip version remains in production for more complex applications.

Colm Compon, Longo predicted that by 1978 single 1C chips would be in production with as many as 30,000 transistors. He also hinted that a 1-chip microcomputer with a 2K-byte ROM, capable of running programs twice as long as either present F8 version can, might appear next spring. Details, of course, remain speculative.

Meanwhile, according to some reports, the Microsystems Div of Motorola, Inc, Austin, Tex, and Intel Corp, Santa Clara, Calif, were working on 1-chip microcomputers of their own, but were not quite ready to talk about them by the time of Compon.

---

**Analyzer/Controller is Compatible With 6800 µProcessor Systems**

Both the functions and conveniences of a sophisticated minicomputer console, as well as those features oriented toward development of microprocessor systems, are contained in the 6800 microprocessor analyzer (model MPA AO 6800). Designed to meet all microprocessor system problems from development to field service, the development and debugging tool provides extensive capabilities previously unavailable.

Standard functions include setting and examining registers (A and B accumulators, index, stack pointer, condition codes, and program counter), examining and depositing in memory (65K), hardware breakpoint and monitor, run/halt, and single step. Displays are provided for system status, analyzer status, address bus, and data bus, with an optional hexadecimal display for both address and data.

Special control functions also are furnished. An execute control allows the insertion of instructions independent of normal program flow, and an optional sequence recorder stores the addresses of up to 128 instructions, and can display the program sequence forward or backward.

Manufactured by A O Systems, Inc, 1736 Front St, Yorktown Heights, NY 10598, the instrument can be connected to any 6800 microprocessor system without placing constraints on the system hardware or software design. Accessories enabling portability include a DIP clip buffer probe that attaches directly to the microprocessor chip, and a field service case with power supply and cables.

---

**Standalone System Offers Built-in I/O Peripherals**

A fully configured, portable microcomputer, DE68 is a standalone system equipped with built-in I/O support peripherals which allow it to offer more than just an interface to an external CRT terminal or teletypewriter. Microperipherals include a 96-character keyboard, miniature cassette tape system to store up to 100K bytes of program or data per cassette, and 20-column alphanumeric display to operate system interactive communication.

Announced by Digital Electronics Corp, 415 Peterson St, Oakland, CA 94601, the system is structured around the 6800 microprocessor. In addition
CORTRON IS WRITING
THE SOLID STATE
KEYBOARD SUCCESS STORY

A new name in keyboards, CORTRON actually has a history dating back to 1968, when Illinois Tool Works Inc. made news with the introduction of its first solid state keyboard through its Licon Division. ITW has emerged as a major producer of solid state keyboard products and has supplied thousands upon thousands of custom-designed keyboards to meet specific customer requirements.

CORTRON DIVISION FORMED BY ITW
With a strong market demand and a promising future for keyboard products, ITW formed a new division, CORTRON, to handle full responsibilities for electronic keyboards and key switches. Following a proven ITW strategy, CORTRON concentrates a special division team of experienced Licon design, manufacturing and marketing people on this new major business opportunity.

KEYBOARD MARKET DIVERSIFIED
Typical applications for CORTRON™ Keyboards include data and word processing, computerized accounting, production and inventory control systems, retail point-of-sale and remote banking terminals, airline reservation and seat assignment stations, typesetting and text editing systems. And new applications are continually surfacing.

PROVEN PRODUCT RELIABILITY
The CORTRON Division offers proven keyboard products with an established reputation for excellence and reliability. The CORTRON Series 555 Solid State Keyboard is a sophisticated electronic device. Its high reliability protects against costly service calls and the hardship of downtime. The low profile alpha numeric keyboard has the human engineered "feel" required by your marketplace. This promotes speed, accuracy and greater operator productivity.

CORTRON KEY SWITCH MAKES THE DIFFERENCE
The CORTRON Contactless Key Switch is the heart of the solid state keyboard. The CORTRON Key Switch is respected throughout the industry for its ultra reliable 100 million cycle life rating. Utilizing a ferrite core switching technology, the key switch is mechanically simple with only four basic parts.

CORTRON RESPONDS TO CUSTOMER NEEDS
Since keyboard products are CORTRON's only business, the ITW Division is highly responsive to individual customer needs and requirements. CORTRON offers expert application engineering assistance, and has the high volume keyboard production capability so essential to large customer demands. Further, the division is backed by the resources of ITW, a worldwide corporation. Whether you want to buy keyboards or build them, CORTRON can supply the key elements necessary to success. For complete details, contact CORTRON, A Division of Illinois Tool Works Inc., 6601 West Irving Park Road, Chicago, Illinois 60634. Phone: (312) 282-4040, TWX: 910-221-0275.

CORTRON is writing the solid state keyboard success story.

TO BE CONTINUED . . .
to the standard 1K bytes of read/write memory (expandable to 4K, 8K, or 32K), the computer features DEbug—a 5.5K-byte p/ROM operating system. DEbug firmware includes a mnemonic translator which allows software to be written and debugged entirely in the assembly language mnemonics of the 6800 microprocessor. Selectable memory entry/display modes all allow communication in assembly mnemonics, hexadecimal notation, or ASCII characters. The command set simplifies software development. Commands include memory examine and change, search, move, memory block, and tape commands; others permit setting multiple breakpoints, software single step, and tracing 6800 MPU register activity.

Computer is packaged in an attache-style carrying case. Bus lines are available on a single edge connector for direct I/O expansion as needed. Programmed, interrupt-initiated, and DMA data transfers are possible. An optional Micro-Printer provides built-in hardcopy output capability. An educational package includes a teaching module and manual for microcomputer training.

Circle 174 on Inquiry Card

Add-On Modules Are Available for Learning System

Three preassembled, add-on modules—controller, memory, and input/output—have been announced by Texas Instruments Inc., PO Box 5012, Dallas, TX 75225 for the Microp­rogrammer Learning Module (see Computer Design, Mar 1976, p. 124). These self-contained units complete the user-paced system for understanding microprocessors. Users progress in a logical sequence from micro to macro level programming to the operation of a fully automated digital system with the modules, each of which has an instruction manual, battery, charger, cables, and connectors.

In the LCM-1002 controller module a 256 x 20 p/ROM (five chips) is used to store macroinstructions, each containing eight or 16 microinstructions. The module also has a memory data register, instruction register, and program counter. Interfacing the controller with a read/write memory presents assembly-language and hexadecimal ideas. Single step manual or automatic clock, macroinstruction load, a program counter load, and a memory data register clear are accessible by pushbutton or toggle switches.

The standalone R/W static RAM, organized as 1024 words of 12 bits each, stores macroinstructions. A 12-bit instruction word provides an operation code and an operand address; the 1024 words may include instructions, constants, or variable data. Switches are provided on the LCM-1003 memory module for manual loading. An address counter then automatically increments the address, facilitating both initial loading and the insertion of blocks of data at individual locations in memory. VLED indicators are used to observe address and content of each selected location. Multiplexers are used for either address and data bus isola­tion of the memory during manual loading, or direct operation from a remote device.

Designed to accomplish I/O interfacing to the microprocessor, the LCM-1004 I/O module is the final step in the microsystem development. Four 4-bit input ports and four 4-bit output ports with latches provide temporary data storage within the system, allowing synchronization of the user's program with outside data. Ports may be operated independently or in combinations of two, three, or four ports. Up to three I/O modules may be used for system expansion.

As an additional aid, a 390-page book, "Software Design for Microprocessors," is available, designed to give the reader an understanding of the basics of microprocessor machine code and assembly language, and of fundamental hardware/software relationships.

Circle 175 on Inquiry Card

Bipolar Microprocessor Is Optimized For Control Operations

A high speed monolithic microprocessor with a fixed instruction set, the model 8X300 employs bipolar Schottky technology and a partitioned bus
Why Do More Top Designers Insist On Working With Harris Generic PROMs?

The compatibility and depth of our Generic PROM family simplifies selection, application, and production. But that's only the beginning. Here are a few specific reasons for choosing Harris.

- Identical programming specifications means that one programmer programs the entire family.
- Single pulse one millisecond per bit programming achieves fast programming and superior reliability.
- Industry's highest programming yield increases production efficiency, regardless of PROM size.
- Access times are guaranteed over full temperature and voltage ranges and any random addressing sequence.
- Harris is the only JAN-38510 QPL-1 approved PROM supplier.
- Proven Nicrome fuse design and Schottky technology.
- Complete family availability from prototype quantities to production volumes.

Now See How The 1Kx4 PROM Can Improve Your System.

- High-density 16 or 18 pin packages greatly reduce board area.
- HM-7644 (16 pin, no enables) provides direct upgrade for systems using 1K or 2K PROMs and having less than 1024 words.
- HM-7642/43 (18 pin, 2 enables) extends high density packaging to large memory configurations.
- Low power per bit: (Icc<140 ma or <180 µW/bit).

For a quick look at our PROM family check the chart. And for complete details call your nearby sales location or write to Harris Semiconductor, P.O. Box 883, Melbourne, Florida 32901.

<table>
<thead>
<tr>
<th>Device #</th>
<th>No. of Bits</th>
<th>Organization</th>
<th>No. of Pins</th>
<th>Max. Access Time*</th>
</tr>
</thead>
<tbody>
<tr>
<td>HM-7602</td>
<td>256</td>
<td>32x8</td>
<td>16</td>
<td>40ns 50ns</td>
</tr>
<tr>
<td>HM-7603</td>
<td>256</td>
<td>32x8</td>
<td>16</td>
<td>40ns 50ns</td>
</tr>
<tr>
<td>HM-7610</td>
<td>1024</td>
<td>256x4</td>
<td>16</td>
<td>60ns 75ns</td>
</tr>
<tr>
<td>HM-7611</td>
<td>1024</td>
<td>256x4</td>
<td>16</td>
<td>60ns 75ns</td>
</tr>
<tr>
<td>HM-7620</td>
<td>2048</td>
<td>512x4</td>
<td>16</td>
<td>70ns 85ns</td>
</tr>
<tr>
<td>HM-7621</td>
<td>2048</td>
<td>512x4</td>
<td>16</td>
<td>70ns 85ns</td>
</tr>
<tr>
<td>HM-7640</td>
<td>4096</td>
<td>512x8</td>
<td>24</td>
<td>70ns 85ns</td>
</tr>
<tr>
<td>HM-7641</td>
<td>4096</td>
<td>512x8</td>
<td>24</td>
<td>70ns 85ns</td>
</tr>
<tr>
<td>HM-7642</td>
<td>4096</td>
<td>1024x4</td>
<td>18</td>
<td>70ns 85ns</td>
</tr>
<tr>
<td>HM-7643</td>
<td>4096</td>
<td>1024x4</td>
<td>18</td>
<td>70ns 85ns</td>
</tr>
<tr>
<td>HM-7644</td>
<td>4096</td>
<td>1024x4</td>
<td>16</td>
<td>70ns 85ns</td>
</tr>
</tbody>
</table>

*Access time guaranteed over full temperature and voltage range.
Industrial (Ta = 0°C to 70°C, VCC ± 5%)
Military (Ta = -55°C to 125°C, VCC ± 10%)

Proven PROM Capability

HARRIS SEMICONDUCTOR
A DIVISION OF HARRIS CORPORATION

CIRCLE 60 ON INQUIRY CARD
structure, to increase operational simplicity and system efficiency. Designers need only interface the device to selected program storage and I/O devices, and clock mode.

The single-chip processor features a dual-purpose address/data bus partitioned into a right and left bank, with logic distributed along the data path. This and the double operand instruction set, along with eight 8-bit working registers; separate instruction address, instruction, and I/O data buses; on-chip oscillator; and dedicated program counter enable 8-bit parallel data to be accessed and processed in one 250-ns cycle.

According to Signetics, 811 E Arques Ave, Sunnyvale, CA 94086, industry-standard peripheral circuits, assembler, and prototyping system provide support for the microprocessor. Peripheral circuits include both synchronous (8T32/8T33) and asynchronous (8T35/8T36) I/O ports, and the 8T39 bus extender. These circuits are field programmable so that the user can set the addressing of the microprocessor. Program storage is provided by a variety of p/ROMs; working storage is provided by RAMs.

Circle 176 on Inquiry Card

System Features
Dual Audio Cassette and Video Terminal Interface

Key features of the Jupiter IIC, a low cost complete microprocessor-based computer system with 8K RAM and 3K ROM, offered by WaveMate Computers and Systems, 1015 W 190th St, Gardena, CA 90248, are video terminal interface and keyboard, and the dual audio cassette interface. I/O capability of the unit's M6800 microprocessor is extended with an 8-level prioritized and maskable interrupt system, and single cycle and block DMA transfer modes. Wire-wrap modules allow custom tailoring of system logic; plug-in modules provide sockets for 8- to 64-pin ICs.

The video terminal interface converts any black and white TV set into a monitor or CRT terminal. Features of the interface and key-
Ask Control Data for the first horizontal font 300-600-900 lpm family of OEM printers with the print band any operator can change in 30 seconds.

We have it.

GET 1130 LPM FOR LESS THAN $10,000 IN 48-CHARACTER SET APPLICATIONS, OEM QUANTITIES.

Here now: CDC horizontal font Band Printers with truly operator-interchangeable bands—plus exclusive choice of 10 and 15 cpi bands! Just look at their advantages:

**Users can switch bands in 30 seconds!** Single-piece band weighs less than an ounce! Stores conveniently in cabinet. No need to lift out the ribbon! Insert a new band—the printer automatically adjusts for pitch and character set (adjustment between 64/96 characters standard; 48/64/96 or 64/96/128 optional). Eleven bands now available.

**Paper-saving condensed pitch!** Prints 132-character lines either on 14½" or 11" paper! Unique 15 cpi bands cut user paper costs and storage needs by reducing paper volume 40%!

**Three look-alike models.** Only six differences between units; identical spare parts kits. Offer a choice of speeds—without tying up capital in spare parts inventories!

**Minimum operator attention.** Exclusive patented control permits use of double-length 48-yard ribbon, cuts ribbon changes 50%! Electric eye automatically reacts to any paper feed jam-up, permits use of lighter-weight paper.

**Superior readability.** These CDC Band Printers deliver full, solid strokes—top to bottom—even on super- and sub-scripts.

Make these advantages your advantages!

Write for complete information plus sample printout. Compare our sample with copy from any printer. See how CDC Band Printers offer print quality and printer features never before available in a medium-to-high-speed printer under $10,000!

New compact 34" width. Takes a minimum of precious floor space; produces up to 900 lpm (using 64-character sets).

---

Phone (313) 651-8810 or write: Harrison Craig, Peripheral Products Sales Manager, Control Data Corporation, 1460 N. Rochester Road, Rochester, Michigan 48063. Ask a CDC Sales Representative to bring me a Band Printer evaluation unit. Send more information and sample print-out.

---

Ask the CDC OEM people
board include upper and lower case character sets (including the Greek alphabet), and dot graphics. A dual port memory allows display refreshing without the use of CPU cycles, providing minimum CPU loading and high display resolution due to ANSI standard sync and video signals. Basic interface displays 16 lines with 64 char/line, expandable to 32 lines with 64 char/line.

The dual audio cassette interface serving as a complete paper tape replacement interfaces two portable audio cassette units to the system, and provides start/stop motor controls. It operates at 600 and 1200 baud. Sophisticated error recovery circuitry gives data reliability.

A monitor/debugger package includes an interrupt handling system and 1/O monitor call instructions. Systems are also supplied with a programmable macro editor, expanded assembler, and proposed ANSI standard BASIC. In kit form the system costs $2200; assembled and tested, it costs $3200, which includes two audio cassette units and a 12" black and white TV set.

Circle 177 on Inquiry Card

Single Board Computer Combines Functions of Four Boards in One

The 80AI is a low cost expandable single board microcomputer which contains all components needed to build either a system compatible with Altair® and IMSAI backplanes, or a standalone microcomputer. The single PC board combines all of the functions of Altair's CPU, RAM, ROM, and SIO boards. With the addition of power and a terminal, the microcomputer is ready to use after assembly.

Based on the Zilog Z-80 microprocessor (see Computer Design, Feb 1976, p 132), the system from Quay Corp., PO Box 386, Freehold, NJ 07728 runs on a 2.5-MHz clock. This enables both Altair 8800 or Intel 8080 software to be run. Maximum flexibility can be obtained from an 8080-compatible 2-phase clock and sync signal synthesized in the kit.

With the Z-80 instruction set more powerful software can be developed. There are 158 instructions including 78 8080A, block transfer, and block search instructions. The system also includes two index registers (17 internal registers), three interrupt, an 8080A, 6800-type, and Z-80 vectored modes.

Memory is supplied onboard. The monitor is supplied on a ROM, and a 1024 x 8 dynamic RAM is provided for user programming. Sockets can hold up to four 1024 x 8 EPROMs for program storage development.

Three communication support circuits are standard: RS-232-C, teleprinter 20-mA current loop, and parallel ASCII keyboard. The ROM-resident monitor with listings samples three communication interfaces, eliminating user strapping. Serial baud rates from 110 to 2400 with one or two stop bits are supported. The kit also includes a parallel port, EPROM programmer, documentation package, PC board, and 40- and 24-pin sockets—for $450. Factory assembled and tested the system costs $600.

Circle 178 on Inquiry Card

Programmable CPU Module Is Available for Microcomputer

Designed for the company's System 8 series of 8-bit bipolar microcomputers, the M-8Z is a single board (4.5 x 4.5") microprogrammable CPU. Available from the Electronic Products Div of the Warner & Swasey Co., 7413 Washington Ave, Edina, MN 55435, the CPU allows the user to select his own instruction set, either emulating another 8-bit computer instruction set, or defining his own set.

With a micro-cycle time of 250 ns, the CPU interfaces with all System 8 modules, which include a programmer's console so that the user can microcode standard console functions or define his own to fit the exact application. Applications include high speed execution of special-purpose algorithms, or dedicated OEM applications with unusual instruction set requirements.

Module comes with a microassembler program (written in FORTRAN) available on Dialcom timesharing, and microprogramming manual.

Circle 179 on Inquiry Card
THE J325 IC TEST SYSTEM.
THERE'S A SPECIAL PREMIUM IN EACH ONE.

The premium is productivity. To squeeze every last bit out of the J325 digital IC test system, we combined a single mainframe with two optimized test stations, one for ECL, TTL, and DTL, the other for CMOS and static MOS.

The CMOS/MOS station gives you low current and differential voltage measurements, programmable clock phases, and comparator strobe delays. The ECL/TTL station provides solid-state switching, low noise, one millivolt resolution, and subnanosecond time measurements with the optional S357 add-on. The system can handle up to four of these stations in whatever combination is most productive for you.

The J325 really shines on the production line, but it also delivers excellent service in incoming inspection, device evaluation, and QC. To help make your operation even more productive, the system feeds back Schmoo plots, distribution analyses, summary sheets, wafer maps, and full datalogging of all tests.

