Computers & Electronics

AUGUST 1983

formerly Popular Electronics

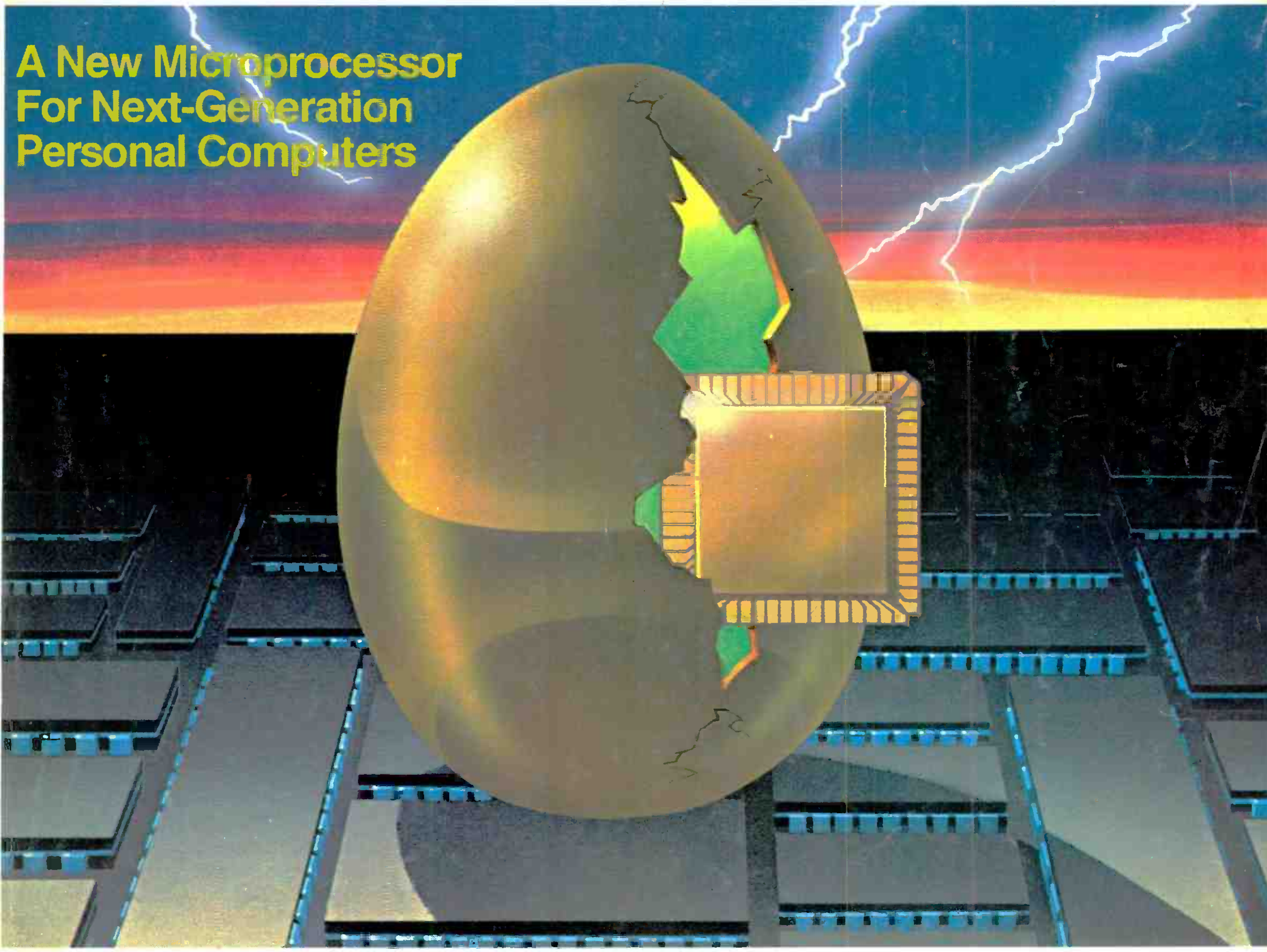
$1.50

Printers for Small Computers

Radio Shack's New Micro Color Computer

Testing the Microbuffer II Printer Interface

Compact Disc Digital Audio Systems



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The Latest Flat-Panel Displays

First Look at Magnavox's CD Record Player

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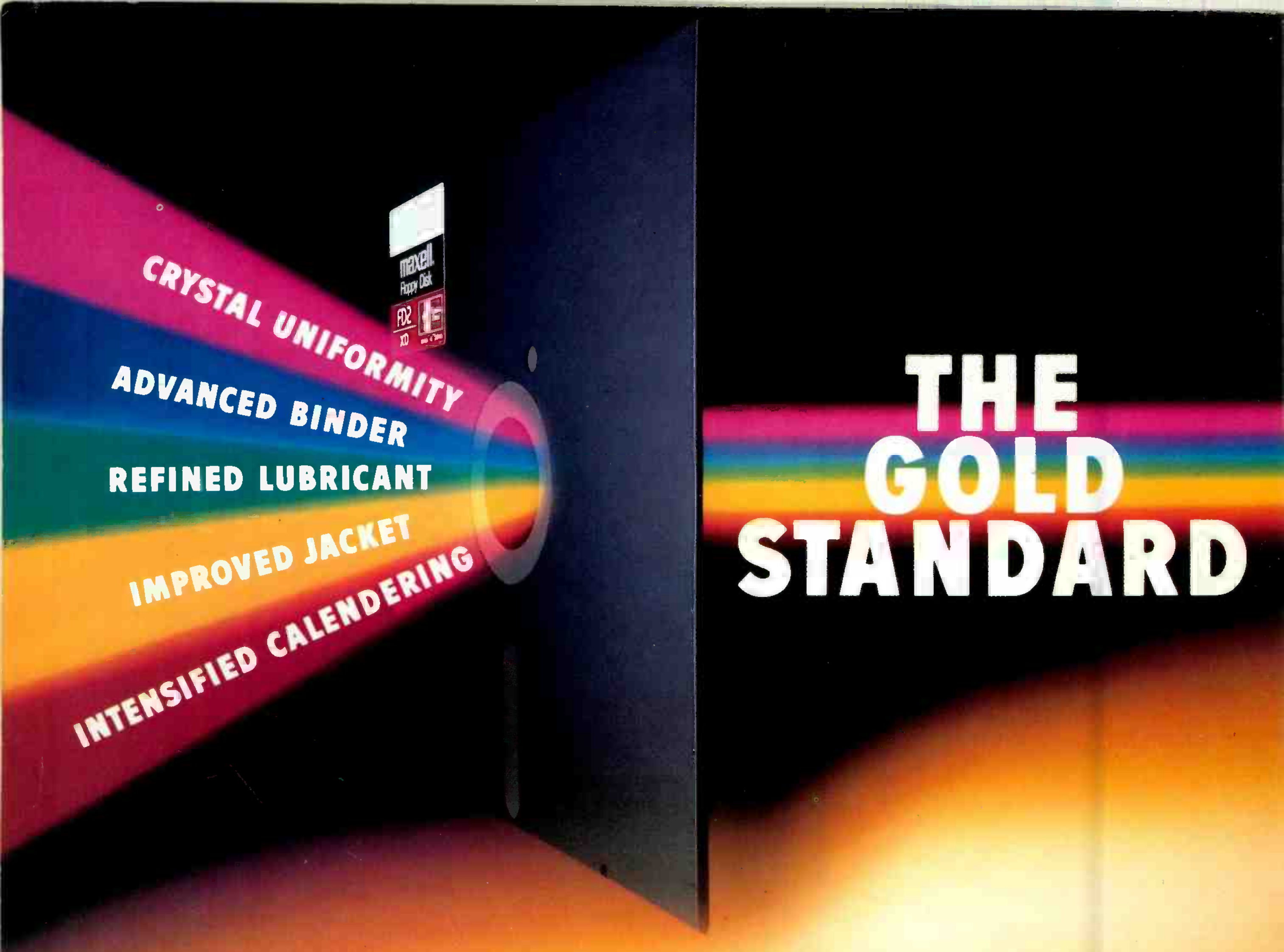

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An advanced binder bonds oxides to the base material preventing time and money-wasting dropouts. Calendering then smooths the surface for a read/write signal that stays clear and accurate. And lubricants reduce friction between head and disk for a longer media and head life. To house it, we then constructed a new jacket heat-resistant to 140° F to withstand drive heat without warp or wear. And created the floppy disk that leads the industry in error-free performance and durability.

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The KLH Solo

Price Slashed

List Price $199-Suggested Retail $169
January 1983 Dealer Cost $106

NOW $68

It's been killing us. We bought these KLH stereos in April, but we agreed not to sell them till June. You see, the local KLH dealers still had lots of them in stock. Most were selling the Solo for $169 (the very cheapest discount ad we've seen was $129). And, the dealers had to have time to sell out their stock before our ads hit. So, we've been raring to go since April, while we've sat on DAK's best buy ever.

The KLH Solo was built to sell for $169 to $199 and to wholesale for $106. It represents the very top end, state of the art in electronics. It's the audiophile's choice in personal stereos. But, unfortunately because of our last recession there just haven't been as many rich audiophiles around. So KLH ended up with 14,000 of these remarkable stereos.

DAK bought them all for cold hard cash. So if you're into absolutely the best sound in cassettes, complete with auto-reverse, dual flywheel anti-rolling design, and if you'd like incomparable FM reception from the included FM stereo tuner pack, the KLH Solo is for you.

And don't worry. All of our KLH Solos are brand new factory sealed direct from the manufacturer.

The KLH Solo will make the sound of your cassettes and FM stereo explode with life. It gives you auto-reverse. The sound is simply breathtaking, and so is the incredible $68 price.

It's vibrant. And, the sound seems to be alive. The KLH Solo brings thunderingly powerful realism to personal stereo. And frankly for its $169 price tag, it had better sound great.

In a market flooded with cheap Hong Kong imports, the KLH stands out as the Audiophile's choice. And even though DAK is able to offer the KLH Solo to you for just $68 (a $101 saving), let's look at what has made it worth $169.