We back up the J325’s productivity with our unique 10-year circuit module warranty and a global service program supported by local parts stocking centers. We also provide all software, interfaces to probers and handlers, and ongoing applications support.

System design will always be a question of trade-offs. At Teradyne, we’ll always take the alternatives that give our systems the greatest productivity. And we’ll continue to build them in a way that guarantees they’ll remain productive for as long as they’re needed. Productivity is something you can’t have too much of.

Teradyne. 183 Essex Street, Boston, Massachusetts 02111.

WE SELL PRODUCTIVITY.

TERADYNE
Microprocessor-Based Controller is Minicomputer Compatible

The 1000 series microprocessor-based controller, designed around the 2900 low power Schottky, 4-bit slice microprocessor, allows direct plug compatible interconnection between the company's memory peripherals and Digital Equipment Corp., Data General, or Hewlett-Packard minicomputers. Xebec Systems Inc., 2985 Kifer Rd., Santa Clara, CA 95051, claims the controller's 150-ns cycle time makes it the fastest on the market. The speed allows such special features as ECC to be incorporated while maintaining plug compatibility.

An additional feature is that the controller is also program transparent. The p/ROM layout for each computer/peripheral combination permits total hardware and software compatibility. The controller is available in systems with 5 to 1200M bytes of disc storage, 12.5- to 125-in./s mag tape, and Persci double-density floppy discs.

Circle 180 on Inquiry Card

Standalone In-Circuit Emulator Debugs 8080 Systems

Connecting to the host system by a 40-pin connector that plugs into the socket usually occupied by the user's 8080, the portable standalone MAS-80 microcomputer analyzer system debugs 8080 systems. The in-circuit emulator displays all important 8080 signals.

Unit requires no development system or teleprinter to operate and supplies all dc power for ICs and 8080, allowing users to monitor and control any 8080 project. An add-match feature causes the 8080 to wait or provide a sync pulse when switch-selected address is reached. Data bus indicator has three switch-selected options to monitor the bus during all cycles while the system is running.

Module contains its own 8080, which is protected from damage by buffer circuits. High quality components are used in the front panel to reduce finger fatigue. Small debug machine programs can be entered in the user's RAM; debugging is further enhanced by a continuous deposit feature, and by using the control panel's single-step mode.

Internal 5-V supply provides power; input voltage is 117 Vac. The system, available from California Micro Computer, 9323 Warbler Ave., Fountain Valley, CA 92708, supplies

Circle 180 on Inquiry Card

SAC SCIENCE ACCESSORIES CORPORATION
970 Kings Highway West Southport, Connecticut 06490 (203) 255-1526
Victor's high-speed matrix printer can fit into your systems design.

If you're starting from scratch in designing your own print mechanism, the Victor Model 129 matrix print head will optimize your price-performance ratio.

You can enjoy this popular and reliable device already built into the Victor Matrix Printing Mechanism 130 (which can be integrated readily into all types of data generating devices).

It's also available in the Multi-Position Printing Mechanism 150 that can print three documents simultaneously.

You'll find Victor terminals meet your needs, too.

The 5010 allows interfacing with RS232C, 8-bit parallel or TTY current loop. With Intel MCS-40, you have a data terminal with a mind of its own.

The 5005 terminal comes complete with a matrix printing mechanism, integrated power supply, and driver circuitry.

So, to see how Victor components can fit into your program, just send the coupon.

THE VICTORS

Victor Comptometer Corporation
3900 North Rockwell Street
Chicago, Illinois 60618

Yes, I'd like detailed specs on Victor components.

☐ 129  ☐ 130  ☐ 150  ☐ Terminals

Name________________________
Company_____________________
Address______________________
City/State_____________________
Zip_________ Phone__________
dc power for its 65 SSI, MSI circuits, and the 8080.

Controls include data-address select, start-stop, reset, load add, step, enter data, exam, sync address stop, and delay switches; run and power indicators; sync pulse test point; 16 LED address indicators; and 8 LED data indicators.

Circle 181 on Inquiry Card

**Savings in Memory Size and Time Are Obtained With Multilevel Language**

MicroFORTH™, a multilevel microprocessor language, offers large reductions in application development time, program execution time, and memory requirement. The developers, Forth Inc, 815 Manhattan Ave, Manhattan Beach, CA 90266, state that execution times have been reduced by as much as a factor of 10, compared with those of other high level languages (PLM and BASIC).

For an application requiring 2K bytes coded in assembly language, the language can reduce the memory requirement to 1K or less.

The language runs on a microprocessor development system with a minimum of 6K bytes of memory, diskette, and terminal. In an 8K configuration, this leaves approximately 2K for customers' applications. Programs written in microFORTH are transferrable among most manufacturers' microprocessor systems.

Now offered on the Intel MDS 800 and the RCA CDP 1800 development systems, the package will be available for the exorciser and other systems by late fall 1976. The standard package, selling for $1000, includes a compact disc operating system, powerful macro-assembler, the company's compiler and interpreters, text editor, and interactive debugging aids. Documentation includes a self-teaching primer and technical manual. Extended math, BCD I/O, and other optional functions are available.

Circle 182 on Inquiry Card

---

**Superior performance... Significant cost advantages... Off-the-shelf delivery.**

**Miniature ironless rotor DC motors. Ideal for cassette drives.**

The typical performance graph shown above speaks for itself. Our miniature ironless rotor 12 VDC motors not only have the desired characteristics for cassette drives, they also offer an important price advantage—under $10.00 in 500-piece lots. As low as, if not lower than, any competitive motor. Fast, off-the-shelf deliveries, too!

Motor time constant is 23 MS; rotor torque 50 gcm; starting torque 230 gcm. Plus, low noise levels and smooth cog-free operation. The motor can also be ordered with dual shaft for use as a tach motor. 24 VDC models also available.

Send for information today!

A.W. HAYDON CO. PRODUCTS

NORTH AMERICAN PHILIPS CONTROLS CORP.

---

**Second Sourcing of 2900 4-bit µProcessor Slice Family Is Arranged**

Motorola Semiconductor Products, Inc, PO Box 20294, Phoenix, AZ 85036, has elected to second-source the 2900 series of Schottky-TTL processor components originated by Advanced Micro Devices, Inc of Sunnyvale, Calif. Mask sets have been purchased for the 4-bit microprocessor slice (MC2901), microprogram sequencer (MC2909), and one-by-two-port register (MC2918).

Samples will be available in the fourth quarter of 1976, with quantity production slated for first quarter, 1977. Availability of the MC2911 sequencer, a mask option version of the 2909, will closely follow that time schedule.

Future products for the family, notably single- and dual-port bus transceivers and a priority interrupt controller for system hardware interrupts, are also included in the agreement. These products are scheduled for introduction in 1977.
NOW...a complete, up-to-date MICROCOMPUTER COURSE BOOK LIBRARY!

from the learning tree™

INTEGRATED COMPUTER SYSTEMS, INC.

THE LEADING TECHNICAL EDUCATION FIRM SPECIALIZING IN MICROCOMPUTER TRAINING

No mere general introduction, each course book will have an immediate, valuable impact on your job function.

- UNBIASED, VENDOR-INDEPENDENT
- PRACTICAL, NOT ACADEMIC

NOW AVAILABLE:

156: SOFTWARE DEVELOPMENT: TOOLS AND TECHNIQUES FOR MICROCOMPUTERS (Replaces Course 134) (320 PAGES)
201: MILITARY AND AEROSPACE MICROPROCESSOR SYSTEMS (420 PAGES)
187: BIT-SLICE MICROPROCESSORS, PLA'S AND MICROPROGRAMMING (310 PAGES)
220: MICROPROCESSORS IN MANUFACTURING AND INDUSTRIAL CONTROL (325 PAGES)
205: MICROPROCESSORS AND LSI IN TELECOMMUNICATIONS APPLICATIONS (400 PAGES)
168: MOTOROLA'S 6800 vs. INTEL'S 8080 (300 PAGES)
410: COMPUTER IMAGE PROCESSING (192 PAGES)
101: A MANAGER-LEVEL OVERVIEW OF MICROPROCESSORS AND MICROCOMPUTERS (249 PAGES)
105: FUNDAMENTAL CONCEPTS OF MINICOMPUTERS AND MICROCOMPUTERS (302 PAGES)
106: MINICOMPUTER/MICROCOMPUTER REAL-TIME SOFTWARE SYSTEM TECHNIQUES AND APPLICATIONS (270 PAGES)

ORDER NOW! EACH COURSE BOOK ONLY $99.50

Each book is available today for immediate shipment to you. Each is backed by a 15-day money-back guarantee.

Attached is my check, money order or purchase order. Please send the courses I have noted below immediately!

☐ SEND ME THE FOLLOWING COURSE BOOKS PLUS THE TWO FREE BONUS BOOKS

102  156  201
187  220  205
168  410  101
105  106

First course @ $99.50. Each subsequent course @ $89.65. My total order is _ courses at $ _ California residents add 6% sales tax. Shipping and handling ($7.00 per course in U.S. and Canada, $15.00 per course to all other countries). Total $ _

ORDER NOW and receive two BONUS BOOKS — 800 pages of vital reference material:

Technical Reprints — A 250-page bound volume of carefully selected articles on advanced hardware and software design techniques and detailed applications examples.

Manufacturers Literature — A 550-page bound volume of up to date manufacturers data and product descriptions. Includes microprocessors, support chips, microcomputer board systems, software development systems, peripherals, software services and hardware debug equipment.
High speed arithmetic capability, exceptional communications performance, and the ability to work with high level languages are claimed as key features of Varian Data Machine's V77-200 computer, the smallest member of the V77 family. Designed to function as either a stand-alone processor in a laboratory environment, handling a heavy volume of scientific calculations, or as part of a multiple-computer distributed processing network with larger members of the family, this computer is as powerful as many large scale minicomputers. Although its architectural scheme is characteristic of upper-end minicomputers, including the ability to run a multitasking operating system, it provides a high performance/price ratio.

**Characteristics and Capabilities**

The V77-200 has fully microprogrammed architecture, an 8-register central processing unit (CPU), and a 32-bit arithmetic capability which permits handling of 8-, 16-, or 32-bit data, working with a set of 187 instructions. Many of the instructions incorporate multiple operands, using combinations of 16- and 32-bit word lengths for effective memory use and efficient memory addressing. Byte manipulation instructions are also incorporated to support byte-
oriented operations such as data communications. The instruction set is implemented by microinstructions stored in a block of 16K bits (512 words x 32 bits) of read-only memory (ROM) devices.

One feature that separates it from low-end OEM processors is the speed of its arithmetic functions. Signed multiplication functions, for instance, are performed in 4.9 µs and divide functions in 8 µs. The company states that medium-scale integration (MSI) was chosen for the circuitry in preference to large-scale integration (LSI) in order to obtain the high performance of MSI, even though it meant trading off the low cost of LSI.

Throughput speed is 165 ns per microinstruction. In addition, each microinstruction contains multiple fields which are coded to select the next microinstruction address while concurrently performing functions such as shifting or manipulating bytes in a selected register, performing logical or arithmetic functions in the address, or starting a memory cycle or I/O operation. The microcode also includes an automatic bootstrap loader for implementing multiple devices.

Need for a programmer's console is eliminated by virtual console logic which permits an operator to control the computer from a teletype-or CRT terminal keyboard. This logic is a combination of firmware (ROM) in the control store and programming in main memory.

An optional data communications multiplexer (DCM) halfboard plugs into the computer chassis and transfers into memory via a direct memory access (DMA) channel. Data communications capabilities are supported by a DCM and associated line adapter which provide a virtually universal data communications hardware interface. A single DCM can serve as an interface for large numbers of synchronous and asynchronous terminals and communications lines, permitting concurrent execution of a variable number of real-time and background tasks. Data are transferred through the system by the DCM at rates exceeding 60K bytes/s.

I/O structure features DMA for high speed devices and programmed I/O for devices of lower speeds. A dual bus architecture enables the processor to communicate with I/O devices without tying up the bus to memory; the I/O end of the bus accommodates programmed I/O, interrupts, and DMA while the other provides a direct channel to memory. Standard programmed I/O uses separate program instructions for each character or word transfer. DMA uses a cycle-stealing sequence to transfer blocks of data at rates to 330,000 words/s.

Up to 64 external vectored interrupts are supported. External interrupts are driven by the I/O bus with interrupt addresses determined externally. A number of internal interrupts, with fixed vectors and priorities, are generated by CPU hardware and do not affect the I/O bus. Interrupt servicing can simply identify a device and vector to a device handler or perform functions such as saving machine state, switching stacks, updating priority, and enabling an interrupt before branching to the device handler.

Although the smallest member of the V77 family, the -200 is physically and electrically compatible with the other family members of superior processing power. For instance, its dual bus scheme enables it to function either in a distributed processing environment with multiple combinations of the same type processor or with a larger computer on a shared-memory basis.

All are supported by the company's multiprogramming vortex operating system as well as the library of programs and languages for all V70 series machines. Included are FORTRAN IV, HASP/RJE, and VTAM telecommunications software. The last consists of a collection of processing modules that provide a network definition language, operator network control, storage management, and interrupt servicing.

Other standard features include an integral teletype/CRT controller, real-time clock, and automatic program loaders. Options include operator's console, power fail/restart, integral power supply, system chassis, and 660-ns memory board with 8K, 16K, or 32K words capacity.

**Price and Delivery**

Single unit price for the V77-200 minicomputer is $1100 for the processor board alone or $5100 for a chassis mounted computer including 16K memory and all features required to run an operating system. OEM discounts are available. Deliveries are scheduled to begin in January 1977. Varian Data Machines, 2722 Michelson Dr, Irvine, CA 92664. Tel: (714) 833-2400.

For additional information circle 199 on inquiry card.
**PRODUCTS**

**Numeric Data Entry Terminals Are Readily Dedicated to User's Applications**

Operators with little or no experience with computers are the intended users of the first of a series of numeric data terminals for industrial and commercial applications. HP 3070A is designed for optimum performance with the HP 1000 computer system as well as with HP 2100 and 21 MX computers; the 3071A is for use with computers of most other manufacturers. Both have numeric-only keypads for entering data and bright, 16-digit numeric displays. Keys and LED indicators can be specially labeled to customize the terminals for the user's specific computer programs. Terminals can be used to link HP1B-compatible instruments to the computer system, enabling the computer to control instruments up to 1.24 miles distant. As many as 56 terminals can also be connected to a computer system via a single twisted pair cable. Weight is 10.3 lb, dimensions are 10.9 x 4.6 x 15.7". Their ability to interface a wide range of instruments to a remote computer adapts them to electronic manufacturing and test installations. Hewlett-Packard Co, 1501 Page Mill Rd, Palo Alto, CA 94304. Circle 200 on Inquiry Card

**DC Servomotor Improves Control of Instantaneous Speed Variations**

Although specifically designed for use as capstan or reel drivers in tape drive and tape transport systems up to 50 in./s, 2000 and 2100 series de permanent magnet servomotors also meet the requirements of line or character printers for paper feed and carriage drive systems. Integral tachometers reduce ripple to 2% pk-pk without external filtering. Use of an alnico field improves tempco to 0.015%/°C, eliminating the need for compensation networks and the resulting high impedance outputs. Unique bearing construction results in better seating of brush at higher speeds and longer brush life. Larger bearings also yield greater radial and axial load ratings and provide longer bearing life. Design of the brushholder makes it virtually immune from typical breakage problems. Large shaft diameters allow high mechanical resonant frequency between motor and tachometer, as well as heat radiation qualities of the casing, to provide lower thermal resistance and increased life expectancy. Torque Systems Inc, 225 Crescent St, Waltham, MA 02154. Circle 201 on Inquiry Card

**Microprocessor-Based Modems Reduce Line Equalization Times**

MPS 48 and 48 Dial, 4800-bit/s modems featuring microprocessor technology, are designed to reduce line equalization time for greater transmission efficiency. Operating at full data rate, they equalize dial-up lines and dedicated point-to-point or multidrop lines in 26 ms, as opposed to at least 50-ms clear-to-send time generally required by conventional 4800-bit/s modems to achieve equalization. Remote test features available for use in either point-to-point or multidrop networks allow the user to isolate system faults from the central site without involving personnel at remote sites. The modems are tolerant of widely varying line conditions and operate with significantly low error rates in both dial-up and multidrop polling systems. They measure 5½ x 8 x 19"; two can fit side by side in a standard 19" rack. International Communications Corp, 8600 NW 41st St, Miami, FL 33166. Circle 202 on Inquiry Card
Want to see it again?

Just call Plessey and ask to see the 16-bit MIPROC 16, the first microcomputer fast enough for your real-time systems.

We’ll show you three models, with throughputs of 2, 2.85 and 4 million instructions per second. An optional 10 megaword per second direct memory access channel. 82 powerful instructions that eliminate costly, time consuming microprogramming and hardware design and debugging. And an architecture that achieves this ultra-high speed with less expensive MOS memories.

To round out your systems, we’ve got a full range of software and hardware support. Everything you need for signal processing and Fast Fourier Transforms, process control and data acquisition, real-time telemetry and data communications. Even an extended temperature range and/or ruggedized version for your military systems.

The Plessey MIPROC 16 is yours for as little as $500 in quantity, so if you’re still paying the price of hardwired logic just to get speed, ask for the details.

We’ve just brought microcomputing up to speed.

Plessey Microsystems

U.S.A.: Irvine, CA (714) 540-9945
Wheaton, MD (310) 949-1664
United Kingdom: Towcester (0327) 50312
Wang's new printer is getting called a lot of names...

like yours.

Call it what you will, Wang's new 120 Line Printer is an OEM natural. Quiet... Fast... Versatile... Beautiful. The 120 gives you and your customers what you've always wanted: Full Features. Reliability. Ease of operation. Crisp, legible printouts. Low price. Wang Quality.

The 120 boasts a wide array of features at a surprisingly low cost. 120 CPS, 7x9 dot matrix; fully-buffered 112 character line; upper and lower case 96 character set with full ASCII; a double-axis bearing plate for long life; a servo-driven head.

Wang's 120 comes in two models. The W-1 has 112 columns. The W-2, 132 columns. Both are available with vertical format control, mini-exerciser and RS232C. Your customers will love the clean, crisp copies delivered by Wang's exclusive 9-pin head design. And the 120's expanded character-size capability lets them emphasize printouts with bold, eye-catching letters or numbers.

To find out more about the printer that lives up to your name, fill out the coupon or call Wang OEM Sales at (617) 851-4111.

Please send me more information on Wang's 120 printer. Mail to: OEM Sales, Wang Laboratories Inc., 1 Industrial Ave., Lowell, MA 01851
Name ___________________________ Phone ___________________________
Company ___________________________ Address ___________________________
City ___________________________ State ___________________________ Zip ___________________________

CIRCLE 98 ON INQUIRY CARD

DIGITAL CASSETTE

Certified digital cassette features mag tape with a new oxide to achieve higher signal output, increased environmental stability, and improved wear characteristics. Signal output of the Scotch brand No. 834 cassette exceeds NBS reference and std tapes by 20%. Magnetic coating, which does not soften at high temp or become brittle at low temp, improves environmental stability, resulting in consistent head-to-tape contact. Improved coating wearability provides no appreciable signal loss, or change in signal uniformity. 3M Co, Data Recording Products Div, PO Box 33600, St. Paul, MN 55133.