KLH

DEALER PRICE SCHEDULE

EFFECTIVE: JANUARY 1, 1983

Model	Description	Nationally Advertised Price	Suggested Retail Value	New Dealer Cost
S-200	The Solo Auto Reverse - Includes FM Tuner Pack, Headset, Carrying Case, Accessory Case, Shoulder Strap, Hand Strap and Belt Clip	$199.95	$169.95	$106.00

AUTO REVERSE

The anti-rolling transport of this deck is incredibly stable. It uses twin matched stabilization flywheels in conjunction with a specially designed motor to give you rock stable bi-directional play.

With auto reverse, your cassette need never stop. It just plays back and forth over and over again. It makes listening while you're on the run a real pleasure.

And, at home or in the office, with our optional home stereo cable you can plug this auto-reversing deck into any 'aux' jacks on your stereo system for an evening or a day of uninterrupted music.

Wait till you hear the quality of the sound from this audiophile cassette deck. And, while this deck is plugged into your stereo system, you can copy cassettes by playing them on the Solo and copying them on your home cassette deck.

FABULOUS FM STEREO TOO

Here's where you can really hear the difference. The Solo provides FM reception that is incredible. We think you'll get more and cleaner FM stations than with any other personal stereo.

But don't take our word for it. Test it yourself. Start at the bottom of the dial and compare station to station with any other high end personal stereo.

Then, when you've left them in the dust, do the same test against the tuner in your own stereo system. You might just be in for a very big surprise.

The FM tuner pack simply fits into the Solo like a cassette. And retracting pins direct-connect it with the Solo.

The FM signal goes directly into the amplifier, not through the head and it works off the deck's power. It uses the headphone cable as a super antenna.

There's no tape/tuner switch because the KLH Solo is intelligent enough to know when its tuner pack is inserted.

But, all of the above wouldn't mean anything if it weren't for the incredibly sensitive FM tuner circuit. It utilizes a sophisticated 20 pin integrated circuit to produce dramatically alive FM sound.

ALL THE BELLS AND WHISTLES

The Solo comes with a heavy duty protective leatherette case, a matching case that holds 3 cassettes, a shoulder strap and a removable wrist strap.

You can attach the case to your belt or look at this, there's a 'screw-on' living hinge belt or waist band clip too.

So many features. There's a metal/normal equalization switch. The Solo reverses automatically plus even its reverse button is power assisted.

There are 2 LED arrows to show tape direction. And while we're on the subject of 2s, there are 2 headphone jacks and 2 volume controls.

Along with the 2 stability flywheels, there are 2 capstans. There's only one mute button. But, it cuts off the sound on 2 channels to hear the outside world.

The stereophones are the latest Samarium Cobalt mylar® diaphragm type that deliver earth shaking thunderous sound with such precise definition and detail, that music is almost three dimentional.

BUT IT'S THE SOUND

Take the KLH Solo to your local HiFi store. Compare its dramatic sound and super stability with other top of the line stereos, then you'll really appreciate the achievement that the Solo represents.

The Solo is only 1/4" wider than a cassette box (4½" X 3½" X 1½"). It operates on only two AA batteries (not included). And, it's backed by a limited 90 day warranty by KLH.

TRY THE KLH SOLO RISK FREE

Take the Solo on walks, as you commute to work, while you work or relax.

Don't put it away when you get home or to the office. With our optional cable, you can plug into your home or office stereo system for continuous **nonstop** play of your favorite cassettes. Here's a stereo you can use all the time.

If you aren't 100% satisfied, simply return it to DAK in its original box within 30 days for a courteous refund.

To order your KLH Solo with FM Tuner Pack risk free with your credit card, call toll free or send your check not for the the $169 suggested retail price or even the $103 Jan 1983 dealer cost. Send just **$68** plus **$3** for postage and handling. Order No. 9683. CA res add 6% tax.

And there's more. We have a bonus cable that you plug into an earphone jack on the Solo and into any stereo 'aux' inputs on your home stereo. Just add **$4** ($1 P&H) Order No. 9200.

Never buy batteries bonus. We'll include a charger and 4 nicad batteries (that's two in and two charging) so you'll always have music. It's a $24.65 retail value, but it's yours for just **$12.99** ($1.50 P&H) Order Number 9206.

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Computers & Electronics

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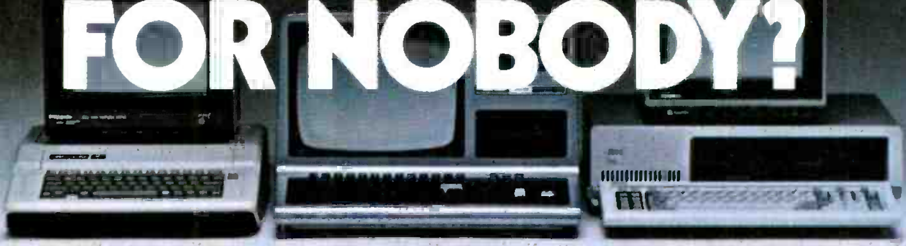
IF PERSONAL COMPUTERS ARE FOR EVERYBODY, HOW COME THEY'RE PRICED FOR NOBODY?



$1395* APPLE® IIe 64K

$999* TRS-80® III 16K

$1355* IBM® PC 64K

A personal computer is supposed to be a computer for persons. Not just wealthy persons. Or whiz-kid persons. Or privileged persons.

But person persons.

In other words, all the persons whom Apple, IBM, and Radio Shack seem to have forgotten about (including, most likely, you).

But that's okay. Because now you can get a high-powered home computer without taking out a second mortgage on your home.

It's the Commodore 64. We're not talking about a low-priced computer that can barely retain a phone number. We're talking about a memory of 64K. Which means it can perform tasks most other home computers can't. Including some of those that cost a lot more. (Take another look at the three computers above.)

By itself, the Commodore 64 is all the computer you'll ever need. Yet, if you do want to expand its capabilities some day, you can do so by adding a full complement of Commodore peripherals. Such as disk drives. Modems. And printers.

You can also play terrific games on the Commodore 64. Many of which will be far more challenging than those you could ever play on a game machine alone.

And as great as all this sounds, what's even greater-sounding is the price. It's hundreds of dollars less than that of our nearest competitor.

So while other companies are trying to take advantage of the computer revolution, it seems to us they're really taking advantage of something else: Their customers.

*Manufacturers' suggested list prices as of March 20, 1983. Monitor included with TRS-80 III only. Commodore Business Machines, P.O. Box 500R, Conshohocken, PA 19428; Canada–3370 Pharmacy Avenue, Agincourt, Ont., Can. M1W 2K4.

commodore COMPUTER

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EDITORIAL

Friendly Computers

ARE computers "friendly"? I suppose if I asked that question of 100 people, 99 would probably respond with a resounding "No!" But what is a friendly computer anyway? Let's dodge the question for a bit, and examine some other supposedly friendly machines.

The first one to come to mind is the television receiver. Is it truly friendly? Consider TV's purpose: to bring entertainment and information into the home. Now how much effort does it take to accomplish this purpose? Just turn on a switch—very friendly. However, think back to the time when you first bought the TV. If it had a mechanical tuner, you just plugged it in, turned it on, and selected a channel. But if it had pushbutton electronic tuning, you had to set (or fine tune) the desired stations before the TV progressed into its friendly mode.

How about an electronic typewriter? Usually it's a cinch to slide paper into the machine, turn it on, and produce hard copy. Truly a friendly machine you might say. But how about when you try to take advantage of some of its special features, such as automatic tabs and error correcting—or what about the basics such as setting margins and centering copy? Does a typewriter seem a little less friendly now? Let's also mention that both the TV and the typewriter are "dedicated" machines, meant to do one specific job.

Before we return to our original question, let's look at the computer in contrast to the other machines. Firstly, the computer is not a dedicated machine. It can handle a wide variety of tasks as we all know. Secondly, when a computer is used to accomplish a task, the user usually wants it to perform many sophisticated functions. Take word processing as an example. We are not satisfied to place a sheet of paper in a printer and use the computer's keyboard to produce hard copy. We want the computer to do all the normal tasks like setting margins, centering, etc. We also want it to check spelling, move paragraphs around, add footnotes, and maybe even suggest (thesaurus-like) possible alternate words to use. No wonder it seems unfriendly at times!

But hardware manufacturers and software authors are really striving to make the computer more friendly. In the hardware area, we are seeing products like the mouse, touch pad, light pen, and touch-sensitive video screen. In the software area, authors are using metaphors and icons, and, in general, a more graphic approach to the interface between man and machine.

Machines such as Apple's Lisa have taken a giant step in the direction of the friendly computer. Of the less-expensive machines, Epson's QX-10 and Radio Shack's Model 100 appear to be moving in the right direction with important applications packages built in. Current machines such as the IBM Personal Computer and the Commodore 64 will become more friendly with the addition of software such as VisiCorp's VisiOn, which is an easy-to-use window-oriented software system, and Commodore's Magic Desk, which uses pictorial images to convey information to the user.

Are computers friendly? The answer right now is no. Will they be more friendly in the future? Yes, definitely. Will they ever be friendly in the same sense as a TV or typewriter? Probably not. But then again, you can never hope to accomplish with a TV, typewriter, or any other dedicated and "dumb" machine the same things you can accomplish with a computer.

Art Salsberg

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The quality of Wabash diskettes is stressed throughout the entire manufacturing process. After coating, all Wabash diskettes go through a unique burnishing process that gives each diskette a mirror-smooth appearance. Wabash then carefully applies a lubricant that is specially formulated to increase diskette life. Then, to keep out foreign particles, a unique heat seal bonds the jacket and liner together to help prevent contamination. After 100% hypercritical testing and certification, Wabash then packages each diskette, (except bulk pack) in a super strong and tear resistant Tyvek® evelope. The final Wabash product is then shrink-wrapped to insure cleanliness and reduce contamination during shipment. Wabash diskettes are so very reliable that Wabash now offers a six year warranty in case of defects in materials or workmanship on all diskettes purchased directly from Communications Electronics.

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Communications Electronics has teamed up with Wabash to provide a single-source solution for the diskette duplication requirements of software developers, OEM's and distributors. All service is in-house, to give you fast, dependable service. In most cases, delivery can be completed in five days. Whether you require 100, 1,000, or 10,000 copies per week, call CE first for a no obligation price quote. For additional information, please write us on your letterhead with your requirements.