CIRCLE 203 on Inquiry Card

LIGHTED PUSHBUTTON SWITCHES

Offering a series of five colored pushbuttons (opaque or translucent backgrounds), seven colored screens, and four colored filters, PLI pushbuttons are designed for use with the company’s “Push-Lite” lighted switches and indicators which feature leaf-spring switching, front of panel mounting and relamping, momentary and push-lock/push-release actuation, and twin and single lamp illumination. A variety of legend options are available. Switchcraft, Inc, 5555 N Elston Ave, Chicago, IL 60630.

CIRCLE 204 on Inquiry Card

IMPACT LINE PRINTER

Operating at 300 to 500 lines/min., the model 200 is available in both 80 and 132 col widths. Tractor feed is used for continuous forms operation. The printer uses a fully formed char font on a horizontal type carrier, which is operator removable and replaceable for multiple font changeover. A hammer per position produces 64- and 96-char ASCII sets. Mechanism contains two full line buffers and is available with most popular interfaces. An automatic motor turn-off feature is included. Data Test Corp, 2450 Whitman Rd, Concord, CA 94518.

CIRCLE 205 on Inquiry Card

ADC APPLIED DATA COMMUNICATIONS
1509 East McFadden Avenue
Santa Ana, Ca., 92705. (714) 547-6954

CIRCLE 66 ON INQUIRY CARD

COMPUTER DESIGN/NOVEMBER 1976
A QUANTUM STEP IN SIZE AND PRICE REDUCTION!

TWO NEW CRYDOM CHALLENGER SOLID-STATE RELAYS!

The new Crydom Series 2 and 3 SSRs combine small size and low price, challenging all comparably rated SSRs. Hybrid relays, in-house designs on a size/cost/performance basis. They provide photo isolation, zero voltage switching, high current rating and rugged packaging - first established by the original Crydom Series 1, now the world's leading SSR design. Designed for UL/Csa approval, they offer the advantages of long life, RFI-free switching, logic level control, and excellent electrical and mechanical isolation of signal and power circuits.

The application of SSRs is no longer limited by size and cost. Crydom Challengers have knocked down these barriers, SSR control of motors, heaters, lamps, transformers, solenoids, valves and contactors now becomes practical in many new applications.

Think about it for your product... and join the Challengers!

INTERNATIONAL RECTIFIER CRYDOM DIVISION
1521 Grand Avenue, El Segundo, CA 90245 (213) 322-4987
CIRCLE 39 ON INQUIRY CARD
...the pacesetters!
PRODUCTS

OCR WAND
Automatically entering human-readable source data into distributed data processing terminals such as the IBM 3270, the class P130 OCR wand reads machine-printed, human-readable alphanumeric characters produced either in the OCR-A or OCR-B (subset 1, ECMA 71) type font. All output is computer compatible. The wand is connected between an intelligent terminal and its keyboard, enabling existing communications links between the keyboard and terminal to be maintained. Data are read and input at speeds of 30 to 130 char/s. Recognition Equipment Inc, PO Box 22307, Dallas, TX 75222. Circle 206 on Inquiry Card

PAPER TAPE READER/PUNCH
A quiet (58 dB) combination which attaches to any terminal through the RS-232 or current loop connector, SRP-300 may be remotely controlled from the line or terminal through std DC1-DC4 codes. Full/half duplex, line/local, search/edit control, back space, tape feed, and selectable baud rates are all standard. Compact (12" wide) unit features MODUPERT tape punch mechanism which cuts all paper, Mylar, rolled, and folded tapes without re-adjustment or modification. Data Specialties, Inc, 3455 Commercial, Northbrook, IL 60062. Circle 207 on Inquiry Card

900-LINE/MIN. PRINTER FOR SYSTEM/3
The 6609 System/3 printer, designed for use with IBM System/3 model 8, 10, 12, and 15 computers, is available as a direct replacement for all IBM 5203 and 1403 printer models currently used with System/3 computers. Featuring 900-line/min. performance, the units operate under std system software and require no change to user programs. They deliver clear, readable characters on single through 5-part forms. Rated speeds are attained when printing a full 63-char set over a 132-column print line. Decision Data Computer Corp, 100 Witmer Rd, Horsham, PA 19044. Circle 208 on Inquiry Card

For immediate need, circle 67 on Inquiry Card. For information only, circle 68 on Inquiry Card.

THIS TIME
MICRODATA
HAS GONE TOO FAR!

THEIR OEM PERIPHERALS WERE UNFAIR BEFORE, BUT LODESTAR IS TOO MUCH! NOW THEY'VE FOUND A WAY TO PUT 10 MEGABYTES ON A 3M-TYPE CARTRIDGE, 6400 BPI ON 1/4 INCH TAPE!

TALK ABOUT UNFAIR COMPETITION! THAT'S TWICE THE CAPACITY OF MY BEST 3M CARTRIDGE DRIVES. AND LODESTAR IS PLUG AND SOFTWARE COMPATIBLE WITH STANDARD REEL-TO-REEL SYSTEMS.

EVEN AT THOSE HIGH DENSITIES, LODESTAR'S MTBF IS OVER 4000 HOURS. AND IT'S SO DARN COMPACT YOU CAN MOUNT TWO OF THEM IN 7 INCHES OF VERTICAL RACK SPACE. BOY, THEY DON'T MISS A TRICK.

I HOPE NONE OF MY OEM CUSTOMERS FIND OUT ABOUT THIS ONE!
REFLEX? HERE'S MY REFLEX!
IT'S INCREDIBLE! NOW MICRODATA'S UNHOOKING MY DISC MEMORY BUSINESS!

THIS NEW REFLEX DRIVE HAS THE RELIABILITY OF FIXED MEDIA AND THE SPEED OF WINCHESTER TECHNOLOGY AT A LOWER COST PER BIT THAN ANYTHING ELSE ON THE MARKET.

THEY'VE CUT ACCESS TIME WITH FASTER HEAD POSITIONING, FASTER ROTATION AND TWO HEADS PER SURFACE. THERE'S EVEN A FIXED HEAD-PER-TRACK OPTION.

YOU'D THINK THAT WOULD BE ENOUGH, BUT NOT FOR MICRODATA, THEY LOVE TO PILE IT ON. COMPATIBILITY WITH STORAGE MODULE, BETTER RELIABILITY, BETTER PERFORMANCE, COMPACT 7-INCH RACK MOUNT PACKAGE. IT JUST NEVER STOPS.

MY ONLY HOPE IS MAYBE THEY CAN'T DELIVER.

Sorry, Chuck, we're taking orders right now. OEM's should call or write directly to Microdata Corporation, P.O. Box 19501, Irvine, California 92713, Telephone: 714/540-6730.

PRODUCTS

FREQUENCY-TO-VOLTAGE CONVERTER

The 9001 family is offered in std input frequency ranges of 100, 20, and 10 kHz, with all units factory pretrimmed within 0.4% (max) of full scale. Self-contained modules require only a single 15-V supply. Typical linearity is within 0.01%, and peak ripple is <25 mV typ. Gain TC is held within 100 ppm/°C (max). Designed to accept ragged input waveforms without pulse-shaping, units have an internal timing section that makes them insensitive to variations in input waveform duty cycle. Dynamic Measurements Corp, 6 Lowell Ave, Winchester, MA 01890.

Circle 209 on Inquiry Card

p/ROM PROGRAMMER

Consisting of M920 master control unit and a plug-in p/ROM personality module, series 92 uses interchangeable personality modules (same as series 90) to program all major MOS or bipolar p/ROMs. A built-in 20-mA current loop allows operation with teleprinter or with any terminal, computer, or microprocessor development system having this interface. The unit can be commanded to program, list, duplicate, or verify p/ROMs; or can be used as a stand-alone p/ROM duplicator. Pro-Log Corp, 2411 Garden Rd, Monterey, CA 93940.

Circle 210 on Inquiry Card

GAS DISCHARGE PANEL DISPLAYS

Displaying between 19 and 96 characters depending on desired character format, series C4101 has 17 horizontal rows x 192 columns which easily adapt for displays of graphs, signatures, and waveforms. Panel can be programmed to display 19 x 12 char nearly 1/2" high, or 96 x 5 char (each 0.27" high) in three rows of 32 each. Single self-scan unit, with anode and cathode drive electronics, measures 12 x 2 x 1", requires max of 23 connections, and weighs 10 oz. Burroughs Corp, Electronic Components Div, PO Box 1226, Plainfield, NJ 07081.

Circle 211 on Inquiry Card

Microdata


For immediate need, circle 107 on Inquiry Card. For information only, circle 108 on Inquiry Card.
The
IMSAI 8080.
A commercial
yet personally
affordable
computer.

If you thought you could never afford a computer at home, think again. The IMSAI 8080 is built for rugged industrial performance. Yet its prices are competitive with Altair's hobbyist kit. Fully assembled, the 8080 is $931. Unassembled, it's $579.

The IMSAI 8080 is made for commercial users, and it looks it. Inside and out. The cabinet is attractive, heavy gauge aluminum. The heavy duty lucite front panel has an extra 8 program controlled LEDs. It plugs directly into the Mother Board without a wire harness. And rugged commercial grade paddle switches are backed up by reliable debouncing circuits.

The system is optionally expandable to a substantial system with 22 slots in a single printed circuit board. And the durable card cage is made of commercial-grade anodized aluminum.

The IMSAI 8080 power supply produces a true 28 amp current, enough to power a full system. You can expand to a powerful system with 64K of software protectable memory plus an intelligent floppy disk controller. You can add an audio tape cassette input device, a printer plus a video terminal and a teletype. And these peripherals will function with an 8-level priority interrupt system. BASIC software is available in 4K, 8K and 12K.

Get a complete illustrated brochure describing the IMSAI 8080, options, peripherals, software, prices and specifications. Send one dollar to cover handling to IMS. The IMSAI 8080. From the same technology that developed the HYPERCUBE Computer architecture and Intelligent Disk systems.

Dealer inquiries invited.

IMSAI 8080

40-PIN IC TEST CLIPS
Proto-Clip™ 40 is compatible with 0.6" center ICs up to 40 pins. Test clip offers a narrow throat for bringing IC leads up from high density PC boards—practically eliminating accidental shorts while testing live circuits. It can be used to inject signals and wire unused circuits into other boards. Scope probes and test leads lock onto the gripping contact teeth. Noncorrosoive nickel/silver contacts provide simultaneous wiping action, and low resistance connections to IC leads. Continental Specialties Corp, 44 Kendall St, PO Box 1942, New Haven, CT 06509. Circle 213 on Inquiry Card

MICROPROCESSOR-CONTROLLED DIGITAL CASSETTE RECORDER
Factory dedicated to a specific instrument the dcr/10 comes complete with proper interface cable. Processor edits data to produce consistent blocked records for computer analysis. Firmware control allows units to accommodate serial or 8-bit parallel data at any baud rate, as well as any code conversion required. Tapes may be read directly by a computer's cassette system. Models currently available include TI Silent 733 A5R, Wang 2200 series, and Digital Equipment Corp with DECassette. William Palmer Industries, 1627 Pontius Ave, Los Angeles, CA 90025. Circle 214 on Inquiry Card

SOLID-STATE IMAGE SENSORS
Line scanners are available with 15-µm (H series) and 25-µm (G series) element-to-element spacing. G series is offered in 128, 256, 512, 768, and 1024 element configurations and contains onchip monolithic drivers and video amps. Instead of multiphase clocks, it accepts single phase TTL drive, simplifying required peripheral circuits. Cascaded devices readily drive one another for high resolution applications requiring multiples of 1024 elements. H series is available in 1024 and 1728 element formats for single chip facsimile and OCR use. Reticon Corp, 910 Benicia Ave, Sunnyvale, CA 94086. Circle 215 on Inquiry Card

PC BOARD
SOLID-STATE RELAYS
Miniature solid-state relays require a 1.27 sq in. area, switch up to 3 A at 120 or 240 Vac, and are available with 3 to 8, 8 to 16, and 18 to 32 Vdc inputs to minimize input current and op temp. Capable of being driven directly by TTL logic, the units offer zero crossover switching, photo-isolation between input and output, total epitax encapsulation, IC compatibility, long life, and immunity to shock and vibration. Elec-Trol, Inc, 26477 N Golden Valley Rd, Saugus, CA 91350. Circle 216 on Inquiry Card
Introducing The FlexiFile Family From Tri-Data...

**FlexiFile 10**

requires NO software modification in your present system. Tri Data provides an RS-232 coupler for data communications interface. So you can replace your data set or terminal. Connected between the terminal and modem, the FlexiFile 10 can serve as a recording device for both units. And you can replace high speed paper ... 816 feet per single floppy disk.

**FlexiFile 11**

is user-defined. It's as easy as pushing the reset switch. 8 LED'S indicate each operating mode ... using your own protocols, control words, and commands. The FlexiFile 11 is Microprocessor Controlled and floppy disk based. Our fully modular interfaces include an RS 232 coupler, and IEEE-488 instrumentation Bus, and an 8 Bit Parallel Bus. Complete program loading and on-line storage. Stand alone or rack mount options.

---

**PRODUCTS**

8-WORD PLUG-IN INTERFACE FOR PDP-8A

To meet the need for increased input capacity (96 bits) in the PDP-8A, the 8-word interface allows direct input from a number of external data sources or peripherals. IOT codes for the group of input words and associated interrupt/skip/clear functions are jumper selectable for max software flexibility. Two words and two interrupts are arranged in each of four input connectors. Model 8W can be used with the std DEC instruction set to interface the company's model 400 high speed tape reader to the PDP-8A. **Forte Technology Inc**, 15 Strathmore Rd, Natick, MA 01760.

Circle 217 on Inquiry Card

**COMPUTER/PERIPHERAL INTERFACE UNIT**

A coaxial cable interface unit, model CCI-4000 is designed for computer to computer and computer to peripheral communication at any bit rate up to 1M baud. Two or more computers can be connected to a single coaxial cable. Computer/peripheral connections can also be provided by the addition of plug-in peripheral point boards. Peripherals may be intermixed and operated at different speeds. Transmission distance can be as high as 40K ft, without repeaters, on low loss coaxial cable. **Computrol Corp**, Berkshire Industrial Pk, Bethel, CT 06801.

Circle 218 on Inquiry Card

**HIGH SLEW RATE OPERATIONAL AMPLIFIERS**

Models A970 and A975 operational amplifiers are wideband and feature high slew rate. In addition to low bias current, high input impedance, and high CMRR, they are packaged in TO-99 cases. Specs include slew rate of 80 V/µs for the A975; and gain bandwidth of 100 MHz, and an open loop gain of 95 dB for the A970. Both have input impedance of >100 MΩ. Devices operate over a temperature range of 0 to 70°C. **Hybrid Systems Corp**, Crosby Dr, Bedford, MA 01730.

Circle 219 on Inquiry Card

---

**Fenner Endless Belts**

Fenner Posi-Drive "40 DP" Belts are designed for precision performance in sensitive drive applications. These gear tooth belts are ozone-resistant and will operate at pulley speeds up to 20,000 RPM. Available in 64 different sizes, with either Kevlar or Polyester construction, Fenner Posi-Drive Belts offer excellent flexibility to meet your most exacting design requirements.
**HIGH EFFICIENCY POWER SUPPLY**

Model HE252 achieves 75% efficiency and is contained in a 6.5 x 4.5 x 3.2" package weighing 3.25 lb. Cool operating unit is designed with the “footprint” and mounting hole configuration of Lambda’s B package size supplies. Output is 5 V, 20 A at 45°C; input is 90 to 130 Vac (180 to 260 Vac, model HE254E) at 47 to 450 Hz. Line and load regulation is ±0.1% max for a 10% change in line from no load to full load. Other specs include 50-mV pk-pk max ripple and noise; and 0.01%/°C tempco typical. Computer Products, 1400 NW 70th St, PO Box 23849, Fort Lauderdale, FL 33307.

**SOLID-STATE RELAYS**

Challenger series units offer power ratings to 8 A, and feature zero voltage turn-on, internal snubbers for the Triac, half-cycle response, and firm bistable turn-on action. In addition, they accept spade-type quick-connect terminals. Series 2, a panel mount version, is transfer molded with overall dimensions of 1.75 x 0.81 x 0.60". Load current rating is 8 A rms when mounted on a heat sink. Series 3, a PC mount version, is ¾" high and is rated for 2 A rms. International Rectifier Corp, Crydom Div, 1521 Grand Ave, El Segundo, CA 90245.

**IEEE-BUS-COMPATIBLE MAGNETIC TAPE FORMATTER**

Model 1015A allows the user to add any industry std magnetic tape drive to the general-purpose interface bus (IEEE 488-1975). It provides asynchronous data transfer to and from synchronous tape recorders. Features include read-after-write error checking with automatic correction, rapid recording rates, and no loss of data during interrecord gaps. A dedicated Z-80 microprocessor manages both bus interface and memory management functions. Formatter is available in 7-track (200, 556, or 800 char/in. NRZI), 9-track (800 char/in.), or 9-track 1600 char/in. PE. Dylon Corp, 7854 Ronson Rd, San Diego, CA 92111.

**HIGH TEMPERATURE PC CARD BUS**

E series model B10200/B10300 is capable of withstanding high temperatures and extended dwell times in wave soldering. Utilizing Nomex and Kapton, combined with a special thermostetting adhesive system, the parts (both vertical and flat DIP bus) withstand soldering temperatures up to 520°F and solder wave dwell of up to 30 s with no danger of delamination or deterioration. Buses are available in single- and multi-layer types. Radius pin tips are provided for easy insertion. Busco Engineering Inc, 119 Standard St, El Segundo, CA 90245.

**SYNCHRONOUS MULTIPLEXER**

Timeline 290 Miniplexer, a synchronous time division multiplexer, will split a 2400-, 4800-, or 9600-bit/s facility, DDS or conventional, into two, three, or four separate channels. Users of Bell 209 data sets can switch to DDS without losing handsplitting benefits. Inputs may be a mix of DDS and conventional at speeds of 600, 1200, 2400, 4800, and 7200 bits/s. Input speeds are switch selectable and LED indicators display mode of operation. A switch for each channel sets it in local loop or test mode. Infotron Systems Corp, 7900 N Crescent Blvd, Pennsauken, NJ 08110.