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8" DSDD Soft Sector (Unformatted)	F14A	2.99
8" DSDD Soft Sector (256 B/S, 26 Sectors)	F144	2.99
8" DSDD Soft Sector (512 B/S, 15 Sectors)	F145	2.99
8" DSDD Soft Sector (1024 B/S, 8 Sectors)	F147	2.99
5¼" SSSD Soft Sector w/Hub Ring	M11A	1.49
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5¼" DSDD Soft Sector w/Hub Ring	M14A	2.69
5¼" Same as above, but bulk pack w/o envelope	M14AB	2.49
5¼" DSDD 10 Hard Sector w/Hub Ring	M44A	2.69
5¼" DSDD 16 Hard Sector w/Hub Ring	M54A	2.69
5¼" SSQD Soft Sector w/Hub Ring (96 TPI)	M15A	2.59
5¼" DSQD Soft Sector w/Hub Ring (96 TPI)	M16A	3.69
5¼" Tyvek Diskette Envelopes - Price per 100 Pack	TE5	12.00

SSSD = Single Sided Single Density; SSDD = Single Sided Double Density; DSDD = Double Sided Double Density; SSQD = Single Sided Quad Density; DSQD = Double Sided Quad Density; TPI = Tracks per inch.

Quantity Discounts Available

Wabash diskettes are packed 10 disks to a carton and 10 cartons to a case. The economy bulk pack is packaged 100 disks to a case without envelopes or labels. Please order only in increments of 100 units for quantity 100 pricing. With the exception of bulk pack, we are also willing to accommodate your smaller orders. Quantities less than 100 units are available in increments of 10 units at a 20% surcharge above our 100 unit price. **Quantity discounts** are also available. Order 500 or more disks at the same time and deduct 1%; 1,000 or more saves you 2%; 2,000 or more saves 3%; 5,000 or more saves 4%; 10,000 or more saves 5%; 25,000 or more saves 6%; 50,000 or more saves 7%, 100,000 or more saves 8%, 500,000 or more saves 9% and 1,000,000 or more disks earns you a 10% discount off our super low quantity 100 price. Almost all Wabash diskettes are immediately available from CE. Our efficient warehouse facilities are equipped to help us get you the quality product you need, when you need it. If you need further assistance to find the flexible disk that's right for you, call the Wabash compatibility hotline. Dial toll-free 800-323-9868 and ask for your compatibility representative. In Illinois or outside the U.S. dial 312-593-6363 between 9 AM to 4 PM Central time.

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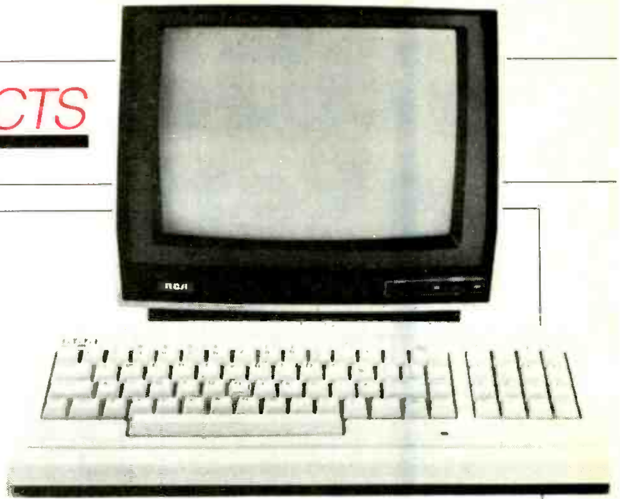

RCA ALL-PURPOSE TERMINALS

RCA's line of all-purpose terminals (APT) for multi-database timesharing and dedicated, direct computer-connected applications have either full-stroke or membrane keys and come with or without a 12" terminal. Features include menu-controlled operation; programmable "personality" to match communication requirements for each database; built-in, direct-connect 300-baud modem; tone or pulse auto-dialing of up to 26 stored phone numbers; and automatic log-on. Standard 60-key alphanumeric keyboard includes two user selectable keys and there is also a 16-key calculator pad. Full-keystroke with terminal (shown): $598.

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CAR AUDIO CASSETTE RECEIVER

The YCR-900 cassette receiver from Yamaha features 18 W/channel output into 4 ohms, both channels driven. It also has electronic synthesizer tuning, automatic reversing, and a bottom-loading tape transport with full logic control. Tuner section has automatic "seek" and manual tuning in both directions, 6 AM and 6 FM illuminated station presets, Yamaha's FM Automatic Noise Control, and adjustable muting threshold. Specs: sensitivity, 17.3 dBf; 50-dB quieting, 20.7 dBf; alternate channel selectivity, 80 dB; S/N, 65 dB; frequency response, 30-15,000 Hz. $550.

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BRIEFCASE COMPUTER WITH DISK DRIVE

The Pied Piper has a full ASCII keyboard, is built around the Z80A CPU, and has an integral slim-line minifloppy disk drive with 748K bytes (formatted) and accommodations for a second 748K-byte floppy drive. The STM Electronics Corp. computer has 64K RAM, 4K ROM, 2K video display buffer, and 2K ROM for character generation. A 5M- or 10M-byte hard-disk subsystem can be added. It can interface a standard CRT monitor providing a 24-line by 80-character format. An r-f modulator is also available. For hard-copy printout, there is a parallel port for Centronics/Epson-style printers. The Pied Piper operates on CP/M 2.2 and the Perfect Software package (word processing, spelling dictionary, electronic spreadsheet, and data filing/merging system) is included. Dimensions: 4" × 20" × 11"; weight: 12.5 lb. $1299.

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NETWORK CAPABILITY IN PORTABLE COMPUTER

TeleTote I, from TeleVideo Systems Inc, is claimed to be the first portable computer with the capability of being connected to a network. An optional RS-422 port enables it to be linked to a TeleVideo network for access to shared files, printers, and electronic mail. Weighing 25 lb, it has a 9" display screen with 640 by 240 graphics resolution. Display is 24 lines by 80 characters. It has a Z80A CPU, 64K RAM, expandable to 128K, a 368.6K (formatted) 5¼" floppy-disk drive, a SuperMouse port for cursor manipulation, and two RS232 printer/modem ports. $1499.

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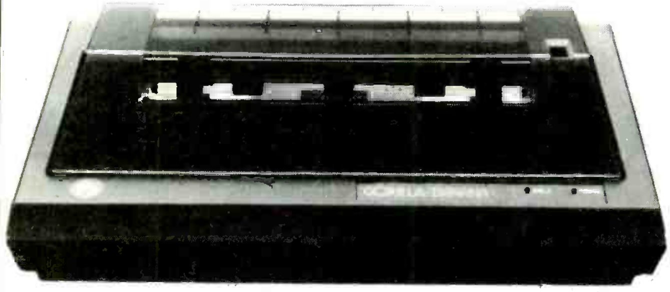


LOW-COST DOT-MATRIX "BANANA"

The Gorilla/"Banana" dot-matrix printer, features 50 cps print speed, dot-addressable graphics, 5 × 7 dot matrix, tractor paper feed, self-inking ribbon cassette, parallel or serial interface, and 10" carriage. From Leading Edge Products, it can print either 10 or 5 cpi, the former providing 80 columns. Printhead pressure is adjusted with a 7-position switch. Four special character sets are included for US, UK, Germany, and Sweden. Has rotating thumbwheel advance and single-hammer construction. Weighs 10 lb. $249.95.

Circle No. 87 on Free Information Card

16K TIMEX SINCLAIR 1500

The Timex Sinclair 1500 features 16K RAM (expandable to 32K), extended BASIC, and 40 moveable keys. Each key can perform as many as six functions including keyword entry. The 1500 is said to be compatible with all of the peripherals and software available for the TS1000. Additionally, instant-load software cartridges can be inserted into a low-cost interface that plugs into the computer. $79.95.

Circle No. 88 on Free Information Card

PORTABLE COMPUTER IS IBM-PC COMPATIBLE

The Columbia VP is an 8088-based microcomputer said to provide IBM compatibility in a portable package. It features a 9" video monitor, two 5¼" half-high floppy-disk drives, IBM-standard keyboard, 128K RAM (expandable to 256K), an RS232 interface, and parallel printer interface. Video display is 600 × 200 or 320 × 200 pixels. Disk drives are 320K double-sided, double-density. Dimensions: 18" × 14" × 8"; weight: 32 lb. $2995.

Circle No. 89 on Free Information Card

TELEVISION WATCH

Claiming it to be the first television watch, Seiko has introduced a digital wristwatch that also contains a 1.2" LCD TV screen and weighs less than 2 oz. Accompanying the wrist unit are a pocket-size power-pack/tuner and stereo headphones (which also contain the antenna). The set will receive all 82 vhf and uhf channels and FM stereo radio. The display has 31,920 elements. $495.

Circle No. 90 on Free Information Card

ENHANCED DAISY-WHEEL PRINTER

Smith-Corona's TP-II has a dual interface for RS232 or Centronics operation; a 10/12-pitch ASCII 93-character printwheel; panel switches for form fed, line feed, and self test; interior switches for baud rate, parity, and character length, and for foreign languages; automatic underscore; programmable margins and tabs; and 256-character buffer. Print speed is 12 cps. $895. Optional tractor feed, $149.

Circle No. 91 on Free Information Card

Critical circuits are pre-assembled, making the H-100 easier and faster to build!

Want beautiful high-resolution graphics? You can create extensive charts, drawings, graphs and symbols to meet your needs – using the H-100's bit-mapped graphics and its 640 x 225 pixel video display.

The H-100 gives you total communications flexibility. Three interface ports let you plug in dot-matrix and letter-quality printers, as well as other peripherals.

Compare the H-100's exceptional capabilities with other desktop computers:

COMPUTER:	Heathkit H-100	IBM Personal Computer	Apple III
MICROPROCESSORS:			
16-bit:	8088	8088	–
8-bit:	8085	–	6502
RANDOM ACCESS MEMORY:			
Minimum:	128KB	16KB	128KB
Maximum:	768KB	576KB	256KB
FLOPPY DISK STORAGE:			
Per Diskette:	320KB	320KB	140KB
Maximum Internal:	640KB***	640KB	140KB
8" Floppy Support:	Standard	—	—
EXPANSION SLOTS:	Five S-100 (four available)	Five (three available)	Eight
I/O PORTS			
Parallel:	1	Optional	–
Serial:	2	Optional	1
VIDEO DISPLAY:			
Line Columns	25 x 80	25 x 80	24 x 80
Pixels Colors	640 x 225 (8 colors)	640 x 200 (2 colors) 320 x 200 (4 colors)	560 x 192 (16 colors)
OPERATING SYSTEMS:	CP/M-85, Z-DOS (MS-DOS)	CP/M-86 PC-DOS (MS-DOS) UCSD P-System	Apple SOS

*Information current as of 8/31/82. ***External disk storage available soon.