**IEEE-BUS-COMPATIBLE MAGNETIC TAPE FORMATTER**

Model 1015A allows the user to add any industry std magnetic tape drive to the general-purpose interface bus (IEEE 488-1975). It provides asynchronous data transfer to and from synchronous tape recorders. Features include read-after-write error checking with automatic correction, rapid recording rates, and no loss of data during interrecord gaps. A dedicated Z-80 microprocessor manages both bus interface and memory management functions. Formatter is available in 7-track (200, 556, or 800 char/in. NRZI), 9-track (800 char/in.), or 9-track 1600 char/in. PE. Dylon Corp, 7854 Ronson Rd, San Diego, CA 92111.

**HIGH TEMPERATURE PC CARD BUS**

E series model B10200/B10300 is capable of withstanding high temperatures and extended dwell times in wave soldering. Utilizing Nomex and Kapton, combined with a special thermostetting adhesive system, the parts (both vertical and flat DIP bus) withstand soldering temperatures up to 520°F and solder wave dwell of up to 30 s with no danger of delamination or deterioration. Buses are available in single- and multi-layer types. Radius pin tips are provided for easy insertion. Busco Engineering Inc, 119 Standard St, El Segundo, CA 90245.
The publishers of COMPUTER DESIGN and the leading industrial market research company INTERNATIONAL DATA CORPORATION announce a significant new market research report entitled:

Survey of Microprocessor/ Microcomputer Buyers

7000 COMPUTER DESIGN readers were surveyed to determine:

- the type of equipment using µPs/µCs they are currently designing.
- the µP/µC models selected and the criteria for the selection
- the memories selected and the criteria for the selection.
- peripherals used with the equipment.
- various aspects of software and test.
- opinions on current µPs/µCs and peripherals.
- recommendations for their improvement.
- future plans for using µPs/µCs and much more.

The 150 page report contains more than 50 tabulations of data from the survey, many of them correlating use factors and selection criteria with type of equipment. Each table is accompanied by an explanation of its meaning and an interpretation of its significance.

For a more detailed description of the report, circle 120 on the Reader Inquiry Card, or write:

Survey of Microprocessor/ Microcomputer Buyers

Computer Design
Market Research Group
143 Swanton St.
Winchester, MA 01890

PRODUCTS

SPDT SUBMINIATURE SLIDE SWITCH

With a PC mounting terminal, model 1101CQ features a low profile slide actuator measuring 0.152 in. (3.86 mm) x 0.200" H (5.08 mm). Switch body measures 0.500 (12.7 mm) x 0.260 (6.60 mm) x 0.250" (6.35 mm). Actuator sits atop field proven internal mechanism. With spring-loaded teflon contact follower, slide retains same terminal sealing and options available with toggle switches. Contact rating is 6 A with resistive load at 120 Vac or 28 Vdc; 3 A with resistive load at 250 Vac. C&K Components, Inc, 103 Morse St, Watertown, MA 02172. Circle 225 on Inquiry Card

DIP SOCKET/RECEPTACLE

ZIP DIP II socket/receptacle series features enlarged entry for use with a wider range of devices, and a flat top plate for easier entry and extraction. Contacts are on even 100-mil spacing (300-400-600 mil) for convenient mounting on std hardware. A built-in “stop” insures that the socket handle cannot be easily overstressed. Top mounted assembly screws facilitate replacement of damaged or worn internal parts. Virtually eliminating mechanical re­jects, device has a typ life of 25,000 to 50,000 insertions. Textool Products, Inc, 1410 W Pioneer Dr, Irving, TX 75061. Circle 226 on Inquiry Card

PC CARD GUIDE/HEAT SINK

Series 1000 metal (phosphor bronze, beryli­lium copper, or stainless steel) PC card guide, when assembled into an aluminum heat sink guide bar (GBH-1000), offers exceptional heat dissipation. Spring-finger action of the card guide firmly presses one edge of the PC card into contact with the guide bar over its entire length, providing an extremely large contact area for effective heat transfer. Guide bar and card assembly can be mounted with mounting clips at each end or epoxied or riveted directly to the chassis. Unitrack Div, Calabro Plastics, Inc, 8738 W Chester Pike, Upper Darby, PA 19082. Circle 227 on Inquiry Card

Switch Access From Racked PC Boards

Grayhill Piano-DIP™ Side-Actuated Rocker DIP Switches

SPST circuitry under each rocker... Dimensionally compatible with SPST, SPDT, and DPDT Rocker DIP switches and standard sockets.

- Positive identification of rocker position from the side of the mounted switch.
- Low profile...can be readily edge mounted on racked PC boards.
- Grayhill’s reliable spring loaded, sliding ball contact system...life rated at 50,000 operations with positive wiping action and immunity to normal shock and vibration.

Here's the latest entry to the comprehensive and innovative Grayhill DIP switch line...a new switch that can be actuated without removing the PC board from its rack. Because of its distinctive shape and side ac­tuation, Grayhill calls this the PIANO-DIP®. It's ideal for mounting on the exposed edge of a racked PC board, allowing engineer or technician easy programming access. PIANO­DIP® switches are now offered with 7 rockers; future versions will include 4 to 10 switch stations. Complete information is contained in Bulletin 260R321, available free on request from Grayhill, Inc., 561 Hillgrove Avenue, La Grange, Illinois 60525; phone: (312) 354-1040.
CO-3000L INC tape is DECtape® compatible and offers media interchangeability with any computer equipped with DEC-tape. With capacity for 148K 16-bit words in blocks of 256, the unit offers direct access storage suitable for tough industrial environments. A tape driver for DEC's RT-11 operating system supports MACRO, EDIT, FORTRAN IV, and BASIC. The system can be used in real-time systems for overlays and data acquisition. Controller occupies a quad slot in the LSI-11 and contains a FIFO buffer and optional ROM bootstrap. Computer Operations, Inc, 9700-B George Palmer Hwy, Lanham, MD 20801. Circle 228 on Inquiry Card

5-OUTPUT SWITCHING POWER SUPPLY

Producing up to 750 W of power in a 5.10 x 7 x 12.75" package, model MM-450 is up to 80% efficient and features 1% pk-pk or 50-mV pk-pk ripple and noise on output, line regulation of 0.4% over the entire input range, and load regulation of 0.4% from no-load to full-load. Response time is 200 µs to 1% after 25% load change. Primary output is 5 V at 150 A; the four other outputs can be 5 V at 5 A, 12 V at 5 A, 15 V at 5 A, 18 V at 4 A, or 24 V at 3 A to a total max of 750 W. LH Research, Inc, 1821 Langley Ave, Irvine, CA 92714. Circle 230 on Inquiry Card

SYNCHRO-TO-RESOLVER CONVERTER

The 60-Hz unit (part number 52448) converts 90-V line-to-line synchro information to 6-V sine and cosine information. Nominal dimensions are 1 x 1 1/4 x 1 1/8", providing close board to board spacing in multiboard systems and in potted modules; 0.040" diameter pins are provided for mounting. Basic accuracy of 1 arc min. is achieved by accurate magnetic transformation ratio, and is independent of temperature or age. With isolation from high common mode synchro bus voltage and transients, no synchro bus grounding is required. Magnetoic, Inc, 182 Morris Ave, Holtsville, NY 11742. Circle 231 on Inquiry Card
MARK-SENSOR ARRAYS

The CYCLOPS single channel device has a micro-miniature GaS emitter and Si detector in one integral package. Field of vision is zero and there is no focal point or blind spot as with conventional configurations. Used to detect paper or card edges, holes, pencil marks, patterns, applications include industrial processing and control, computer card reading, and shaft or position encoders. A 6-channel custom array on 0.125" centers, and a 22-channel array on 0.1" centers are also available. Ultra Sensors, Inc, 2400 W 102nd St, Suite 313, Minneapolis, MN 55431. Circle 232 on Inquiry Card

REMOTE DATA ENTRY KEYSTATION

Remote keystation capability for the CMC 1800 allows operators at remote sites to enter, verify, correct, and update data via telephone lines under control of a central supervisor. A keypunch-style keyboard (1155) or a typewriter-style keyboard with numeric pad (1156) are independently movable; both models use standard CMC software. Data transmission to and from remote stations is asynchronous, full-duplex, on 2- or 4-wire systems. Pertec Computer Corp, CMC Div, 2500 Walnut Ave, Marina del Rey, CA 90291. Circle 235 on Inquiry Card

AUTOMATIC POSITIONING SYSTEM CONTROLLER

Using a microprocessor for positioning up to four axes for combinations of linear or circular motion, Anomatic controllers feature the use of a 12-V CMOS bus, which interconnects the microprocessor to all I/O devices. All logic and controls are CMOS; microprocessor, pROM, and ROM, located in one section of a card, are TTL. Noise immunity is 4.8 V throughout. System contains built-in pROM programmer to provide nonvolatile memory, and can be programmed from internal memory, paper tape, cassettes, or mag cards. Anorad Corp, 115 Plant Ave, Smithtown, NY 11787. Circle 268 on Inquiry Card

FLOPPY DISC SEND/RECEIVE TERMINAL

A 2-way batch terminal with complete editing and data search capability, disc storage for over 311K char, and full RS-232 interface compatibility, the RDS/FDSR is plug-compatible with existing RS-232 data terminals. Over 2400 addressable lines of 128 char can be accessed from the terminal within 0.3 s or from asynchronous CRT or keyboard/printer terminal. Randal Data Systems Inc, 365 Maple Ave, Torrance, CA 90503. Circle 270 on Inquiry Card

DIGITAL CASSETTES

Abraxas V cassettes feature selection of write enable-write inhibit, optional BOT/EOT marker holes, and interlocking tongue and groove construction to eliminate contamination. Model V-P is a general-purpose unit designed to function on tape drives with built-in guidance systems; model V-C provides its own tape control. V-W is made for word processing equipment, automatic text editing typewriters, and computer-aided word processors; and the V-I is designed for Wang programmable calculators. CFI Memories, Inc, 365 Crescent Way, Anaheim, CA 92801. Circle 236 on Inquiry Card

ACOUSTIC COUPLER

Model 302C provides for data transfer between a remote computer, a local terminal, and an ordinary audio mag tape cassette unit. Unit is a 300-haud acoustically coupled modem providing carrier indicator, full/half-duplex, and mag tape unit interface. Data are recorded and retrieved in the form of records and blocks as determined by an operator selectable switch which may be set to retrieve all data without marker interruptions. At 300 baud, the recorder stores up to 150K characters on ordinary cassettes. ComData Corp, 8115 Monticello, Skokie, IL 60076. Circle 234 on Inquiry Card

FLOATING POINT ARRAY FOR H-P 2100

Computational capability of Hewlett-Packard's 2100 series can be greatly expanded by the addition of this programmable array processing peripheral which increases the system's processing speeds by as much as several orders of magnitude without sacrificing accuracy or precision. Ability to efficiently handle a wide range of algorithms is gained; multiprocessor architecture offers enhanced speed and the advantage of optimized throughput by overlapping input, output, arithmetic, and executive operations. CSP Inc, 209 Mid-dlesex Tpk, Burlington, MA 01803. Circle 269 on Inquiry Card

DUAL OUTPUT LIGHT PEN

Solid-state assembly of the 120-1 utilizes optoelectronic and hybrid circuitry to provide TTL-compatible "light pen switch" and "light pen bit" outputs. A switch signal is generated whenever the tip of the pen is pressed against the CRT faceplate; hit occurs when an unblanketed spot on the faceplate is under the pen tip. Signals are transmitted through the light pen cable to control logic of the terminal subsystem. The IBM-compatible unit features fast signal response time, excellent resolution, and high ambient light rejection. HEI, Inc, Jonathan Industrial Ctr, Chaska, MN 55318. Circle 271 on Inquiry Card
SMALL WIREWRAP IC BOARDS

IC pluggable packaging assemblies measure as little as 4.86 x 4.38" and contain as many as 12, 18, or 24 IC positions. A universal version consists of 12 columns of 35 socket/terminals on 0.100" centers; a high density version has from 16 to 20 universal columns and 12 test terminals. Card-edge connector is std on all versions. Series ECM 72 has 14 or 16 socket/terminals per IC position, with or without voltage and ground sockets. Wirewrap posts can be provided for 1-, 2-, or 3-level wrapping.

Garry Manufacturing Co, 1010 Jersey Ave, New Brunswick, NJ 08902. Circle 237 on Inquiry Card

ENDLESS LOOP TAPE TRANSPORT

Model A5 uses std NAB A size cartridge and has a self-governed dc motor that maintains exact speed over a 10- to 16-V range. Electrically controlled for remote operation, the fail safe design protects tape and transport in case of power interruption. Industrial 4-point mounts for both heads provide separate zenith, height, and azimuth adjustments. High traction, self-aligning pinch roller contains instrument hall bearing, eliminating tape edge wear. Front panel permits easy cartridge loading. Amilon Corp, 49-12 30th Ave, Woodside, NY 11377. Circle 238 on Inquiry Card

INTELLIGENT MODEM

The model 4910 provides dial-up capability for timesharing terminals through DDD at 10, 20, or 30 char/s transmission speeds, access to the TWX network, direct hook-up for a local computer communications front-end, or access to the TWX/DDD networks for multiple add-on terminals through a special RS-232-C interface. Switch-selectable printing speeds are 10, 20, and 30 char/s, 80 or 132 print positions. Single or dual magnetic tape cassettes and 1200-baud tape transmission are provided. Omnitec Corp, 2405 S 20th St, Phoenix, AZ 85034. Circle 239 on Inquiry Card

DATA TABLET/GRAPHIC CALCULATOR INTERFACES

Capable of interfacing the company's products to the Tektronix 4051 graphic calculator, interfaces are available for both series of data tablets. Interface for the HW series is housed in a separate box while the microprocessor-controlled digitizer ID series is contained on a card internal to the electronics controller. Interface enables the transfer of X-Y coordinate values from the tablet to the calculator. All status bits, control functions, and handshaking signals are also transmitted. Summagraphics Corp, Box 781, Fairfield, CT 06430. Circle 241 on Inquiry Card

SIMPLE BECAUSE ITS SMART

Now its simple to tie almost any device directly to the IBM 360/370 I/O channels because of our smart controller. Tie your device to our controller (either parallel or serially) and it can appear as a supported device to the IBM 360/370.

If you design systems or manufacture terminals, peripherals, computers, instruments, or anything else that might benefit from an easy direct interface to the IBM 360/370's — contact us. The Austron Programmable Controller can open new market areas for you.

Austron INC
1915 KRAMER LANE, AUSTIN, TEXAS 78758 (512) 836-3523 TWX 910/874-1256

132-COLUMN LINE PRINTERS

Using the rotating belt technique, two models impact-print 1/1c text. Speed depends on the number of printable char/line. Model 9212 prints 120 to 240 lines/min.; model 9214 prints 230 to 240 lines/min. Operator controls and indicator lamps are straightforward and easily understood. Ample use of sound-deadening material keeps noise to a minimum. Std sprocketed paper can be fed directly from the shipping carton and the finished printout stacked in a tray for easy removal. Datapoint Corp, 9725 Datapoint Dr, San Antonio, TX 78284. Circle 240 on Inquiry Card

DATA TABLET/GRAPHIC CALCULATOR INTERFACES

Capable of interfacing the company's products to the Tektronix 4051 graphic calculator, interfaces are available for both series of data tablets. Interface for the HW series is housed in a separate box while the microprocessor-controlled digitizer ID series is contained on a card internal to the electronics controller. Interface enables the transfer of X-Y coordinate values from the tablet to the calculator. All status bits, control functions, and handshaking signals are also transmitted. Summagraphics Corp, Box 781, Fairfield, CT 06430. Circle 241 on Inquiry Card
LOW PROFILE SOLDER-TAB SOCKETS

With a profile of only 0.156" above the board, the 14- and 16-pin sockets feature good lead-in for IC leads as well as closed-entry for protection of contact springs. Contact spring compliance is achieved without compromise in the normal force on component leads. Design includes inverted contacts which apply pressure to the flat sides of the DIP lead, and a molded lead-in funnel which guides the DIP into the contact area and protects against contact damage. Housings are glass-reinforced nylon. Cambridge Thermionic Corp., 445 Concord Ave, Cambridge, MA 02138. Circle 242 on Inquiry Card

BIT ERROR RATE TESTER

Complete end-to-end performance testing of communication links, tape recorders, bit synchronizers, or any PCM system having a bit rate within the 1- to 5M-bit/s range is provided by the model 721. Two basic data patterns generated are a 16-bit word, with each bit front panel selectable; and a 2047-bit pseudo-random word. Frame length is selectable from 1 to 512 words/frame, in increments of powers of two. A bit-blanking function is provided for bit synchronizer flywheeling or coasting measurement. EMR-Telemetry, PO Box 3041, Sarasota, FL 33578. Circle 243 on Inquiry Card

DIGITAL IMPACT PRINTER

Model 102 digital impact printing mechanism is a parallel-entry 18-col printer with std 13-char font that can also be customized. Print speed is 2.7 lines/s, in black and red, on 2½"-wide std paper (pressure sensitive may be used). Driven by a Shinshu Seiki transistorized brushless constant-speed dc motor requiring low operating power (15 Vdc, 490 mA max), printer is guaranteed for MTBF of 5M lines of continuous operation. Printer measures 9½ x 5½ x 4½". C. Itoh Electronics, Inc., Systems and Components Div, 200 Park Ave, New York, NY 10017. Circle 244 on Inquiry Card

PDP-11/70 PLUG-COMPATIBLE CORE MEMORY

The ARM-1170, a transparent alternative to or replacement for MJ11 memories used in PDP-11/70 computers, is available in 128K-byte (32K words of 36 bits each) increments and is capable of expanding the computers to their max 4M-byte capacity within the two system cabinets. Throughput enhancement is provided by 2- or 4-way internal interleaving. 4-way interleaving gives an effective cycle time of 350 ns, compared with 800 ns for the basic memory or 1000 ns for DEC memory. Ampex Corp., Memory Products Div, 200 N Nash St, El Segundo, CA 90245. Circle 245 on Inquiry Card

PROCESSOR STORAGE SYSTEM

Multimemory/168 for IBM 370/168 computer installations is designed for memory capacities of up to 8M bytes on a single processor and 16M bytes on a multiprocessor. It is completely compatible and attachable to all IBM 168 models. A maintenance deferral system allows the operator to detect memory failure via lighted display on the system's panel, and correct the failed memory block by flipping a switch to automatically remove the block from the system and restore address continuity. Electronic Memories and Magnetics Corp., Systems Equipment Div, 3216 W El Segundo Blvd, Hawthorne, CA 90250. Circle 246 on Inquiry Card

This announcement is neither an offer to sell nor a solicitation of an offer to buy these securities. The offer is made only by the Prospectus.

September 16, 1976

410,336 Shares

ROLLM CORPORATION

Common Stock

Price $14 Per Share

Copies of the Prospectus may be obtained in any State in which this announcement is circulated only from such of the undersigned as may legally offer these securities in such State.