Learn by building. When you build and operate the H-100, you learn more about this sophisticated computer system and its unique 16-bit/8-bit software capabilities.

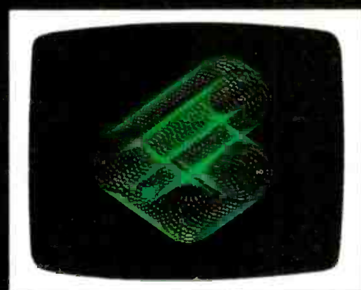
Learn from outstanding documentation. One of the most important parts of any computer system is documentation – and Heathkit documentation is among the industry's best. Our instruction and operating manuals are fully detailed, in the world-famous Heathkit tradition.

Learn by doing. Many of our software programs come with a complete set-up and operating manual. More complete than most other software documentation, each manual not only tells you what the program will do – it shows you the easiest way to accomplish each task.

We back you all the way. With Heathkit computer products, technical assistance and expertise is as close as your telephone – or the nearest Heathkit Electronic Center.* Complete technical assistance and service is available at over 60 locations nationwide.

Buy from a leader. When you choose a Heathkit computer, you get the backing and reliability of the world's leader in quality electronic kits for over 50 years! You can count on us for quality service, reliability and value – at kit prices that give you more computer for your dollar!

See the H-100 in action. Visit your nearby Heathkit Electronic Center, which has the world's first 16-bit/8-bit computer kit, peripherals and software programs on display. See your telephone white pages for the nearest store location. Or mail the coupon today for a FREE, full-color Heathkit computer catalog.



Always in graphics mode, you can control each of the H-100's 144,000 screen dots! (Color graphics optional)

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Please send my FREE Computer Catalog, with details on the new 16-bit/8-bit H-100 Computer Kit, today!

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Circle No. 24 on Free Information Card

Hands-On Reviews of Recently Released Game Software

ONE of the more intriguing developments for what are traditionally home-type computers is the rash of "serious software" products coming out for such machines as the Atari 800 and the Commodore VIC-20. Foremost as members of this group are the several word-processing programs we've seen—some fairly venerable, others brand new.

Atari has had its own WP for quite a while; and though it is more complex than most, it comes with a tutorial tape cassette that helps make life easier for the complete neophyte. Atari also reports a new, improved WP program. We haven't seen it yet, but it's supposed to be extra-easy to learn.

One that's been out for a while and that we found especially easy and quick to learn is DataSoft's "Text Wizard." The various command functions are a breeze to assimilate, and the supplier has thoughtfully provided a quick-reference crib card—something that would be very helpful from *every* software supplier. Maybe they did it this way because they're primarily a game vendor and used to putting concise instructions on a card in the package.

A brand new one is the "Bank Street Writer," just landed from Broderbund Software. It comes with a tutorial on the reverse side of the diskette. To retrieve the tutorial, play the diskette *upside-down*—a feat that's possible with the Atari disk drive. Unlike most other low-cost WP programs, Bank Street Writer presents the screen display the way it will appear on the printed page instead of jumbling it all together in one mish-mash. This is a definite plus, and the designers are to be congratulated on their thoughtfulness and thoroughness in putting this package together.

For the VIC-20, we have two entries of import: the Quick Brown Fox and Wordcraft 20. They're both on plug-in ROM cartridges. The Q.B.F. is super-cheap (about $65), a price probably made possible by the fact that it's been around for a while and just recently surfaced in a VIC version. In its unexpanded version, the ROM cart provides about 2K of space for creating files. Adding memory expansion is a big help here. Like most such programs, it relies heavily on your willingness to save the goodies on a cassette tape at your earliest convenience. All the usual features are there: variable page parameters, rapid scroll, find and replace, etc. And it's easy to use.

The principal problem with the Q.B.F.—as with most anything you run on the VIC-20—is the fact that the computer has a nonstandard printer output and you need a special interface converter such as the one from Cardco (about $79) that lets the computer run with *any* parallel printer. It is a cheap and quick way to get word processing on a low-cost computer.

Another VIC-20 entry, Wordcraft 20 from U.M.I. (another game house), costs a bit more (about $150), but has some additional features that make up for the higher price tag. For one thing, it doesn't require that special interface to run the printer. Instead, it has specific programming addresses built in so it will drive just about any parallel printer right from the VIC's user port.

Also, the Wordcraft has a 40-column screen display converter built into its circuitry, which makes the VIC somewhat more feasible as a word processor than does its normal 23-column display. You do need a special connecting cable for most typical printer hookups, but any good computer store will make this up for you. When you compare Wordcraft with Q.B.F., neither one comes off with a particular price edge, since the Wordcraft has features built in that are otherwise available only with additional hardware when you use the Q.B.F. But the latter system has a big attraction—the low initial cost, which makes it painless to buy and add to later.

One thing about all these word processors—whether they're for the Atari or the VIC—a decent-quality monochrome monitor is important in order to read print on the screen easily. Substituting an excellent amber-and-black-screen monitor for a color-TV set made an enormous difference! Both the VIC and the Atari have a composite video output at a five-pin DIN connector, so attaching the monitor was no problem at all. All that was needed was a $5 DIN-to-RCA adapter.

ARCHON

Diskette for Atari 400/800
Electronic Arts, 2755 Campus Drive, San Mateo, CA 94403, 415-571-7171. $40.00
Graphics ★★★★
Gameplay ★★★★
Sustained Interest ★★★★
Type: *Joystick strategy/adventure game*
Memory Required: *32K*

Once in a while, we come across a new company with some really brilliant computer game concepts. This is one of those rare cases. The emergence of Electronic Arts with its line of "thinking" computer games may show the way for a lot of successful entries in the future. We've had a peek at some of the other games to come from this company, and we think they'll be real winners.

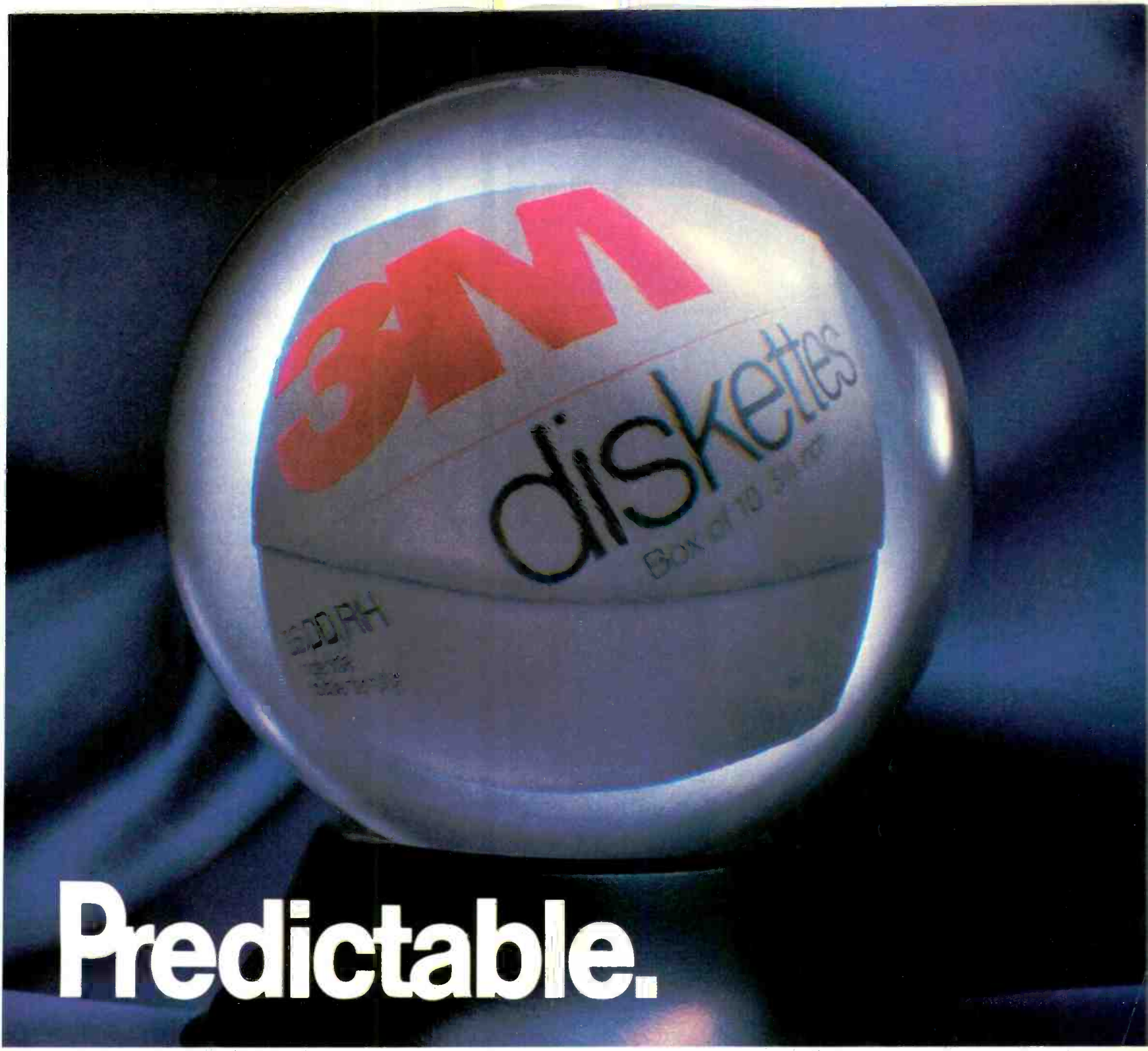
Archon is a combination of several

types of games. It starts out looking something like a chess board, except the players are mostly fantasy-allegorical characters such as the wizard, sorceress, unicorn, phoenix, shapechanger, and others. Each playing piece, called an "icon," has particular move limits that it can make on the board; and each has its own special way of doing battle.

This is best played as a two-player game, although you may elect to play against the computer—in which case, you may not stand a chance. Each icon has a specific battle weapon, and you engage an enemy piece by trying to occupy the same square on the chessboard that the enemy is on. When you press your fire button to "engage," the screen changes, and the two of you square off on a field of battle that has many trees and shrubs to act as obstacles and shields.

Some pieces, like the knights and goblins, are sword-swingers and club wielders, so their range of effectiveness is limited. But when you play against the computer, watch out for those lowly goblins; they're fast and mean! Other icons have long-range weapons such as fireballs, lightning bolts and arrows. The phoenix has a field of fire, while the wizard and sorceress (on opposing teams) can throw fireballs. They can also cast a number of very useful spells such as teleport, heal, revive (a dead icon), summon an element (wind, water, fire, etc. to act as combatants), imprison (a troublesome opposing icon), or reverse time. Each spell can be used just once during a game, and it's important to remember what you have left and to

(Continued on page 16)



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Look in the Yellow Pages under Computer Supplies and Parts for the 3M distributor nearest you. In Canada, write 3M Canada, Inc., London, Ontario. If it's worth remembering, it's worth 3M diskettes.

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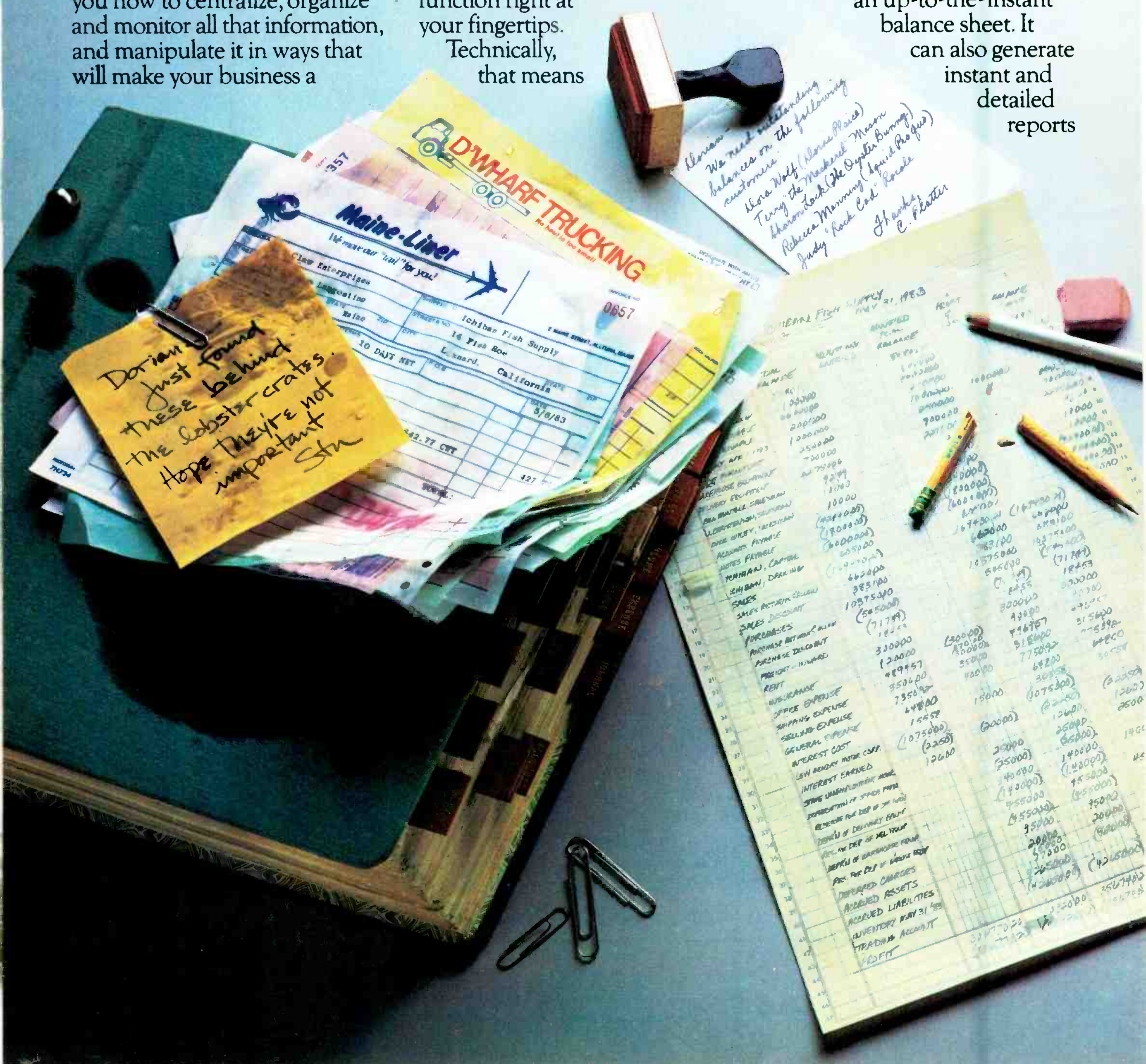
With BPI, your Apple III can give you a snapshot of your company's financial condition, an up-to-the-instant balance sheet. It can also generate instant and detailed reports



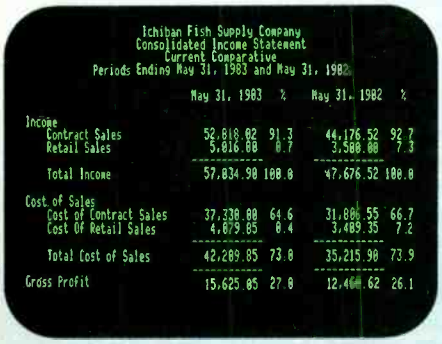
gain your balance.

on your customers and vendors.

So you know who owes whom, how much, and how come.

And just how well your cash flow is flowing.

And where to give credit where credit is due (a customer inquiry



Ichiban Fish Supply Company
Consolidated Income Statement
Current Comparative
Periods Ending May 31, 1983 and May 31, 1982

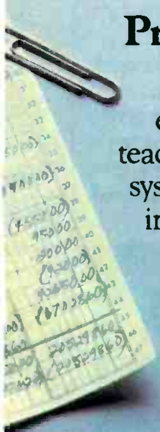
	May 31, 1983	%	May 31, 1982	%
Income				
Contract Sales	52,818.02	91.3	44,176.52	92.7
Retail Sales	5,016.88	8.7	3,500.00	7.3
Total Income	57,834.90	100.0	47,676.52	100.0
Cost of Sales				
Cost of Contract Sales	37,330.00	64.6	31,806.55	66.7
Cost Of Retail Sales	4,879.85	8.4	3,409.35	7.2
Total Cost of Sales	42,209.85	73.0	35,215.90	73.9
Gross Profit	15,625.05	27.0	12,4[illegible].62	26.1

Your Apple can generate instant income statements (with expense ratios) or balance sheets, and let you compare them to last month's or year's, then print them out to suit your banker.

feature allows you to make credit decisions based on the most current information).

You can also list your purchases by discount dates. And take advantage of them in no uncertain net terms. You can even keep payroll records without paying more, because it's part of the same package.

Profit from history.



In business as in life, experience is the best teacher. And the Apple/BPI system can provide you with instant comparisons of this-month-this-year vs. this-month-last-year, or this-year-to-date vs. last-year-to-date.

So you can quickly spot changing expense ratios and make decisions with 20/20 foresight.

The BPI General Accounting Package also lets your income statements be coded by location, department or product line. So you know where your money's coming from.

And where it's not.

Ichiban Fish Supply Company
Merchandise Purchased By Due Date
As Of 05 31 83

Date	Vendor No. Name	Invoice Number	Acct No.	Detail	Net Amt
05/02/83	1 Herring World Due: 06/03/83	35270532	5010-01		501.23
05/05/83	2 Consolidated Cod Due: 06/05/83	4562	5010-01		209.36
05/05/83	3 Levy Sushi Farm Due: 06/05/83	212	5010-01		459.00
05/05/83	4 Mussel Men, Inc. Due: 06/05/83	657	5010-01		68.26
	Total				1,237.85

It can also allow you to take full advantage of merchandise discounts. So you'll know whom to pay, when to pay, how much to pay—and save a lot of clams in the process.

Make a timely statement.

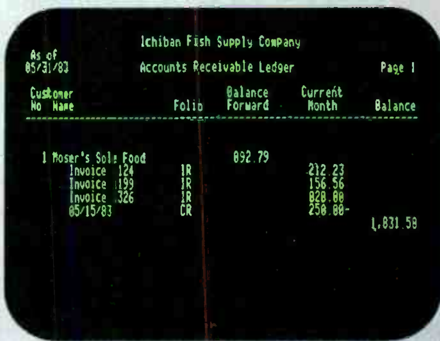
Add an Apple Dot Matrix or Daisywheel printer to your Apple III, and you can print out your entire balance sheet in minutes.

Or any number of reports, from cash receipts to payroll ledger to income. You can even print checks and customer statements.

The impressively professional results will make an important statement to everyone you deal with—including your banker.

More ways Apples pay.

There are more people in more places doing more things with



Ichiban Fish Supply Company
As of 05/31/83 — Accounts Receivable Ledger — Page 1

Customer No Name	Folio	Balance Forward	Current Month	Balance
1 Moser's Sole Food		892.79		
Invoice 124	IR		212.23	
Invoice 199	IR		156.56	
Invoice 326	IR		820.00	
05/15/83	CR		250.00-	
				1,831.58

To avoid fishy transactions, you can instantly display customer's payments, charges and current balance. In this case, a few more cans of tuna would put Mr. Moser over his $2,000 limit.

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Circle No. 35 on Free Information Card

use them before you lose the game. When you lose your Wizard (or Sorceress) the game is over—just as a chess game ends when your King is checkmated.

There are so many built-in, adventure-like variations and combinations that it's really impossible to do them justice in a short review. The game rates extra high on the scales.

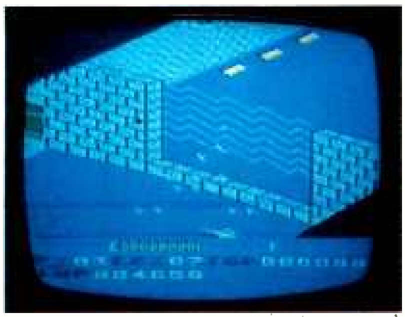
ZAXXON

Cassette or Diskette for Atari 400/800
DataSoft, Inc., 9421 Winnetka Ave., Chatsworth, CA 91311; 213-701-5161. $39.95
Graphics ★★★★
Gameplay ★★★★
Sustained Interest ★★★★
Type: *Joystick action game*
Memory Required: *16K cassette; 16K or 32K diskette*

Zaxxon is already enshrined among those favorite arcade games that we'd like to be able to bring home, and DataSoft has finally made it possible. The game is currently available in three versions: a 16K cassette and a diskette with both 16K and 32K versions (one on each side) for the Atari computer and a 48K disk for the Apple.