E. F. Hutton & Company Inc. Robertson, Colman, Siebel & Weisel
Bache Halsey Stuart Inc. Dillon, Read & Co. Inc.
Blyth Eastman Dillon & Co. Incorporated
Donaldson, Lufkin & Jenrette
Securities Corporation
Goldman, Sachs & Co.
Kidder, Peabody & Co. Incorporated
Paine, Webber, Jackson & Curtis Incorporated
Dean Witter & Co.
Shearson Hayden Stone Inc.

The First Boston Corporation
Dillon, Read & Co. Inc.
Drexel Burnham & Co. Incorporated
Hornblower & Weeks-Hemphill, Noyes Incorporated
Loeb, Rhoades & Co.
Reynolds Securities Inc.
Hambrecht & Quist
C. E. Unterberg, Towbin Co.

CIRCLE 77 ON INQUIRY CARD 175
DIGITAL SCANNER SYSTEM

Featuring time and frequency division multiplexing in each compact transmitter and receiver module, QSS-1130 is an all solid-state system that permits transmission and reception of up to 11 discrete data points at speeds up to 50 bits/s as std, or control in some applications. System consists of a QST-1130 scanner transmitter, QSR-1130 scanner receiver, optional QSD-1130 status display unit, and optional (separately mounted) QSK-1130 relay output. Combination QSKD-1130 relay and status display unit is also available. System uses CMOS digital logic. QEI, Inc, 60 Fadem Rd, Springfield, NJ 07081. Circle 247 on Inquiry Card

INCREMENTAL-DIGITAL POSITIONING CONTROL

CSR servo translator is a high response, closed loop system that accepts digital positioning commands in the form of a serial pulse train. Each pulse causes the motor to move one step in either a clockwise or counterclockwise direction. Rate at which pulses are received determines motor speed. Features include absolute digital translator subtractor circuitry and a patented pulse-width modulated driver for controlling high response, permanent magnet motors. Torques are provided up to 300 in-lb. Control Systems Research, Inc, CSR Bldg, 632 Fort Duquesne Blvd, Pittsburgh, PA 15222. Circle 248 on Inquiry Card

LED PUSHBUTTON SWITCHES

A funnel-shaped reflector at the base of the diode helps beam red, yellow, and green lights to the front display surface of the pushbutton/indicator. The 5-, 10-, and 15-Vdc switches have an internal re­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­­…
LSI-11 COMPATIBLE D-A SYSTEM

Model 600-LSI-11D is a digital to analog system compatible with the DEC LSI-11 and PDP-11/03 microcomputers. Basic system configuration, contained on a single 5 x 8½" PC board, consists of bus interface, dc-dc power converter, scope control, and one, two, three, or four 12-bit DACs. Scope control permits visual display of data without extraneous data, such as normally occurs during DAC updating intervals. Cable and documentation are also included. A third wire sense lead from each DAC is optional. ADAC Corp, 15 Cummings Pk, Woburn, MA 01801. Circle 250 on Inquiry Card

SCIENTIFIC COMPUTER

For scientific, instrumentation, and computational applications, Eclipse S/230 features main memory capacity of up to 512K bytes of high speed semiconductor, core, or mixed memories; full memory mapping and protection; and an expanded data channel memory space. The 16-slot computer also has a 16-bit microprogrammed architecture with optional writable control store. This consists of 256 56-bit words of user-programmable RAM for writing specialized instructions, optional high speed single- and double-precision floating point processor, and comprehensive instruction set. Data General Corp, Southboro, MA 01772. Circle 251 on Inquiry Card

DATA ACQUISITION CONTROLLER

Microcomputer-based data collection and control system has both analog and digital inputs and outputs. Analog and digital input may be used for local control or stored and then sent serially to a remote site or computer. Front panel controls of the modular unit are software activated as needed. Functions are also defined in software so that changes need be made only in p/ROM, not in hardware. Additional modules include cassette, printer, and terminal interfaces, and solid-state relay controller. Tychon, Inc, PO Box 242, Blacksburg, VA 24060. Circle 252 on Inquiry Card

BUSSCO BUS BARS

SEND FOR NEW UPDATED 1976 CATALOG

CIRCUIT BOARD BUSSES

When used with a two sided board these busses replace more expensive multi-layer boards. Low inductance and high distributed capacitance offer low impedance power distribution. Also available as a bus under rows of ICs.

BUS STRIPS*

For busing rows of wrap terminals. One quick, press on operation saves two wraps per terminal. Available in standard grid patterns or special order. Sequential or random busing.

LAMINATED BUS BARS

Busco multi-layer, laminated bus bars replace wire bundles. Low inductance, low resistance and high capacitance makes this device ideal for power distribution in high speed, solid state systems.

BUSSCO ENGINEERING INC.

*U.S. Patent Nos. 3,582,864 and 3,668,820

CIRCLE 80 ON INQUIRY CARD
NEW FOR OEM

Miniature
PAPER TAPE PUNCH & READER

Unique brushless DC motor affords small size and top performance

Epson’s miniature punch/reader pair strips away bulk, adds reliability and cuts OEM cost.

Compare these value features

6110 Paper Tape Punch has:
- Long life steel punchblock
- Operation at 50 characters per second
- Easy to design control circuit
- Price in OEM quantities less than $200

6510 Paper Tape Reader has:
- Photoelectric reading of 400 characters per minute
- Built-in read and magnet-drive circuits
- TTL input/output signals employed
- Magnet brake that stops on character
- Reliable capstan roller tape drive

Customer must supply controller for both 6110 and 6510.

Complete factory parts, repair and customer training located at our Torrance main office.

Write or call for complete information

Epson
EPSON AMERICA, INC.
2990 W. Lomita Blvd., Torrance, CA 90505
(213) 530-6533

EPSON products are manufactured by SHINSHU SEIKI CO., LTD., Japan

PRODUCTS

EROM STORAGE AUTOPROGRAMMER

Model 583 will store, on interchangeable EROM cartridges, a sequence of programming commands which will automatically control the output of the company’s programmable generators. Particularly useful in systems applications involving repetitive tests, the instrument stores a sequence of up to 99 separate tests on each EROM cartridge; each can be called up as required. Test cycling can be either automatic or manual. Autoprogrammer will automatically sequence through up to 100 tests (addresses 00 through 99) displaying the current test address. By programming a stop command, processing can be halted at any given address within a test. Processing can then be manually continued by control panel key. EROM cartridges can be programmed using an EROM programmer or can be custom programmed. WaveTek, 9045 Balboa Ave, San Diego, CA 92125.

Circle 253 on Inquiry Card

INDUSTRIAL APPLICATION MINICOMPUTER

The P851M MicroMini uses LOCOS LSI technology, which combines LSI performance with improved noise immunity and low power consumption. The unit can be used as a micro or minicomputer to match application needs. Application software can be developed on any member of the P850M family. The general purpose bus expands to accommodate std I/O controllers and an I/O processor to ensure fast data transfer and direct memory access facility. Interface cards for digital and analog I/O mount directly in the CPU chassis. Static memories are available with from 6.5K to 2K words; dynamic memories with 4K or 8K words. Storing user applications programs, REPROMs are available in modules of 1K, 2K, or 4K words; they can be combined with RAM modules. A built-in panel gives diagnostic capability for maintenance. Philips Data Systems, PO Box 523, Eindhoven, The Netherlands.

Circle 254 on Inquiry Card

300-BIT/S ACOUSTIC COUPLER

Model FM30 transmits and receives asynchronous serial digital data at up to 300 bits/s, full- or half-duplex on DDD networks. An acoustically coupled data modem, the device permits data communication through the handset of an ordinary telephone, making it easier for timesharing users to cope with changing systems requirements, and providing mobility and portability to terminal usage. The unit is compatible with WE series 103 and 113 A/B data sets and with EIA RS-232-B/C, 20-mA current loop and TTL interfaces. Transmit frequencies are crystal controlled; the receiver uses active filters and digital detector. Sensitivity is -40 dBm. Frequency stability is ±0.15%, and transmit level is -16 dBm. Power requirements are 115 Vac, 60 Hz. Multi-Tech Systems, Inc, 9406 University Ave SE, Minneapolis, MN 55441.

Circle 255 on Inquiry Card
The Para-Probe™ system permits simple assembly of fixed point probe cards from a kit of components. A patented double cantilevered probe block eliminates pad scrub while retaining wipe action to remove surface oxides for virtually zero point-to-pad contact resistance. Probe blades are replaceable, probe cards rebuildable, and components reusable. The parallel method of construction allows high probe densities, making it possible to build cards with multiple interlocking parallel base blocks and forming a single module with an infinite number of probes in a straight line. Base blocks can also be mounted at 45-deg to dice side for contacting corner pads. Center-to-center spacing of 0.004" can be achieved. Alignment Enterprises, Dept 100, 9537 Telstar Ave, Suite 132, El Monte, CA 91732.

Circle 256 on Inquiry Card

16-CHANNEL ANALOG MULTIPLEXER
Model 4550 contains digital input buffers, decoder logic, analog switches, and an output buffer amplifier in a single package. It switches one of 16 inputs (switching action is break-before-make) to a common output depending on the state of the four address lines and the enable input. The unit can accept an input voltage range to ±10 V with an accuracy of ±0.01%, and has a max input overvoltage of ±35 V. Digital inputs are buffered with Schmitt trigger logic and have an overvoltage capability of ±19 V. Output settling time for a 20-V step to ±1 mV is 3 µs max (including 1-µs switching time). The number of input channels may be expanded by tying additional multiplexers together by connecting the op amp input terminals. Teledyne Philbrick, Allied Dr at Rt 128, Dedham, MA 02026.

Circle 257 on Inquiry Card

MULTI-OUTPUT SWITCHING POWER SUPPLY
A 4-output, 400/475-W supply, the model 674/675 is designed specifically for microprocessors, small computers, or add-on memories. Features include a main output for logic, a second for memory, and two for accessory power needs. Measuring 5 x 8 x 14.33", and weighing 15 lb, the unit has >60% efficiency, and a MTBF of >80,000 h. Outputs are: rail 1—2 or 5 Vdc out at 50/70 A (674/675 respectively); rail 2—±12 Vdc at 10/8 A, or >12 at 120/96 W; rail 3 and 4—±15 at 4/4 A, or >15 at 60/60 W (no second rail). Input is strappable to 102 to 130/188 to 256 Vac, 45 to 63 Hz, single phase. Dynamic regulation is 1% for each 10% of load current step. Output ripple and noise are 20 mV rms typ, 50 mV pk-pk. Trio Laboratories, Inc, 80 Dupont St, Plainview, NY 11803.

Circle 258 on Inquiry Card

Why eliminate world-wide sales with unlisted temperature controls? Many Elmwood snap-action thermostats are available to meet U.L., C.S.A. and European requirements for high limit or control. Choose wide or narrow differentials and tolerances to suit your application at minimum cost. Each is factory pre-set and tamperproof, 100% thermally and operationally tested and available with a variety of terminals, mounting brackets or custom packages. If your application requires exposures from -65° to +550°F, ask for suitable commercial or precision prototypes and prices to meet your needs. Elmwood Sensors, Inc., 1669 Elmwood Ave., Cranston, R. I. 02907. Phone 401/781-6500. European Div., Elmwood Sensors, Ltd. North Shields, Tyne and Wear, England

ELMWOOD SENSORS

CIRCLE 84 ON INQUIRY CARD
Socket Center

EMC HAS IT ALL!
Seeking sockets? EMC stocks the widest variety with the most options you can buy! 6 to 48 pins. Short, long or extra long terminals. Straight or bent leads. Thermoset molded materials. Platins. Standoffs. Short or standard contacts. Solder or Wire-Wrap® terminals. Special sockets custom-molded... even fabricated if you need it. All of the finest, highest quality workmanship, at the lowest prices, in any quantity. EMC does have it all. For you. Today. Call or write for new Catalog '76. Electronic Molding Corp., 96 Mill Street, Woonsocket, R.I. 02895. Phone (401) 769-3800.

PRODUCTS

MICROPROCESSOR-CONTROLLED PROCESS PROGRAMMER

Model 5600 μ-DATA TRAK reduces programming costs and increases flexibility for industrial process programmers by providing one or two analog set point programs for process manipulation vs time, plus seven programmable on/off event functions. Programs are generated by best-fit straightline segments of a desired profile, stored and retrieved using digital and microprocessor techniques. Capacity for up to 40 line segments is available with process resolution to one part in 1000. Programming entry into the micro's memory is via a keyboard on the front panel. Sixteen pushbuttons allow the operator to select 28 functions. Front panel display is 0.47" tall incandescent digits plus sign. The device provides programmed output voltage of 0 to 5 V into 500 Ω and output current of 4 to 20 mA into 500 Ω. Research, Inc., PO Box 24064, Minneapolis, MN 55424.

PUSHBUTTON SWITCHES
Using a pair of formed wires for actuation, contact, and termination, spst switch eliminates the snap-acting leaf spring and provides low bounce characteristics with high current-carrying capacity and long mechanical life. The two formed wires handle three functions: tactile feel and spring return, surfaces for electrical contact, and termination areas for solder or wirewrap connection. Most applications require no buffering; minimum buffering is needed for TTL and MOS circuitry. Contact surfaces move against each other, and are wiped electrically clean during each make/break cycle. Designed for direct-stripe or matrix mounting on PC boards, the switch has a nominal switch life of >10 million cycles carrying a 12-V, 0.4-A load. RTC Inc., 343 E Fillmore, St. Paul, MN 55107.

DATA COLLECTION TERMINAL
A microprocessor-based data collection terminal, the Smart Clock interfaces with virtually any type of processor. The terminal, which can operate in either a real-time/online or standalone mode, reads up to 16 digits of Hollerith code from plastic ID badges and IBM cards, and will also accept numeric information via 10 pushbuttons. The unit contains up to 1.7K of factory-programmed ROM and up to 14K of data capacity. An internal battery insures nonvolatility in the event of power failure. Up to 64 terminals can be connected on the same interface line. Data are relayed to the host processor in ASCII form through either an RS-232-C, 20-mA current loop or built-in 600-baud modem interface. Coastal Data Services, Inc., 1592 NW 159th St, Miami, FL 33169.

CIRCLE 83 ON INQUIRY CARD
SYNCHRONOUS LINE DRIVER

Providing synchronous data transmission rates which allow full utilization of terminals, CPU ports, and data transmission lines, the SLD operates over common loaded multi-gauge cable at baud rates of >4800 bits/s. Over nonloaded cable, speeds of >19,200 bits/s are possible. All data rates are switch-selectable. Transmission distance ranges up to 25 mi. Each unit incorporates complete diagnostic capabilities including local and remote loopbacks, nine diagnostic LED indicators, and a pseudorandom word generator for self testing. Digitally generated sinewave output allows the device to conform to Bell spec 43401. A crystal oscillator is used for both signal generation and system timing. The units perform equally well in half- or full-duplex mode as well as in a polled environment. Prentice Electronics, 795 San Antonio Rd, Palo Alto, CA 94303.
Circle 262 on Inquiry Card

INTelligent PRINTING TERMINALS

The Carousel line features a power front-forms insertion device, which automatically feeds ledger cards, single sheets, and bottom-glued multipart forms into the platen. An additional accessory enables the device to handle multipart forms which are not bottom-glued, even when the sheets are of varying length. Model 320, a complete computer I/O printing terminal, includes a 120-char/s paper tape reader and plotting capability, and can replace an ASR Teletype, high speed printer, and plotter with a single unit. The 350 has a split platen and can accommodate two paper-handling devices simultaneously. The 310 provides a single platen, enables 4800-point/in² plotting capability, and accepts any forms-handling device. Perkin-Elmer Data Systems, Circles Terminals Div, Randolph Pk W, Rt 10 and Emery Ave, Randolph, NJ 07801.
Circle 263 on Inquiry Card

DISC MEMORY READ/WRITE FLYING HEAD ASSEMBLY

The FH 140 assembly incorporates a Winchester-type digital data transducer for use in fixed head-per-track or hybrid (moving plus fixed head) disc systems. Available with both 3-track (model 143) and 5-track (145) zinchal subassemblies, units provide 42 or 70 tracks, respectively. Standard are Winchester-type ferrite sliders with 9.5-nl track widths on 60-mil centers, which provide 67-track/in² density. Design operates on both oxide and nickel-cobalt discs under contact start/stop conditions. When coupled with the assembly, Winchester-type discs provide for a straightforward head/disc interface which can be designed into a complete disc system. The assembly can also be used in existing moving arm drive systems with only nominal design changes. National Micro Netics, Pacific Div, 5600 Kearny Mesa Rd, San Diego, CA 92111.
Circle 264 on Inquiry Card

a plug for our quiet one

ROYTRON
Model 1560-S
Reader/Punch
Serial Interface

High speed, compact, with integral electronics power supply and asynchronous serial interface. Self-contained in a quietized housing.

We’ve just made our popular Model 1560, RS-232C plug compatible. For OEM’s who don’t want the interface hassle. We added the “S” for Serial and Switching.

The 1560-S is designed to be connected between a terminal device (keyboard printer or CRT) and its associated modem or data coupler. And to the serial port of most minicomputers and microprocessors.

It satisfies NC, data communications, graphic arts and computer peripheral applications.

The punch accommodates oiled paper, dry paper, metallized mylar, sandwich paper/mylar/paper and polyester . . . 5, 6, 7 or 8-level tapes. It operates at data rates of 50, 75, 110, 134.5, 150, 300 or 600 baud.

The reader is a photoelectric unit with a highly reliable, stepping motor tape transport. It operates at rates of 50, 75, 110, 134.5, 150, 300, 600, 1200 or 2400 baud.

At OEM prices, of course.

For full details, write or call us.

Lltton 
OEM Products
34 Maple Avenue, Pine Brook, N.J. 07058/(201) 575-8100

IN U.K. — ADLER BUS. SYSTEMS/OEM PRODS., Airport House, Purley Way, Croydon, Surrey, England

IN FRANCE — SWEDA INTERNATIONAL/OEM, 103-107 Rue de Tocqueville, 75017 Paris, France

CIRCLE 82 ON INQUIRY CARD

181
Solve grounding/shielding problems quickly, economically!

The wide variety of Instrument Specialties beryllium copper contact strips and contact rings in many sizes and shapes can help you solve your shielding and grounding problems. Standard catalog items work for most applications, but special adaptations are easily made and provide you with virtually a custom-designed part with only a one-time extra charge.

Send for inexpensive trial kits!

34 strips, various configurations: Assortment 97-272 ....... $25.00
36 different contact rings: Assortment 97-273 ....... $20.00

FREE! Complete catalog of RFI-EMI shielding strips and rings. Write, or use Reader Service Card.

INSTRUMENT SPECIALTIES COMPANY, Dept. CD-82
Little Falls, N.J. 07424
Phone - 201-256-3500 • TWX - 710-988-5732
Specialists in beryllium copper springs since 1938

CIRCLE 85 ON INQUIRY CARD

LOW NOISE MODULAR DESIGN

Switching Power Supplies!