The game presents a three-dimensional scene as you pilot your attack jet fighter through four different screens attacking first the enemy's floating fortress complete with walls, laser barriers, anti-aircraft cannon, and the hazard of crashing into the very objects you want to blast to smithereens. Your view of the screen is at an angle so you can watch the three-dimensional scenario. You move your fighter up and down and from side to side; your control is complete, but you can easily get blasted.

Finish the first screen (fortress) and you face an armada of defending enemy jet fighters. Screen three is a much more difficult fortress with really difficult laser barriers. This is where some fancy flying comes in handy. As with the arcade version, about the only way to gauge your altitude properly for squeezing safely through these barriers is to shoot at the wall and see where your cannon shells explode. Then gauge your approach altitude accordingly.



If you succeed in getting through this screen, you face the deadliest challenge of all—the armored robot. I haven't succeeded in getting this far yet, but the game is exciting and an unbelievable grabber. Just when I thought I had finally outgrown all of those outer-space type shoot-em-ups, this one had to come along! It's actually kept me up later than some of my all-time favorites, which I won't mention here.

Like so many computer games, skill develops with time and practice. Unlike many such games, smaller memory versions are missing some of the refinements. The 16K version, for example, has no surface-to-air missiles defending the enemy fortress. Also, you can't change your ship's altitude during the outer-space dogfight with the enemy fighters.

If you have a choice, and especially since the price is the same for all versions, don't get the cassette; it takes forever to load into the computer. When using the diskette version, start with the 16K game and play it until you get more proficient. Then switch to the 32K side of the diskette. Also, if you have a printer/modem interface for your Atari, make sure it's turned *off* before loading, or you'll find the game erasing from RAM each time you lose your third attack fighter.

ANDROID

Diskette for Atari 400/800
PDI (Program Design, Inc.), 95 East Putman Ave., Greenwich, CT 06830; 203-661-8799. $29.95
Graphics ★★★★
Gameplay ★★★★
Sustained Interest ★★★
Type: *Joystick maze and action game*
Memory Required: *40K + Atari BASIC cartridge*

Maze lovers will jump into this disk with both feet. According to the directions, it's really two different games: "Android" and "Captivity"—but in reality, it's just two different kinds of maze games with the same basic diskette.

Like PDI's earlier release, "Moonbase IO", this disk is accompanied by a voice-track cassette that plays through your Atari's cassette recorder, if you have one. Unlike Moonbase IO, playing the cassette isn't really necessary; it contains no control tracks for the gameplay, but the sound track definitely makes the game more interesting. It supplies the robot-like voice of your remote-controlled Android which has traveled to the black asteroid beyond Jupiter's orbit. The android tries to seize treasures hidden in the labyrinth beneath the asteroid's surface.

The sound track is ingenious and amusing, containing the android's mechanized voice reporting on various status elements—such as, "Radioactivity present, earthquake potential," and "Coke machine operational" (Coke machine???). You find out that it's a real Coke machine, as the android dumps some change into it and then says, "Darn it, I just lost my quarter." Apparently soda is a lot cheaper once you enter the dark asteroid's labyrinthine treasure house.

The treasures are guarded by armed robots, and you need to retrieve keys to get from one level to the next. There are two screens—an overall view of the maze from the top, showing your location—and an eye-level three-dimensional view of the maze from the top, showing your location—and an eye-level three-dimensional view with excellent graphics. In Version 1, a compass pointer indicates which direction you're traveling with the overview of the maze as your map vantage point. Version 2 eliminates the compass and is therefore much harder.

There are natural hazards—such as absorbing too much radioactivity, or getting hit by a blast from a robot guardian. A time bomb can also explode catching your android in its blast, and there's an engulfing slime which is very dangerous. Earthquakes come and go at random, knocking down walls and blocking corridors—often the very ones you wanted to explore. Also, your android can simply run out of energy—in all of these cases, the game ends when your android is destroyed. If you can't complete the tasks, you can at least go for points when new at the game.

The Captivity version is a straight maze/escape game in which you have to find your way out of the maze in a given time period. There are 10 versions with a compass and 10 versions without. Every time you take a peek at the overhead view, it costs you points. ◇

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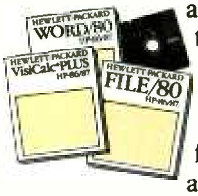

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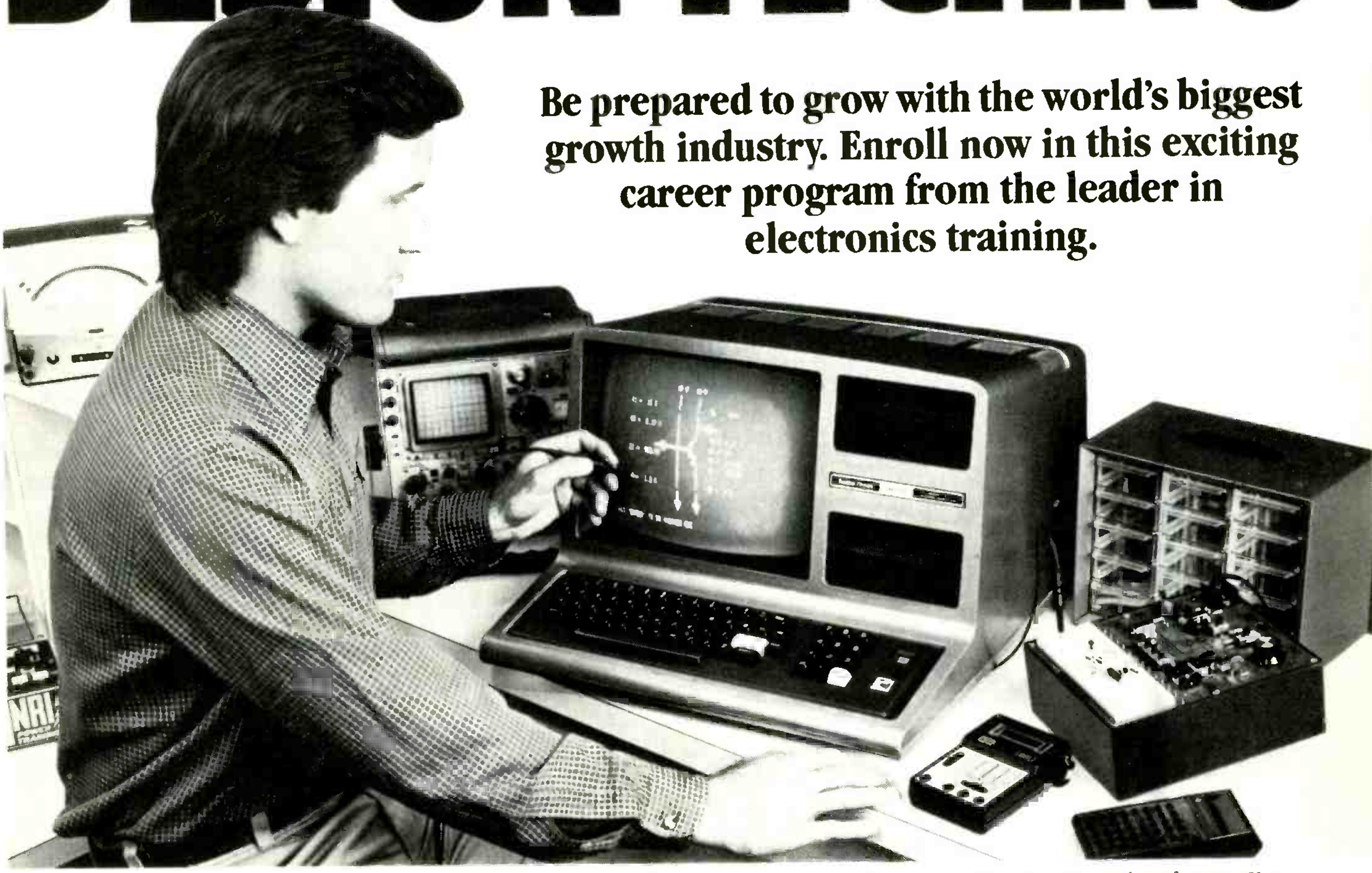

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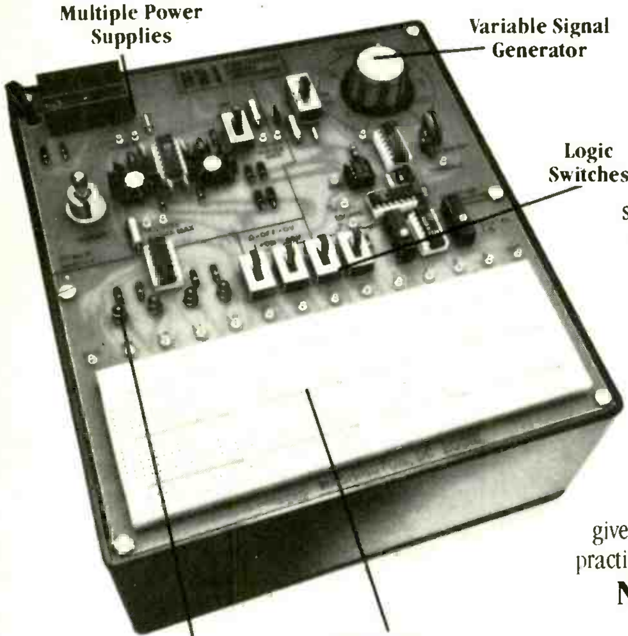

learn to look for better ways and new ideas.

The NRI Circuit Designer is a totally unique instrument with full breadboarding capability, built-in multiple power supplies and a multi-function signal generator for circuit testing. Fast, simple connections let you build up prototype circuits, immediately check them out for function or faults. It handles both linear and digital integrated circuits as well as discrete components such as transistors and diodes. Six practical lab units carry you through both the theoretical and practical world of electronic circuit design.

Professional Working Instruments

Your course also includes the professional multimeter with 3½-digit liquid crystal display to give you fast, accurate readings of voltage, current, and resistance. Slide switches let you select range and function quickly and easily. You also get the famous Texas Instruments TI-30 engineering calculator to speed and simplify circuit analysis and design. It's a true engineering instrument that includes trigonometric functions as well as square root, logarithms, and memory. Together with your Circuit Designer, they work to give you a sound basis of practical experience.

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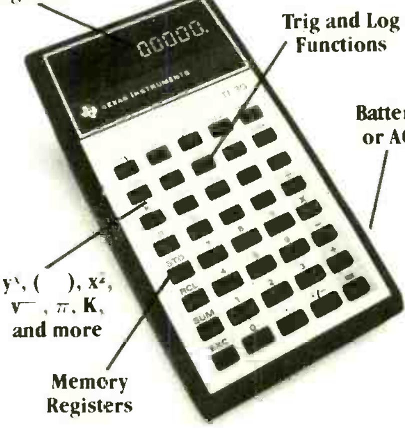
There's so much to tell you about this exciting new course for the electronic 80's, we can't do it all here. Send the postage-paid card for our free, 100-page catalog with all the facts about this and other NRI electronics courses. We'll rush it right to you without obligation. Look it over and discover for yourself why only NRI can prepare you so well for your future. If card has been removed, please write to us.



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We'll give you tomorrow.

A "truly portable" Sinclair/Timex

Wouldn't it be nice to be able to enter a program in your Sinclair/Timex computer and, when you remove the ac power, have the program remain in memory? This, of course, makes the Sinclair/Timex a truly portable computer that can be carried from video terminal to video terminal (or TV receiver to TV receiver). I'd like to tell you how you can do it by building a very simple add-on circuit for your computer. I'll also show you a simple little circuit that will reset your T1000 when you want to "start over."

Even you are not interested in portability, the circuit to be discussed adds one other very useful feature—it provides an uninterruptable power supply that maintains the computer's data integrity if it is connected to the wall socket and commercial power fails.

The circuit (Fig. 1) is a basic diode switcher that has been around for many years. When the power supply is delivering a voltage higher than that of the battery, silicon diode *D1* is forward-biased (acts like a closed switch), while silicon diode *D2* is reverse-biased (acts like an open switch). This effectively isolates the battery from the system. Thus, the line-operated power supply runs the computer. If the line-operated supply is removed—either by physically unplugging the supply from the wall socket or if power fails for any reason—*D2* becomes forward-biased, *D1* becomes reverse-biased, and the battery supplies power to the computer. Battery power cannot be fed back to the wall unit (a possible discharge path) since, under these conditions, reverse-biased *D1* acts as an open switch.

Now, which battery to use? A conventional 9-V transistor radio type will run a minimum computer, but since its 9 V is higher than the approximate 7 V supplied by the wall-supply that comes with the computer, it will soon run down to 7 V—a waste of power. Besides, a conventional 9-V radio battery is limited as to how much current it can deliver over a long period. When RAM or a printer is added to the basic computer, the power demands increase rapidly.

There is one battery that works very well, and best of all, you can get it free. And this battery can deliver 6 V with a lot of current for quite a long time.

I'm talking about the flat battery that comes in Polariod film packs. If you know anyone with a Polariod camera, ask him to save you the plastic frame that is left after all the film has been used up. (The frame is usually thrown away.) Break open the plastic enclosure and you will find a flat, very thin battery about 2" by 3". Electrical connections are made via a pair of metallic contacts on one side. You can determine, and mark, the polarity of the two contacts.

If you are into hardware experimentation, get a couple of these special batteries and use low-value (high wattage) resistors as a load while monitoring voltage across it. You will be surprised at the amount of power.

In the circuit shown here, the two diodes, the Polariod battery, and the physically small POWER switch were fitted together and covered with a layer of black electrical tape. A connector was used to interface to the plug at the end of the wall-mounted supply, and a small cable terminated with a suitable plug was used to connect the package with the computer's power input receptacle. Since solder doesn't adhere very well to the two electrical contacts on the battery, I used a pair of "bobby" pins that were scraped to make good contact.

The taped package can be mounted to the top surface of the computer using double-sided adhesive tape, with the output cable plugged into the computer input receptacle. When the wall supply is plugged into the battery package, and the POWER switch turned on, the system works as normal. When the wall supply connector is removed (or wall power fails), the battery runs the system. When the battery runs down, simply slit the tape, and wire in a new battery.

Adding a Reset Switch. One of the small "goodies" not included on the Sinclair Timex T1000 computer is a "reset" switch to be used when things really go berserk. If you do any programming, you know what that means. To add a reset switch to these machines, connect one end of a slender insulated lead to pin 26 of *IC3* (Z80) or to the junction of *R15* and *C5* as shown in Fig. 2. Connect one end of a similar slim lead to any ground pad. Connect the free ends of these two leads to the connectors of a physically small, normally open pushbutton switch (makes no difference which lead goes where). Mount the pushbutton switch as desired on the plastic enclosure and mark it RESET. Now, when the screen goes blank at any time, depress this switch for a restart. ◊

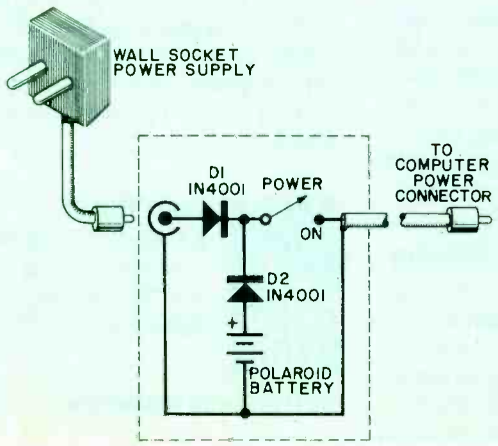
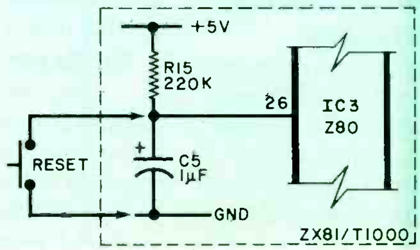


Fig. 1. At left is a circuit using a Polaroid battery to power your computer.

Fig. 2. Below is a circuit for adding a reset button for starting over.



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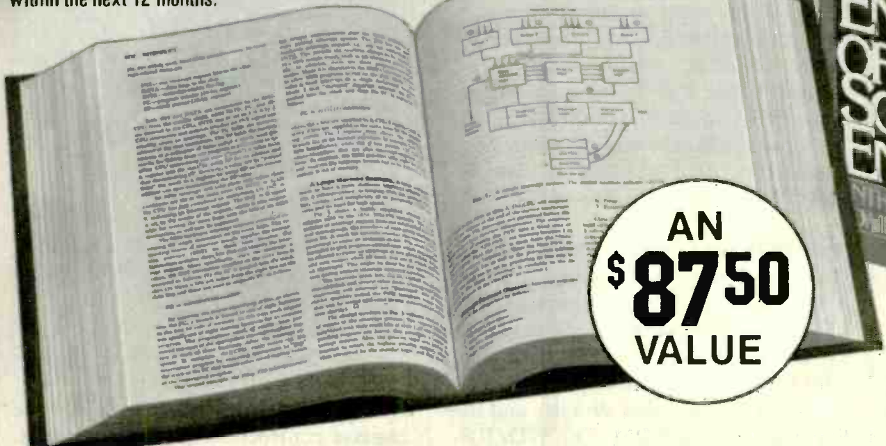

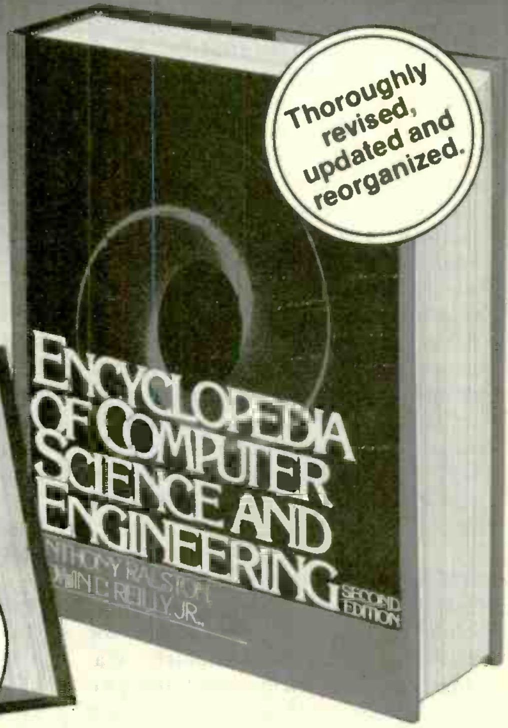

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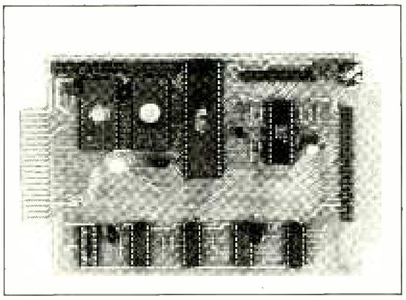
COMPUTER SOURCES

Hardware

IBM Autodialer Modem. The PC212A is a Bell-compatible 212A modem that fits into any slot in the IBM-PC. It can store up to 10 telephone numbers, operates to 300 bps asynchronously in low speed, and 1200 bps synchronously in high speed. It also features an RS232C asynchronous serial port with an internal microprocessor allowing control, operation, and optioning of the modem from the IBM-PC keyboard. A "Help" list of commands is provided, and the modem features auto/manual dial, auto dial next number if first number is busy, instant re-dial once or until answered, and single keystroke dialing of last number dialed even if it was not one of the 10 stored. Battery protection is provided. $495. **Address:** Rixon Inc., 2120 Industrial Pkwy., Silver Spring, MD 20904 (301-622-2121).

TRS-80 Multi-Function Board. The CMJ-IF is a multi-function subsystem for the TRS-80 Color Computer and the TDP-100 Personal Computer, that plugs into the cartridge port and provides speech synthesis accessed from BASIC, two parallel ports allowing the use of a parallel printer, two counter/



timers for use as a real-time clock, a serial communications port for serial printers or modems, and an extender port that enables the user to access a disk controller or ROMpack. 4K or 8K bytes of EPROM/ROM space is also provided. Under $200. **Address:** Magnum Distributing Inc., 1000 S. Dixie HY #3, Pompano Beach, FL 33060 (305-785-2002).