A new line of compact, modular-design switchers that simplify design for 300-600 watt applications and sell for less than 90¢ per watt! End users benefit from low EMI noise levels and highly reliable operation plus easy add-on and maintenance features. Get everything you need to know to evaluate this high quality, money-saving line from:

Magnetic Components Group

CONTROL DATA CORPORATION

7801 Computer Avenue South, Minneapolis, MN 55435
(612) 833-5800 TWX 910 576 2678

CIRCLE 86 ON INQUIRY CARD

PRODUCTS

HAND-HELD DATA COMMUNICATIONS SYSTEM

Designed to monitor data communications systems to EIA spec RS-232-C, the 232 provides a simple yet effective method of checking system operation and enables problems to be identified and located quickly when breakdowns occur. The lightweight, self-contained, and rugged unit can be conveniently carried for use in testing and servicing applications, or left permanently connected to a circuit for continuous monitoring. It indicates the condition of the data communications system under test, permits direct access to individual signal lines, and allows operation of the system terminal in echo mode. Continuous displays of DRT, CD, DSR, CTS, RTS, RD, TD, and Test Indicator are given on eight LEDs. Pin connections are available for oscilloscope monitoring. Goodwood Data Systems, Box 768, Ogdensburg, NY 13669.

Circle 265 on Inquiry Card

DIGITAL LOGIC BOARD TEST SYSTEM

Featuring a guided clip/probe, the Magiclip system is an optional hardware/software package for the 6500 test/programming station. Hardware consists of a 16-pin IC clip and a single-tip probe. Either can be used for troubleshooting; both are cable-connected to circuitry in the 6500 test head. In troubleshooting mode, diagnostic information (ie, clip or probe placement) is retrieved from the data base stored in the 6500. After plugging in the board to be tested and entering a few simple instructions via the keyboard, the operator is told automatically by the system where to place the clip to trace a failure, and the precise cause of failure is reported. In addition to information displayed on the CRT, a printer-generated hardcopy contains full diagnostics plus board serial number. Miroco Inc, Systems Div, 10888 N 19th Ave, Phoenix, AZ 85029.

Circle 266 on Inquiry Card

DISC SUBSYSTEM

Integrating large storage disc capacity and fast access time of cartridge discs with capabilities of DEC's LSI-11 CPU, the Phoenix 145 system is an alternative to DEC's 11V03. LSI-11 architecture is directly interfaced to the Phoenix 45 disc controller, eliminating the need for a Q bus/Unibus adapter. Packaged in a rack-mountable chassis with an operator's control panel and a 9-slot backplane, the system can be configured to support up to 20M bytes of disc capacity, four terminals, line printer, and a 28K-word LSI-11 processor. Housed in a 30" standalone cabinet are the chassis, controller, and 5M-byte disc drive. Controller features include sector address verification, multiple sector transfers, write protect to the sector level, and self-test capability. Xylogic OEM Components Group, Inc, 42 Third Ave, Burlington, MA 01803.

Circle 267 on Inquiry Card
LITERATURE

Standard Circular Connectors
In-depth descriptions, specs, and applications of MIL-C-5015 MS std connectors are supplied in brochure featuring charts and drawings. ITT Cannon Electric, Santa Ana, Calif. Circle 300 on Inquiry Card

Disc Cartridge Requirements
Mag media and disc cartridge requirements for D36XX disc drives are discussed in application notes, along with disc storage capacity, storage and handling procedures, and electrical signal characteristics. Pertec Corp, Peripheral Equipment Div, Chatsworth, Calif. Circle 301 on Inquiry Card

Miniperipherals
Illustrated catalog describes uses and features of miniature board, disc, and paper tape peripherals for DEC, Data General, and Interdata minicomputers. Plessey Microsystems, Irvine, Calif. Circle 302 on Inquiry Card

Switches
Detailed descriptions and specs on miniature switch items are listed in catalog featuring subminiatures, miniature 250-V, and line of miniature oil-tight controls. Alco Electronic Products, Inc, North Andover, Mass. Circle 303 on Inquiry Card

Semiconductors
Complete with charts and diagrams, updated condensed catalog consists of latest product listings and technical specs on ICs, interface circuits, MIL devices, and discrete components. ITT Semiconductor, Woburn, Mass. Circle 304 on Inquiry Card

Microprocessor
Brochure on the EA9002 8-bit microprocessor features functional descriptions, timing diagrams, definitions, applications, instruction formats, and two block diagram systems configurations. Electronic Arrays, Inc, Mountain View, Calif. Circle 305 on Inquiry Card

Bipolar Transistors
Modeling the Bipolar Transistor gives circuit designers information on model selection and describes equipment and techniques for parameter measurements. Price is $8. Tektronix, Inc, PO Box 500, Beaverton, OR 97077.

A-D and D-A Converters
Two applications bulletins detail A-D and D-A parameters to improve user understanding of parameter definitions, specs, test methods, and error calculations through diagrams and tables. Teledyne Philbrick, Dedham, Mass. Circle 306 on Inquiry Card

Time Division Multiplexer
Technical information and features of the TDM 1203, which uses LSI technology to provide reliability and minimize power, are contained in bulletin. General Datacomm Industries, Inc, Wilton, Conn. Circle 307 on Inquiry Card

Control Panels
Illustrated layout design guide considers operator requirements, environmental considerations, manual controls, visual displays, and maintainability, as well as color, coding, and illumination. Micro Switch, a div of Honeywell, Freeport, Ill. Circle 308 on Inquiry Card

Data Communication Service
Brochure packet describing the data comm service includes summary information, specs, and characteristics, plus operational and management guidelines. Datapro Research Corp, Delran, NJ. Circle 309 on Inquiry Card

Minicomputer Components
Designed for OEM customers, the 21MX-K series is covered in two brochures providing a summary of applications and hardware specs. Hewlett-Packard Co, Palo Alto, Calif. Circle 310 on Inquiry Card

Display and Recording Devices
Sectionalized by product categories of CRTs, display storage tubes, and flat panel display, illustrated catalog contains spec tables, diagrams, and applications information. Westinghouse Electric Corp, Pittsburgh, Pa. Circle 311 on Inquiry Card

IEEE Standards
Catalog lists over 350 publications and provides a subject index to standards covering test methods, units, definitions, graphic symbols, and application methods. Institute of Electrical and Electronics Engineers, Inc, New York, NY. Circle 312 on Inquiry Card

Computer Power Center
Brochure includes operation, application, and installation details of center which provides flexible power distribution for computer installations. Computer Power Systems Corp, Costa Mesa, Calif. Circle 313 on Inquiry Card

Programmable Rotary Encoded Logic Switch
Brochure provides features, options, specs, and dimensional drawings of the P/rel 700 which achieves up to 60 detent positions. Standard Grigsby, Inc, Aurora, Ill. Circle 314 on Inquiry Card

Incandescent Displays
Short-form catalog provides a chart of complete specs for Pinlite® displays, connectors, decoder/drives, lamps, and assemblies. Refac Electronics Corp, Winsted, Conn. Circle 315 on Inquiry Card

Solid-State Relays
Highlights of short-form catalog include features, electrical specs, spec notes, thermal ratings, and dimensions of SSRs. Opto 22, Huntington Beach, Calif. Circle 316 on Inquiry Card

Indicator Lights
Design considerations and specs of several indicator light series containing solid-state, neon, and incandescent lamps are supplied in OEM selection guide. Industrial Devices, Inc, Edgewater, NJ. Circle 317 on Inquiry Card

Power Supply Efficiency

Rotary Switches and Stepping Drum Programmers
Descriptions and photographs of rotary and impact switches and switch products, as well as application ideas, are highlighted in bulletin. Cole Instrument Corp, Costa Mesa, Calif. Circle 319 on Inquiry Card

Programmed Logic
Presenting sample programs and applications of programmed logic, 56-page plan book deals primarily with design and documentation of 4004 and 4040 microprocessor systems. Copies are $5 from Pro-Log Corp, 2411 Garden Rd, Monterey, CA 93940.
# GUIDE TO PRODUCT INFORMATION

NOTE: The number associated with each item in this guide indicates the page on which the item appears—not the reader service number. Please do not circle the page number on the reader service card.

<table>
<thead>
<tr>
<th>HARDWARE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BUSES</strong></td>
<td></td>
</tr>
<tr>
<td>Buses Bars</td>
<td>177</td>
</tr>
<tr>
<td>Bussco Engineering</td>
<td>170</td>
</tr>
<tr>
<td><strong>CONNECTORS AND INTERCONNECTION SYSTEMS</strong></td>
<td></td>
</tr>
<tr>
<td>Connectors</td>
<td>88</td>
</tr>
<tr>
<td>Eico</td>
<td>88</td>
</tr>
<tr>
<td><strong>HEAT SINKS</strong></td>
<td></td>
</tr>
<tr>
<td>PC Card Guide/Heat Sink</td>
<td>171</td>
</tr>
<tr>
<td>Uniltrack/Calabro Plastics</td>
<td>171</td>
</tr>
<tr>
<td><strong>MOUNTING HARDWARE</strong></td>
<td></td>
</tr>
<tr>
<td>PC Card Guide/Heat Sink</td>
<td>171</td>
</tr>
<tr>
<td>Uniltrack/Calabro Plastics</td>
<td>171</td>
</tr>
<tr>
<td><strong>PANELS AND BACKPLANE</strong></td>
<td></td>
</tr>
<tr>
<td>Logic Panels</td>
<td>170</td>
</tr>
<tr>
<td>Excel</td>
<td>80</td>
</tr>
<tr>
<td>Wirewrap IC Boards</td>
<td>174</td>
</tr>
<tr>
<td>Garry Manufacturing</td>
<td>174</td>
</tr>
<tr>
<td>Wirewrapping Equipment</td>
<td></td>
</tr>
<tr>
<td>OK Machine &amp; Tool</td>
<td>170</td>
</tr>
<tr>
<td><strong>PARTS</strong></td>
<td></td>
</tr>
<tr>
<td>Gear Tooth Endless Belts</td>
<td>169</td>
</tr>
<tr>
<td>Fenner America</td>
<td>169</td>
</tr>
<tr>
<td><strong>SHIELDING</strong></td>
<td></td>
</tr>
<tr>
<td>Shielding Components</td>
<td>182</td>
</tr>
<tr>
<td>Instrument Specialties</td>
<td>182</td>
</tr>
<tr>
<td><strong>SOCKETS</strong></td>
<td></td>
</tr>
<tr>
<td>Sockets</td>
<td>180</td>
</tr>
<tr>
<td>Electronic Molding</td>
<td>180</td>
</tr>
<tr>
<td>Continental Specialties</td>
<td>4</td>
</tr>
<tr>
<td>Solder-Tab Sockets</td>
<td>175</td>
</tr>
<tr>
<td>Cambridge Thermionic</td>
<td>175</td>
</tr>
<tr>
<td>DIP Socket/Receptacle</td>
<td>175</td>
</tr>
<tr>
<td>Textool Products</td>
<td>175</td>
</tr>
<tr>
<td><strong>WIRE AND CABLE</strong></td>
<td></td>
</tr>
<tr>
<td>Wire and Cable</td>
<td>166</td>
</tr>
<tr>
<td>Belden/Electronic</td>
<td>172</td>
</tr>
<tr>
<td>Blak Wire &amp; Cable</td>
<td>186</td>
</tr>
<tr>
<td>Flat Ribbon Cable Assemblies</td>
<td>178</td>
</tr>
<tr>
<td>AMP</td>
<td>78</td>
</tr>
<tr>
<td><strong>COMPONENTS AND ASSEMBLIES</strong></td>
<td></td>
</tr>
<tr>
<td>Magnetic Components</td>
<td>181</td>
</tr>
<tr>
<td>Disc Memory Head Assembly</td>
<td>181</td>
</tr>
<tr>
<td>National Micronetics/Pacific</td>
<td>181</td>
</tr>
<tr>
<td><strong>MOTORS, ROTATIVE COMPONENTS</strong></td>
<td></td>
</tr>
<tr>
<td>Miniature DC Motors</td>
<td>158</td>
</tr>
<tr>
<td>North American Philips Controls</td>
<td>158</td>
</tr>
<tr>
<td>Miniature DC Servomotor</td>
<td>147</td>
</tr>
<tr>
<td>Portescap U.S.</td>
<td>147</td>
</tr>
<tr>
<td>DC Servomotor</td>
<td>162</td>
</tr>
<tr>
<td>Torque Systems</td>
<td>162</td>
</tr>
<tr>
<td><strong>PHOTODEVICE ASSEMBLIES</strong></td>
<td></td>
</tr>
<tr>
<td>Optical Coupler</td>
<td>162</td>
</tr>
<tr>
<td>Monsanto Commercial Products/Electronics</td>
<td>172</td>
</tr>
<tr>
<td>Solid-State Image Sensors</td>
<td>168</td>
</tr>
<tr>
<td>Relicon</td>
<td>168</td>
</tr>
<tr>
<td><strong>CIRCUITS</strong></td>
<td></td>
</tr>
<tr>
<td><strong>CIRCUIT CARDS AND MODULES</strong></td>
<td></td>
</tr>
<tr>
<td>Mark-Sensor Arrays</td>
<td>173</td>
</tr>
<tr>
<td>POWER SOURCES, REGULATORS, AND PROTECTORS</td>
<td></td>
</tr>
<tr>
<td>Power Supplies</td>
<td>173</td>
</tr>
<tr>
<td>Computer Products</td>
<td>170</td>
</tr>
<tr>
<td>Technipower/Genus</td>
<td>22</td>
</tr>
<tr>
<td>Switching Power Supplies</td>
<td>179</td>
</tr>
<tr>
<td>Control Data/Magnetic Components</td>
<td>182</td>
</tr>
<tr>
<td>LH Research</td>
<td>172</td>
</tr>
<tr>
<td>Trico Laboratories</td>
<td>179</td>
</tr>
<tr>
<td>Flexible Disc Power Supplies</td>
<td>12</td>
</tr>
<tr>
<td>Power-One</td>
<td>12</td>
</tr>
<tr>
<td><strong>RELAYS</strong></td>
<td></td>
</tr>
<tr>
<td>Solid-State Relays</td>
<td>165</td>
</tr>
<tr>
<td>International Rectifier/Crydom</td>
<td>165</td>
</tr>
<tr>
<td>Teledyne Relays</td>
<td>63</td>
</tr>
<tr>
<td>PC Board Solid-State Relays</td>
<td>168</td>
</tr>
<tr>
<td>Electrotrol</td>
<td>168</td>
</tr>
<tr>
<td><strong>SEMICONDUCTOR DEVICES</strong></td>
<td></td>
</tr>
<tr>
<td>Silicon Rectifiers</td>
<td>158</td>
</tr>
<tr>
<td>Electronic Devices</td>
<td>158</td>
</tr>
<tr>
<td><strong>SWITCHES</strong></td>
<td></td>
</tr>
<tr>
<td>Thumbwheel Switch</td>
<td>179</td>
</tr>
<tr>
<td>EECO</td>
<td>179</td>
</tr>
<tr>
<td>Rocker Switches</td>
<td>179</td>
</tr>
<tr>
<td>Cutler-Hammer/Specialty Products</td>
<td>86</td>
</tr>
<tr>
<td>DIP Rocker Switches</td>
<td>171</td>
</tr>
<tr>
<td>Grayhill</td>
<td>171</td>
</tr>
<tr>
<td>Miniature Toggle Switch</td>
<td>171</td>
</tr>
<tr>
<td>Alco Electronic Products</td>
<td>174</td>
</tr>
<tr>
<td>Subminiature Slide Switch</td>
<td>171</td>
</tr>
<tr>
<td>C&amp;K Components</td>
<td>171</td>
</tr>
<tr>
<td>Pushbutton Switches</td>
<td>180</td>
</tr>
<tr>
<td>RTC</td>
<td>180</td>
</tr>
<tr>
<td>Lighted Pushbutton Switches</td>
<td>164</td>
</tr>
<tr>
<td>Switchcraft</td>
<td>164</td>
</tr>
<tr>
<td>LED Pushbutton Switches</td>
<td>176</td>
</tr>
<tr>
<td>Micro Switch/Honeywell</td>
<td>176</td>
</tr>
<tr>
<td><strong>THERMAL COMPONENTS</strong></td>
<td></td>
</tr>
<tr>
<td>Thermostats</td>
<td>179</td>
</tr>
<tr>
<td>Elmwood Sensors</td>
<td>179</td>
</tr>
<tr>
<td><strong>INTERCONNECTION DEVICES</strong></td>
<td></td>
</tr>
<tr>
<td><strong>SINKS</strong></td>
<td></td>
</tr>
<tr>
<td>Panels</td>
<td></td>
</tr>
<tr>
<td>AND CABLE</td>
<td></td>
</tr>
<tr>
<td>Wire and Cable</td>
<td></td>
</tr>
<tr>
<td>Wire and Cable</td>
<td></td>
</tr>
<tr>
<td>Belden/Electronic</td>
<td>172</td>
</tr>
<tr>
<td>Blak Wire &amp; Cable</td>
<td>186</td>
</tr>
<tr>
<td>Flat Ribbon Cable Assemblies</td>
<td>178</td>
</tr>
<tr>
<td>AMP</td>
<td>78</td>
</tr>
<tr>
<td><strong>COMPONENTS AND ASSEMBLIES</strong></td>
<td></td>
</tr>
<tr>
<td>Magnetic Components</td>
<td>181</td>
</tr>
<tr>
<td>Disc Memory Head Assembly</td>
<td>181</td>
</tr>
<tr>
<td>National Micronetics/Pacific</td>
<td>181</td>
</tr>
<tr>
<td><strong>MOTORS, ROTATIVE COMPONENTS</strong></td>
<td></td>
</tr>
<tr>
<td>Miniature DC Motors</td>
<td>158</td>
</tr>
<tr>
<td>North American Philips Controls</td>
<td>158</td>
</tr>
<tr>
<td>Miniature DC Servomotor</td>
<td>147</td>
</tr>
<tr>
<td>Portescap U.S.</td>
<td>147</td>
</tr>
<tr>
<td>DC Servomotor</td>
<td>162</td>
</tr>
<tr>
<td>Torque Systems</td>
<td>162</td>
</tr>
<tr>
<td><strong>PHOTODEVICE ASSEMBLIES</strong></td>
<td></td>
</tr>
<tr>
<td>Optical Coupler</td>
<td>162</td>
</tr>
<tr>
<td>Monsanto Commercial Products/Electronics</td>
<td>172</td>
</tr>
<tr>
<td>Solid-State Image Sensors</td>
<td>168</td>
</tr>
<tr>
<td>Relicon</td>
<td>168</td>
</tr>
<tr>
<td><strong>CIRCUITS</strong></td>
<td></td>
</tr>
<tr>
<td><strong>CIRCUIT CARDS AND MODULES</strong></td>
<td></td>
</tr>
<tr>
<td>Mark-Sensor Arrays</td>
<td>173</td>
</tr>
<tr>
<td>POWER SOURCES, REGULATORS, AND PROTECTORS</td>
<td></td>
</tr>
<tr>
<td>Power Supplies</td>
<td>173</td>
</tr>
<tr>
<td>Computer Products</td>
<td>170</td>
</tr>
<tr>
<td>Technipower/Genus</td>
<td>22</td>
</tr>
<tr>
<td>Switching Power Supplies</td>
<td>179</td>
</tr>
<tr>
<td>Control Data/Magnetic Components</td>
<td>182</td>
</tr>
<tr>
<td>LH Research</td>
<td>172</td>
</tr>
<tr>
<td>Trico Laboratories</td>
<td>179</td>
</tr>
<tr>
<td>Flexible Disc Power Supplies</td>
<td>12</td>
</tr>
<tr>
<td>Power-One</td>
<td>12</td>
</tr>
<tr>
<td><strong>RELAYS</strong></td>
<td></td>
</tr>
<tr>
<td>Solid-State Relays</td>
<td>165</td>
</tr>
<tr>
<td>International Rectifier/Crydom</td>
<td>165</td>
</tr>
<tr>
<td>Teledyne Relays</td>
<td>63</td>
</tr>
<tr>
<td>PC Board Solid-State Relays</td>
<td>168</td>
</tr>
<tr>
<td>Electrotrol</td>
<td>168</td>
</tr>
<tr>
<td><strong>SEMICONDUCTOR DEVICES</strong></td>
<td></td>
</tr>
<tr>
<td>Silicon Rectifiers</td>
<td>158</td>
</tr>
<tr>
<td>Electronic Devices</td>
<td>158</td>
</tr>
<tr>
<td><strong>SWITCHES</strong></td>
<td></td>
</tr>
<tr>
<td>Thumbwheel Switch</td>
<td>179</td>
</tr>
<tr>
<td>EECO</td>
<td>179</td>
</tr>
<tr>
<td>Rocker Switches</td>
<td>179</td>
</tr>
<tr>
<td>Cutler-Hammer/Specialty Products</td>
<td>86</td>
</tr>
<tr>
<td>DIP Rocker Switches</td>
<td>171</td>
</tr>
<tr>
<td>Grayhill</td>
<td>171</td>
</tr>
<tr>
<td>Miniature Toggle Switch</td>
<td>171</td>
</tr>
<tr>
<td>Alco Electronic Products</td>
<td>174</td>
</tr>
<tr>
<td>Subminiature Slide Switch</td>
<td>171</td>
</tr>
<tr>
<td>C&amp;K Components</td>
<td>171</td>
</tr>
<tr>
<td>Pushbutton Switches</td>
<td>180</td>
</tr>
<tr>
<td>RTC</td>
<td>180</td>
</tr>
<tr>
<td>Lighted Pushbutton Switches</td>
<td>164</td>
</tr>
<tr>
<td>Switchcraft</td>
<td>164</td>
</tr>
<tr>
<td>LED Pushbutton Switches</td>
<td>176</td>
</tr>
<tr>
<td>Micro Switch/Honeywell</td>
<td>176</td>
</tr>
<tr>
<td><strong>THERMAL COMPONENTS</strong></td>
<td></td>
</tr>
<tr>
<td>Thermostats</td>
<td>179</td>
</tr>
<tr>
<td>Elmwood Sensors</td>
<td>179</td>
</tr>
<tr>
<td><strong>INTERCONNECTION DEVICES</strong></td>
<td></td>
</tr>
<tr>
<td><strong>SINKS</strong></td>
<td></td>
</tr>
<tr>
<td>Panels</td>
<td></td>
</tr>
<tr>
<td>AND CABLE</td>
<td></td>
</tr>
<tr>
<td>Wire and Cable</td>
<td></td>
</tr>
<tr>
<td>Wire and Cable</td>
<td></td>
</tr>
<tr>
<td>Belden/Electronic</td>
<td>172</td>
</tr>
<tr>
<td>Blak Wire &amp; Cable</td>
<td>186</td>
</tr>
<tr>
<td>Flat Ribbon Cable Assemblies</td>
<td>178</td>
</tr>
<tr>
<td>AMP</td>
<td>78</td>
</tr>
<tr>
<td>MAGNETIC CORE MEMORIES</td>
<td>PAGE</td>
</tr>
<tr>
<td>------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Add-On Core Memory</td>
<td></td>
</tr>
<tr>
<td>Ampex/Memory Products</td>
<td>175</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MAGNETIC DISC AND DRUM UNITS</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>(See also Flexible Disc Units)</td>
<td></td>
</tr>
<tr>
<td>Disc Drives</td>
<td></td>
</tr>
<tr>
<td>Diablos Systems</td>
<td>Cover IV</td>
</tr>
<tr>
<td>Peritel/Peripheral Equipment</td>
<td>82</td>
</tr>
<tr>
<td>Storage Module Disc Drives</td>
<td>167</td>
</tr>
<tr>
<td>Microdata</td>
<td></td>
</tr>
<tr>
<td>Disc Systems</td>
<td></td>
</tr>
<tr>
<td>Plessey Microsystems</td>
<td>72</td>
</tr>
<tr>
<td>Disc Subsystem</td>
<td></td>
</tr>
<tr>
<td>Xylogic OEM Components Group</td>
<td>182</td>
</tr>
<tr>
<td>Disc Drive Formatter/Controller</td>
<td></td>
</tr>
<tr>
<td>Ball Computer Products</td>
<td>126</td>
</tr>
<tr>
<td>Microprocessor-Based Disc Controller</td>
<td></td>
</tr>
<tr>
<td>Xebec Systems</td>
<td>156</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MAGNETIC TAPE UNITS</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tape Drives</td>
<td></td>
</tr>
<tr>
<td>AMCOMP</td>
<td>151</td>
</tr>
<tr>
<td>Mohawk Data Sciences</td>
<td>7</td>
</tr>
<tr>
<td>Cartridge Tape Drives</td>
<td></td>
</tr>
<tr>
<td>Microdata</td>
<td>166</td>
</tr>
<tr>
<td>Endless Loop Cartridge Tape Transport</td>
<td>174</td>
</tr>
<tr>
<td>Amilon</td>
<td></td>
</tr>
<tr>
<td>Cartridge Tape System</td>
<td></td>
</tr>
<tr>
<td>Applied Data Communications</td>
<td>164</td>
</tr>
<tr>
<td>Magnetic Tape System</td>
<td></td>
</tr>
<tr>
<td>Computer Operations</td>
<td>172</td>
</tr>
<tr>
<td>Tape Recorders</td>
<td></td>
</tr>
<tr>
<td>Kennedy</td>
<td>1</td>
</tr>
<tr>
<td>Cassette Recorder</td>
<td></td>
</tr>
<tr>
<td>Raymond Engineering</td>
<td>102</td>
</tr>
<tr>
<td>Intelligent Cassette Recorder</td>
<td>168</td>
</tr>
<tr>
<td>Magnetic Tape Formatter</td>
<td></td>
</tr>
<tr>
<td>Dynon</td>
<td>170</td>
</tr>
<tr>
<td>Mag Tape Intelligent Cable</td>
<td></td>
</tr>
<tr>
<td>Computer Automation</td>
<td>168</td>
</tr>
<tr>
<td>Digital Cassette CFIs</td>
<td></td>
</tr>
<tr>
<td>Memories</td>
<td>173</td>
</tr>
<tr>
<td>3M/Data Recording Products</td>
<td>184</td>
</tr>
<tr>
<td>ROM/RAM PROGRAMMERS AND SIMULATORS</td>
<td></td>
</tr>
<tr>
<td>p/Rom Programmers</td>
<td></td>
</tr>
<tr>
<td>ICOM</td>
<td>71</td>
</tr>
<tr>
<td>Pro-Log</td>
<td>167</td>
</tr>
<tr>
<td>EP/Rom Programmers</td>
<td></td>
</tr>
<tr>
<td>Associated Electronics</td>
<td>176</td>
</tr>
<tr>
<td>EROM Storage Autoprogrammer</td>
<td>178</td>
</tr>
<tr>
<td>Wavelet</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SEMICONDUCTOR MEMORIES</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static RAM</td>
<td></td>
</tr>
<tr>
<td>EMM Semi/Electronic Memories &amp; Magnetics</td>
<td>19</td>
</tr>
<tr>
<td>Bipolar RAM</td>
<td></td>
</tr>
<tr>
<td>National Semiconductor</td>
<td>140</td>
</tr>
<tr>
<td>16K RAM</td>
<td>64</td>
</tr>
<tr>
<td>1K ECL RAM</td>
<td></td>
</tr>
<tr>
<td>Motorola Semiconductor Products</td>
<td>139</td>
</tr>
<tr>
<td>p/Roms</td>
<td></td>
</tr>
<tr>
<td>Harris Semiconductor</td>
<td>150</td>
</tr>
<tr>
<td>Semiconductor Memory Systems</td>
<td></td>
</tr>
<tr>
<td>Intel Memory Systems</td>
<td>31</td>
</tr>
<tr>
<td>Electronic Memories &amp; Magnetics/Systems Equipment</td>
<td>175</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>INPUT/OUTPUT AND RELATED EQUIPMENT</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>BADGE READERS</td>
<td></td>
</tr>
<tr>
<td>Data Collection Terminal</td>
<td></td>
</tr>
<tr>
<td>Coastal Data Services</td>
<td>180</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CHARACTER RECOGNITION EQUIPMENT</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCR Wand</td>
<td></td>
</tr>
<tr>
<td>Recognition Equipment</td>
<td>166</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DATA ENTRY EQUIPMENT</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual Output Light Pen</td>
<td></td>
</tr>
<tr>
<td>Portable Data Entry Keypad</td>
<td>173</td>
</tr>
<tr>
<td>Patter Computer/CMD</td>
<td></td>
</tr>
<tr>
<td>Numeric Data Entry Terminals</td>
<td></td>
</tr>
<tr>
<td>Hewlett-Packard</td>
<td>162</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DATA TERMINALS (See also Graphic Equipment)</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Terminals</td>
<td></td>
</tr>
<tr>
<td>Teletype</td>
<td>23</td>
</tr>
<tr>
<td>FlexDisc Send/Receive Terminal</td>
<td>92</td>
</tr>
<tr>
<td>Randal Data Systems</td>
<td>173</td>
</tr>
<tr>
<td>CRT Display Terminals</td>
<td></td>
</tr>
<tr>
<td>Datamedia</td>
<td>119</td>
</tr>
<tr>
<td>Research</td>
<td>48</td>
</tr>
<tr>
<td>Intelligent CRT Display Terminal</td>
<td></td>
</tr>
<tr>
<td>Hewlett-Packard</td>
<td>51-58</td>
</tr>
<tr>
<td>Intelligent CRT Color Display Terminal</td>
<td></td>
</tr>
<tr>
<td>Hewlett-Packard</td>
<td>46</td>
</tr>
<tr>
<td>Intelligent Systems</td>
<td></td>
</tr>
<tr>
<td>Interface Electronics</td>
<td>42</td>
</tr>
<tr>
<td>CRT Display System</td>
<td>132</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DISPLAY EQUIPMENT (See also Data Terminals and Graphic Equipment)</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Discharge Panel Displays</td>
<td></td>
</tr>
<tr>
<td>Burroughs/Electronic Components</td>
<td>167</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GRAPHIC EQUIPMENT</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphic Display</td>
<td></td>
</tr>
<tr>
<td>Sigma Electronic Systems</td>
<td></td>
</tr>
<tr>
<td>Graphic Display Terminal</td>
<td></td>
</tr>
<tr>
<td>Sanders Data Systems</td>
<td>45</td>
</tr>
<tr>
<td>Color Graphic Display Systems</td>
<td></td>
</tr>
<tr>
<td>Ramtek</td>
<td>77</td>
</tr>
<tr>
<td>Sonic Digitizer</td>
<td></td>
</tr>
<tr>
<td>Science Accessories</td>
<td>156</td>
</tr>
<tr>
<td>Data Tablet/Graphic Calculator Interfaces</td>
<td>174</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>INTERFACE EQUIPMENT; CONTROLLERS</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-Word Plug-In Interface</td>
<td></td>
</tr>
<tr>
<td>Forte Technology</td>
<td>169</td>
</tr>
<tr>
<td>Universal Controller</td>
<td>174</td>
</tr>
<tr>
<td>Computer/Peripheral Interface</td>
<td></td>
</tr>
<tr>
<td>Computrol</td>
<td>169</td>
</tr>
<tr>
<td>Microprocessor-Based Memory Controller</td>
<td></td>
</tr>
<tr>
<td>Xebec Systems</td>
<td>156</td>
</tr>
<tr>
<td>Mag Tape Intelligent Cable</td>
<td></td>
</tr>
<tr>
<td>Computer Automation</td>
<td>168</td>
</tr>
<tr>
<td>Magnetic Tape Formatter</td>
<td>170</td>
</tr>
<tr>
<td>Disc Drive Formatter/Controller</td>
<td></td>
</tr>
<tr>
<td>Ball Computer Products</td>
<td>126</td>
</tr>
<tr>
<td>Disc and Tape Drive Controllers</td>
<td></td>
</tr>
<tr>
<td>Western Peripherals</td>
<td>12</td>
</tr>
<tr>
<td>Data Tablet/Graphic Calculator Interfaces</td>
<td></td>
</tr>
<tr>
<td>Summagraphics</td>
<td>174</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>KEYBOARD EQUIPMENT</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keyboards</td>
<td></td>
</tr>
<tr>
<td>Conover/Illinois Tool Works</td>
<td>149</td>
</tr>
<tr>
<td>Remote Data Entry Keypad</td>
<td></td>
</tr>
<tr>
<td>Patter Computer/CMD</td>
<td>173</td>
</tr>
<tr>
<td>Numeric Data Entry Terminals</td>
<td></td>
</tr>
<tr>
<td>Hewlett-Packard</td>
<td>162</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PLOTTING EQUIPMENT</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital Plotters</td>
<td></td>
</tr>
<tr>
<td>Houston Instrument/Blu &amp; Lomb</td>
<td>129</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PRINTER/PLOTTERS</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrostatic Printer/Plotter</td>
<td></td>
</tr>
<tr>
<td>Gould/Instrument Systems</td>
<td>84</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PRINTING EQUIPMENT</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Printers</td>
<td></td>
</tr>
<tr>
<td>Facit</td>
<td>123</td>
</tr>
<tr>
<td>Intelligent Printers</td>
<td></td>
</tr>
<tr>
<td>Parkin-Eker Data Systems/Terminal</td>
<td>181</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COMPUTER SYSTEMS</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUTOMATIC TEST SYSTEMS</td>
<td></td>
</tr>
<tr>
<td>Automatic I.C. Test System</td>
<td>155</td>
</tr>
<tr>
<td>Automatic Logic Board Testers</td>
<td></td>
</tr>
<tr>
<td>Computer Automation</td>
<td></td>
</tr>
<tr>
<td>GenRad</td>
<td>49</td>
</tr>
<tr>
<td>Micr/Systems</td>
<td>182</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COMPUTER AUXILIARY UNITS</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floating Point Array for HP 2100</td>
<td></td>
</tr>
<tr>
<td>CSP</td>
<td>173</td>
</tr>
<tr>
<td>Portable Program Loader</td>
<td></td>
</tr>
<tr>
<td>Computer Operations</td>
<td>22</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONTROL PROCESSORS</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial Application Minicomputer</td>
<td></td>
</tr>
<tr>
<td>Philips Data Systems</td>
<td>178</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MICROCOMPUTERS AND MICROPROCESSORS</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcomputers</td>
<td></td>
</tr>
<tr>
<td>IMS Associates</td>
<td>168</td>
</tr>
<tr>
<td>Data General</td>
<td>101</td>
</tr>
<tr>
<td>Digital Equipment</td>
<td>8</td>
</tr>
<tr>
<td>Plessey Microsystems</td>
<td>163</td>
</tr>
<tr>
<td>Microcomputer Modules</td>
<td></td>
</tr>
<tr>
<td>Motorola Semiconductor Products</td>
<td>13</td>
</tr>
<tr>
<td>Microcomputer Programmable CPU Module</td>
<td></td>
</tr>
<tr>
<td>Electronic Products/Swaray &amp; Swasey</td>
<td>154</td>
</tr>
<tr>
<td>Single Board Microcomputer</td>
<td></td>
</tr>
<tr>
<td>Quay</td>
<td>154</td>
</tr>
<tr>
<td>Portable Micorcomputer</td>
<td></td>
</tr>
<tr>
<td>Digital Electronics</td>
<td>148</td>
</tr>
<tr>
<td>Microcomputer System</td>
<td></td>
</tr>
<tr>
<td>Waveform Computers and Systems</td>
<td>152</td>
</tr>
<tr>
<td>In-Circuit Microcomputer Emulator</td>
<td></td>
</tr>
<tr>
<td>California Micro Computer</td>
<td>156</td>
</tr>
<tr>
<td>Microcomputer Resident Compiler</td>
<td></td>
</tr>
<tr>
<td>Unified Technologies</td>
<td>148</td>
</tr>
<tr>
<td>Single Board Multiprocessor</td>
<td></td>
</tr>
<tr>
<td>Intel/Microcomputer</td>
<td>144</td>
</tr>
<tr>
<td>Computer-On-A-Chip</td>
<td></td>
</tr>
<tr>
<td>Fairchild Camera and Instrument/Systems Technology</td>
<td>146</td>
</tr>
</tbody>
</table>
**GUIDE TO PRODUCT INFORMATION**

<table>
<thead>
<tr>
<th>Product Category</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DATA ACQUISITION SYSTEMS</strong></td>
<td></td>
</tr>
<tr>
<td>Data Acquisition Systems</td>
<td>26</td>
</tr>
<tr>
<td>Neff Instruments</td>
<td></td>
</tr>
<tr>
<td><strong>DATA TRANSFER AND INTERFACE EQUIPMENT</strong></td>
<td></td>
</tr>
<tr>
<td>Process Computer I/O Interface</td>
<td></td>
</tr>
<tr>
<td>Computer Products</td>
<td>Cover III</td>
</tr>
<tr>
<td><strong>MONITORING AND CONTROL EQUIPMENT</strong></td>
<td></td>
</tr>
<tr>
<td>Industrial Application Minicomputer</td>
<td>178</td>
</tr>
<tr>
<td>Philips Data Systems</td>
<td></td>
</tr>
<tr>
<td><strong>Data Acquisition Controller</strong></td>
<td></td>
</tr>
<tr>
<td>Tychon</td>
<td>177</td>
</tr>
<tr>
<td><strong>Automatic Positioning System Controller</strong></td>
<td></td>
</tr>
<tr>
<td>Anordor</td>
<td>173</td>
</tr>
<tr>
<td><strong>Incremental-Digital Positioning Control System Research</strong></td>
<td></td>
</tr>
<tr>
<td>Control Systems Research</td>
<td>176</td>
</tr>
<tr>
<td><strong>Intelligent Process Programmer Research</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>180</td>
</tr>
<tr>
<td><strong>SCANNERS</strong></td>
<td></td>
</tr>
<tr>
<td>Digital Scanner System</td>
<td></td>
</tr>
<tr>
<td>QEI</td>
<td>176</td>
</tr>
<tr>
<td><strong>SYNCHRO-DIGITAL AND DIGITAL-SYNCHRO CONVERTERS</strong></td>
<td></td>
</tr>
<tr>
<td>Digital-Synchronic Converter</td>
<td></td>
</tr>
<tr>
<td>Singer/Kearfott</td>
<td>108</td>
</tr>
<tr>
<td><strong>TEST AND MEASUREMENT EQUIPMENT; INSTRUMENTATION</strong></td>
<td></td>
</tr>
<tr>
<td>IC Test System</td>
<td></td>
</tr>
<tr>
<td>Teradyne</td>
<td>155</td>
</tr>
<tr>
<td><strong>Automatic Logic Tester</strong></td>
<td></td>
</tr>
<tr>
<td>GenRad</td>
<td>49</td>
</tr>
<tr>
<td><strong>Logic Board Tester</strong></td>
<td></td>
</tr>
<tr>
<td>Computer Automation</td>
<td></td>
</tr>
<tr>
<td><strong>Logic Board Test System</strong></td>
<td></td>
</tr>
<tr>
<td>Micro/Systems</td>
<td>182</td>
</tr>
<tr>
<td><strong>Logic Analyzers</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Biomation</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Logic State Analyzer</strong></td>
<td></td>
</tr>
<tr>
<td>Hewlett-Packard</td>
<td>24</td>
</tr>
<tr>
<td><strong>Microprocessor Analyzer</strong></td>
<td></td>
</tr>
<tr>
<td>A O Systems</td>
<td>81</td>
</tr>
<tr>
<td><strong>In-Circuit Microcomputer Emulator</strong></td>
<td></td>
</tr>
<tr>
<td>Phillips Micro Computer</td>
<td>148</td>
</tr>
<tr>
<td><strong>OSCILLOSCOPES</strong></td>
<td></td>
</tr>
<tr>
<td>Digital Delay Oscilloscopes</td>
<td></td>
</tr>
<tr>
<td>Philips Test &amp; Measuring Instruments</td>
<td>131</td>
</tr>
<tr>
<td><strong>Digital Timing Oscilloscope</strong></td>
<td></td>
</tr>
<tr>
<td>Tektronix</td>
<td>67</td>
</tr>
<tr>
<td><strong>OTHER TEST AND MEASUREMENT EQUIPMENT</strong></td>
<td></td>
</tr>
<tr>
<td>Probe Card Assembly System</td>
<td></td>
</tr>
<tr>
<td><strong>Alignment Enterprises</strong></td>
<td>170</td>
</tr>
<tr>
<td><strong>40-Pin IC Test Clips</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Continental Specialties</strong></td>
<td>168</td>
</tr>
<tr>
<td><strong>SIGNAL AND CODE CONVERTERS</strong></td>
<td></td>
</tr>
<tr>
<td>F-V Converter Module</td>
<td></td>
</tr>
<tr>
<td><strong>Dynamic Measurements</strong></td>
<td>167</td>
</tr>
<tr>
<td><strong>OTHER PRODUCTS; SERVICES</strong></td>
<td></td>
</tr>
<tr>
<td><strong>EDUCATION</strong></td>
<td></td>
</tr>
<tr>
<td>Seminars</td>
<td>159</td>
</tr>
<tr>
<td>Integrated Computer Systems</td>
<td></td>
</tr>
<tr>
<td><strong>EMPLOYMENT OPPORTUNITIES</strong></td>
<td></td>
</tr>
<tr>
<td>Employment Opportunity</td>
<td>187</td>
</tr>
<tr>
<td><strong>NCR/Terminal Systems</strong></td>
<td></td>
</tr>
<tr>
<td><strong>MARKET REPORTS</strong></td>
<td></td>
</tr>
<tr>
<td>Microprocessor/Microcomputer Market Survey</td>
<td></td>
</tr>
<tr>
<td>Computer Design/Market Research</td>
<td>171</td>
</tr>
<tr>
<td><strong>SOFTWARE</strong></td>
<td></td>
</tr>
<tr>
<td>Multilevel Microprocessor Language</td>
<td></td>
</tr>
<tr>
<td>Forth</td>
<td>158, 187</td>
</tr>
<tr>
<td><strong>Microcomputer Resident Compiler</strong></td>
<td></td>
</tr>
<tr>
<td>Unified Technologies</td>
<td>148</td>
</tr>
</tbody>
</table>

**Are you buying wire and cable from memory?**

Call Blake for a new concept in quality, service and delivery.

Just tell us what you need.

A single conductor hook-up wire? A special UL-approved computer cable? A complex multi-conductor molded cable assembly?

Blake manufactures and stocks the broadest possible line of electronic wire and cable products. We have the facilities and the know-how to meet your exact requirements. With consistent quality. And prompt delivery.

So don't buy wire and cable from memory. Contact a Blake sales engineer now for a new concept in quality, service and delivery.

Call us at (213) 776-3303. Or write:

**Blake Wire & Cable**

5740 Arbor Vitae Street
Los Angeles, California 90045

**BLAKE WIRE & CABLE**

5740 ARBOR VITAE STREET
LOS ANGELES, CALIFORNIA 90045
microFORTH®
The High-Level Language For Microprocessor Development Systems
microFORTH Will Simultaneously:

- SLASH SOFTWARE DEVELOPMENT TIME UP TO 90%
Users find that software development time is cut from three to ten times. Save important development time and money beginning today! Write for results of a recently completed study.

- SLASH MEMORY REQUIREMENTS UP TO 90%
On development systems—microFORTH's operating system provides powerful interactive high-level capabilities and runs independently of any other system in less than 8K plus diskette. Compare with Intel's PLM, requiring 64K plus diskette!
In production systems—microFORTH produces programs 50% smaller than assembler code, 60-90% smaller than PLM or other high-level languages!

- PRODUCE TRANSPORTABLE PROGRAMS
High-level microFORTH is processor independent! This gives you a new flexibility in choosing microprocessors; you can change later without extensive re-programming.

- CUT RUN TIME BY 60%
microFORTH runs several times faster than other high-level languages. This speed difference can be critical in your present or future microcomputer applications.

Price $1,000.00 plus options
For further information on microFORTH and applications, call or write:
FORTH inc.
815 Manhattan Avenue
Manhattan Beach, CA 90266
(213) 372-8493

TERMINAL SYSTEMS DIVISION-DAYTON
DAYTON, OHIO

Our division is actively involved in the design and implementation of financial terminal systems. If you are seeking a "Hands-On Environment" consider the following positions:

**PROGRAMMER/SYSTEMS ANALYST**
Knowledge in the areas of microprocessors and minicomputers based on real-time operating systems.
Participate in the design and implementation of mini and micro-based real-time operating systems in a distributive network.

**SOFTWARE SYSTEMS DESIGN**
Provide technical expertise and leadership in the areas of real-time terminal control and batch operating systems.
Analysis for state-of-the-art design in terminal operating systems and to provide technical leadership in software architecture.

**SYSTEMS ENGINEERS**
Requires the development of concepts and specifications for new systems for financial terminal systems.
Requires the ability to analyze and participate in hardware and software development programs.
Basic educational qualifications for these positions are a BS or MS in EE, CS or Math and 2 to 7 years experience.
We offer an excellent fringe benefit package and a salary commensurate with your experience. If you are interested in a challenging opportunity, submit your resume and salary requirements to:

Robert L. Opalek
Employment Department
Terminal Systems Division-Dayton
NCR Corporation
Dayton, Ohio 45479

An Equal Opportunity Employer

CIRCLE 98 ON INQUIRY CARD
CIRCLE 900 ON INQUIRY CARD
<table>
<thead>
<tr>
<th>Advertiser</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alco Electronic Products, Inc.</td>
<td>174</td>
</tr>
<tr>
<td>AMCOMP, Inc.</td>
<td>151</td>
</tr>
<tr>
<td>AMP, Inc.</td>
<td>78, 79</td>
</tr>
<tr>
<td>Applied Data Communications</td>
<td>164</td>
</tr>
<tr>
<td>Associated Electronics</td>
<td>176</td>
</tr>
<tr>
<td>Austron</td>
<td>174</td>
</tr>
<tr>
<td>Ball Computer Products, Inc.</td>
<td>126, 127</td>
</tr>
<tr>
<td>BEI Electronics, Inc.</td>
<td>129</td>
</tr>
<tr>
<td>Controls and Instrumentation Div.</td>
<td>176</td>
</tr>
<tr>
<td>Belden Corp.</td>
<td>172</td>
</tr>
<tr>
<td>Biomation Corp.</td>
<td>24, 25</td>
</tr>
<tr>
<td>Blake Wire and Cable Corp.</td>
<td>186</td>
</tr>
<tr>
<td>Busco Engineering</td>
<td>177</td>
</tr>
<tr>
<td>Computer Automation, Inc.</td>
<td>33-40, 60, 61</td>
</tr>
<tr>
<td>Computer Design Publishing Corp.</td>
<td>i, ii*, 171</td>
</tr>
<tr>
<td>Computer Operations, Inc.</td>
<td>22</td>
</tr>
<tr>
<td>Computer Products, Inc.</td>
<td>Cover 11</td>
</tr>
<tr>
<td>Continental Specialties Corp.</td>
<td>4</td>
</tr>
<tr>
<td>Control Data Corp.</td>
<td>153</td>
</tr>
<tr>
<td>Cutron, a division of Illinois Tool Works, Inc.</td>
<td>149</td>
</tr>
<tr>
<td>Cutler Hammer, Specialty Products Div.</td>
<td>86</td>
</tr>
<tr>
<td>Data General Corp.</td>
<td>11, 101</td>
</tr>
<tr>
<td>Datamedia Corp.</td>
<td>119</td>
</tr>
<tr>
<td>Decitec, div. of Jamesbury Corp.</td>
<td>21</td>
</tr>
<tr>
<td>Diablo Systems, Inc.</td>
<td>Cover IV</td>
</tr>
<tr>
<td>Digital Computer Controls, Inc.</td>
<td>5</td>
</tr>
<tr>
<td>Digital Equipment Corp.</td>
<td>8, 9</td>
</tr>
<tr>
<td>Documation, Inc.</td>
<td>132</td>
</tr>
<tr>
<td>EECO</td>
<td>Cover 11</td>
</tr>
<tr>
<td>Elco Corp.</td>
<td>88</td>
</tr>
<tr>
<td>Electronic Devices</td>
<td>158</td>
</tr>
<tr>
<td>EMM SEMI, a subsidiary of Electronic Memories &amp; Magnetics Corp.</td>
<td>19</td>
</tr>
<tr>
<td>Electronic Molding Corp.</td>
<td>180</td>
</tr>
<tr>
<td>Elmwood Sensors, Inc.</td>
<td>179</td>
</tr>
<tr>
<td>Epson America, Inc.</td>
<td>178</td>
</tr>
<tr>
<td>Excel Corp.</td>
<td>80</td>
</tr>
<tr>
<td>Ex-Cell-O Corp., Remex Div.</td>
<td>137</td>
</tr>
<tr>
<td>Facit</td>
<td>123</td>
</tr>
<tr>
<td>Fenner America</td>
<td>169</td>
</tr>
<tr>
<td>Forth, Inc.</td>
<td>187</td>
</tr>
<tr>
<td>GenRad, Inc.</td>
<td>49</td>
</tr>
<tr>
<td>Gould, Inc.</td>
<td>84</td>
</tr>
<tr>
<td>Grayhill, Inc.</td>
<td>171</td>
</tr>
<tr>
<td>Harris Corp., Computer Systems Div.</td>
<td>133</td>
</tr>
<tr>
<td>Semiconductor Div.</td>
<td>150, 151</td>
</tr>
<tr>
<td>Hewlett Packard Corp.</td>
<td>51-58, 81</td>
</tr>
<tr>
<td>Houston Instrument, Div. of Bausch &amp; Lomb, Inc.</td>
<td>129</td>
</tr>
<tr>
<td>E. F. Hutton &amp; Co., Inc.</td>
<td>175</td>
</tr>
<tr>
<td>iCom, Inc.</td>
<td>71</td>
</tr>
<tr>
<td>IMS Associates, Inc.</td>
<td>148</td>
</tr>
<tr>
<td>Instrument Specialties Co., Inc.</td>
<td>182</td>
</tr>
<tr>
<td>Integrated Computer Systems, Inc.</td>
<td>159</td>
</tr>
<tr>
<td>Intelligent Systems Corp.</td>
<td>46, 47</td>
</tr>
<tr>
<td>Intel Corp.</td>
<td>68, 69</td>
</tr>
<tr>
<td>Intel Memory Systems</td>
<td>31</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Company</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>International Rectifier Corp., Crydom Controls Div.</td>
<td>165</td>
</tr>
<tr>
<td>Interstate Electronics Corp.</td>
<td>42, 43</td>
</tr>
<tr>
<td>Kennedy Co.</td>
<td>1</td>
</tr>
<tr>
<td>Magnetic Components Group, Control Data Corp.</td>
<td>182</td>
</tr>
<tr>
<td>Microdata Corp.</td>
<td>166, 167</td>
</tr>
<tr>
<td>Millennium Information Systems</td>
<td>28, 29</td>
</tr>
<tr>
<td>Mohawk Data Sciences Corp.</td>
<td>7</td>
</tr>
<tr>
<td>Monolithic Memories, Inc.</td>
<td>145</td>
</tr>
<tr>
<td>Mostek</td>
<td>64, 65</td>
</tr>
<tr>
<td>Motorola Semiconductor Products, Inc.</td>
<td>13, 139</td>
</tr>
<tr>
<td>NCR, Terminal Systems Div.</td>
<td>130, 187</td>
</tr>
<tr>
<td>NEC Microcomputers, Inc.</td>
<td>90, 91</td>
</tr>
<tr>
<td>Neff Instruments Corp.</td>
<td>26</td>
</tr>
<tr>
<td>North American Phillips Controls Corp.</td>
<td>158</td>
</tr>
<tr>
<td>OK Machine &amp; Tool Corp.</td>
<td>170</td>
</tr>
<tr>
<td>PerSci, Inc.</td>
<td>125</td>
</tr>
<tr>
<td>Pertec Corp., Peripheral Equipment Div.</td>
<td>82, 83</td>
</tr>
<tr>
<td>Philips Test &amp; Measuring Instruments</td>
<td>131</td>
</tr>
<tr>
<td>Plessey Microsystems</td>
<td>72, 73</td>
</tr>
<tr>
<td>Portescap U.S.</td>
<td>147</td>
</tr>
<tr>
<td>Power-One, Inc.</td>
<td>12</td>
</tr>
<tr>
<td>Ramtek Corp.</td>
<td>75, 76, **77</td>
</tr>
<tr>
<td>Raymond Engineering Co.</td>
<td>102</td>
</tr>
<tr>
<td>Research, Inc.</td>
<td>48</td>
</tr>
<tr>
<td>Sanders Associates, Federal Systems Group, Military Data Systems Div.</td>
<td>45</td>
</tr>
<tr>
<td>Science Accessories Corp.</td>
<td>156</td>
</tr>
<tr>
<td>Shugart Associates</td>
<td>15</td>
</tr>
<tr>
<td>Singer Co., Kearff Div.</td>
<td>108</td>
</tr>
<tr>
<td>Sweda International, OEM Products Div.</td>
<td>181</td>
</tr>
<tr>
<td>Systems Engineering Labs</td>
<td>16, 17</td>
</tr>
<tr>
<td>Tally Corp.</td>
<td>2</td>
</tr>
<tr>
<td>Technipower, Division of Benrus Corp.</td>
<td>22</td>
</tr>
<tr>
<td>Tektronix, Inc.</td>
<td>67</td>
</tr>
<tr>
<td>Teledyne Relays</td>
<td>63</td>
</tr>
<tr>
<td>Teletype Corp.</td>
<td>23</td>
</tr>
<tr>
<td>Teradyne, Inc.</td>
<td>155</td>
</tr>
<tr>
<td>TEXAS INSTRUMENTS INCORPORATED, Digital Systems Div.</td>
<td>92</td>
</tr>
<tr>
<td>Tri-Data Corp.</td>
<td>169</td>
</tr>
<tr>
<td>United Technologies, Norden Div.</td>
<td>85, 87, 89</td>
</tr>
<tr>
<td>Victor Comptometer</td>
<td>157</td>
</tr>
<tr>
<td>Wang Laboratories, Inc.</td>
<td>164</td>
</tr>
<tr>
<td>Wangco, Inc.</td>
<td>128</td>
</tr>
<tr>
<td>Western Peripherals, Inc.</td>
<td>12</td>
</tr>
</tbody>
</table>

*Not appearing in subscribers' copies
**Card not appearing in certain regional copies
Monitor or generate analog signals at any level or speed, economically.

RTP is a family of standard products that allows the direct input and output of analog signals to your digital computer, regardless of which computer you select. All are self-contained, plug-compatible, designed for local or remote applications, and delivered virtually off-the-shelf.

So, RTP is an obvious boon to the measurement and control systems designer.

Need to measure a diverse combination of low-level and high-level signals at medium speeds? Use the RTP Wide-Range Controller.

Having trouble with the high speed measurement of low-level signals with high common mode voltages? You need an RTP Low-Level Controller.

Measuring a lot of high-level signals at high speed? You'll be interested in the RTP High-Level Controller.

Want to generate lots of high-level signals? Try the RTP Analog Output Controller.

In any case, circle our number, on the Reader Service card, and stand by for a super booklet, "Using RTP," which will show you how RTP can be a big part of the solution in any measurement and control problem.

Computer Products, Inc.
When you buy a Series 400 disk drive in 26.6, 40 or 53.3 megabyte capacity, you get two drives in one compact package! The first has a removable 13.3 Mbyte cartridge; and the second has 13.3, 26.6 or 40 Mbytes of fixed capacity. It's only possible with our exclusive inertial actuator that gives our Series 400 drives two independent head positioners. That means you can be reading or writing with the upper unit, seeking with the lower unit. And, of course, all the inherent Series 400 features are there: power interrupt protection, data track servo following, common dimensions for all models, 100% common spares, interface compatibility in all models and proven Diablo disk drive performance dependability and reliability.

For a complete presentation of the new Diablo Series 400 disk drive family, call or write Diablo Systems, Inc., 24500 Industrial Blvd., Hayward, CA 94545 or Diablo Systems, S.A., Avenue de Fre, 263, 1180 Brussels, Belgium.

Diablo
Diablo Systems, Incorporated
A Xerox Company
CIRCLE 90 ON INQUIRY CARD

2 disk drives for the price of one