Floppy Protection. The Infoguard is a magnetically shielded floppy-disk enclosure that protects the diskette against X-rays or magnetic damage during shipping. These include accidental exposure to magnetic environments due to lightning storms, passing nearby radiating electric/electronic equipment, power generating equipment, careless handling, or deliberate vandalism via permanent magnets. $9.50 for 5¼" size, and $14.50 for the 8" version. **Address:** Ad-Vance Magnetics, Inc., 625 Monroe St., Rochester, NY 46975 (219-223-3158).

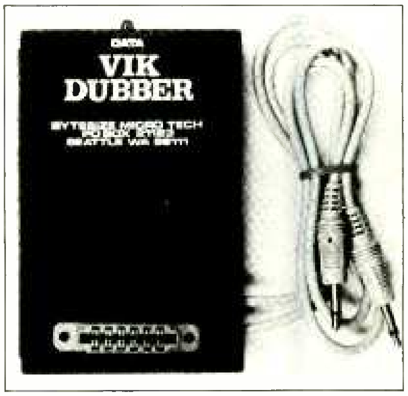
Apple EPROM Programmer. The Model 2300 EPROM Programmer for the Apple II can handle TI 2516 and 2532; Intel 2716, 2732, 2732A, 2764, 27128, and 2816; and SEEQ 5213 and 5213H. The modes of operation include EPROM to disk file, EPROM to memory buffer, read/print contents of EPROM, verify erasure of EPROM, load and program disk file into EPROM, program memory buffer contents into EPROM, read/print memory buffer contents, modify contents of memory buffer from keyboard, and program EPROM addresses directly from keyboard. $429. **Address:** Software Specialties Inc., 305 Larchway Dr., Springboard, OH 45066 (513-748-0471).

Hard Disk for TI 99/4. The WDS/100 Disk and Controller System allows up to 10M bytes hard disk to connect to the TI Peripheral Expansion System in a TI 99/4A or 99/4 computer. The Unix-like Directory Management System is resident on both the utility diskette and the Personality Card ROM. The WD/100-5 stores 5M bytes while the WD-100-10 stores 10M bytes. Cost is $2599 and $2999 respectively. There is a clock option available for $50. **Address:** Myarc, Inc., PO Box 140, Basking Ridge, NJ 07920 (210-766-1700).

IBM Winchester. The Interface Series of Winchester drives for the IBM-PC is available with 5.3M bytes ($1695), 10.6M bytes ($1995), and 15.9M bytes ($2295) of formatted storage. Each system includes all pertinent hardware and software (JEL) for 1.1 DOS. There are 345 tracks/inch. Track-to-track access time is 2 ms, and average access time is 85 ms. Other features include a 512-byte full sector buffer, a 32-bit ECC, and automatic interleaving capabilities. Operation is also provided on 220/240 volts at 50 Hz. **Address:** Interface Inc., 7630 Alabama Ave., Canoga Park, CA 91304 (213-341-7914).

System Controller. This 4" by 4½" controller on a board features a Z8671 that contains a Tiny-BASIC interpreter, up to 6K bytes of RAM and EPROM, an RS232 serial interface with selectable baud rates, and two parallel ports. The system is expandable to 124K bytes and is optimized as a dedicated controller. Connecting a CRT terminal allows immediate BASIC or machine-language programming. Programs can be transferred to 2732 EPROMs for autostart applications. $199. **Address:** The Micromint, Inc., 561 Willow Ave., Cedarhurst, NY 11516 (516-374-6793).

VIC Tape Interface. The Vik-Dubber cassette interface allows VIC-20/64 users to save and load data using a standard cassette tape recorder. It also allows connecting two cassette recorders at the same time to make backups. An



indicator is provided to help adjust the cassette controls for proper operation. Power comes from the computer so no batteries are required. $34.95. **Address:** Bytesize Micro Technology, PO Box 21123, Seattle, WA 98111 (206-236-2983).

Apple Remote Control. The PC-1 plugs into any I/O slot on an Apple II or II+ and provides control of up to 256 Leviton/BSR remote control devices via the normal household power line. The device both sends and receives digital commands at the line carrier frequency of 121 kHz. Included on the board is a bi-directional carrier interface, a CMOS real-time clock with battery backup of two months life and full recharge capability, and switch-selectable interrupts of one hour, one minute, one second, and 1024 Hz. Demonstration software is provided on disk. On-board firmware (2K of ROM) holds all system software, no additional memory is required. $265. **Address:** Bi-Comm Systems, Inc., 10 Yorkton Industrial Court, St. Paul, MN 55117 (612-481-0775).

TTL Pinouts. The MicroChart #6 covers pinouts for virtually all 54/7400 TTL ICs on its two-sided, two-color, full-page plastic sheet. The data covers the part number, family type, description, and pin out. The data is reduced from some 500 pages of data books. \$5.95. **Address:** Micro Logic Corp., PO Box 174, 100 2nd St., Hackensack, NJ 07602 (201-342-6518).

Sinclair/Timex Analog Interface. The high-speed analog interface board features eight channels of A/D and eight channels of D/A for the Sinclair/Timex machines. The board plugs into the rear expansion connector, and on-board jumpers and switches permit maximum versatility. Sequential A/D conversions can occur at 200K samples per second. The electrical specifications include 1.6-μs A/D conversion time with 100-ns sample-and-hold window; 1-μs D/A settling time with 0.13 V/μs slew rate; 2.5- or 5-volt full-scale option; and eight bits resolution and accuracy. \$195 with manual. Box and cable is \$15. **Address:** Computer Continuum, 301 16th Ave., San Francisco, CA 94118 (415-752-6294).

IBM Telecommunications. The PConnection is a plug-in for the IBM-PC that contains a direct-connect modem, a real-time clock, and an additional serial I/O port. The modem is Bell 103/113 compatible and provides autodial (Touch Tone or pulse dialing), and autoanswer in both answer and originate modes. The asynchronous card also contains an additional RS232 port. A firmware timer manages dialer routines, and an autodisconnect is provided in case of failure or carrier loss. The real-time clock allows the board to autoanswer the telephone or autodial predetermined telephone numbers at a preset time. \$375. **Address:** Microperipheral Corp., 2565 152nd Ave., NE, Redmond, WA 98052 (206-881-7544).

Software

Terminal Program Operates up to 9600 Baud. MicroTerm, a new terminal program for TRS-80, IBM, Zenith, and Apple computers, features both standard ASCII and error-free, direct-line transmissions. It has a function that allows the operator to have up to 10 user-defined keys that transmit up to 63 characters at a single stroke. The program will adjust video width, turn on the printer, open the buffer and do many other things before returning to the terminal mode without missing any information. It can emulate any kind of terminal hardware and auto dial up to

10 preset numbers at the touch of a key. It fully supports most major brands of modems. Spooled printer output allows even slow printers to stay on line with the MicroTerm system. $70 for any version. **Address:** Micro-Systems Software Inc., 4301-18 Oak Circle, Boca Raton, FL 33431 (800-327-8724).

Circuit Analysis Program. ACNAP is an ac circuit analysis program available for 8" or 5¼" CP/M machines, or TRS-80 Model I/III with TRSDOS. It is designed to analyze circuits consisting of resistors, capacitors, inductors, a voltage source, and controlled current sources. It can calculate a 5-node circuit in 0.8 seconds. It also works with component tolerances to provide worst-case and Monte Carlo analysis. It calculates the minimum, maximum, mean, and three sigma points of a circuit's gain and phase response to any frequency input including linear or logarithmic frequency sweeps. It can also calculate the circuit's noise-equivalent bandwidth. Other design utilities are also provided. $39.95. **Address:** BV Engineering, PO Box 3351, Riverside, CA 92519 (Tel: 714-781-0252).

Language Teacher. Using the Hangman format, and designed for the TRS-80 Model I, III, and 4 computers, these programs are available in Spanish, French, and Latin. Other programs cover literature, word power, and German and Russian practice. $29.95 per program. **Address:** George Earl, 1302 South General McMullen, San Antonio, TX 78237.

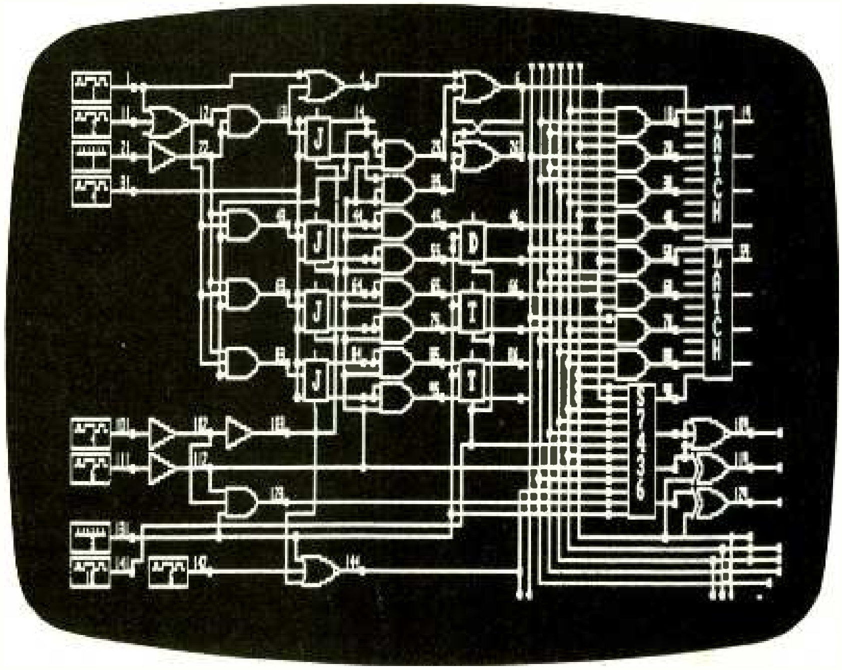
Numismatics. The Coin Collector for the Apple II series consists of six programs in which collection information can be entered, deleted, changed, searched, sorted, and printed. It catalogs foreign or domestic lists by denomination, country, description, year, value, or source. A Meeting List allows sorting and selecting meetings by date and location, a Source List gives sources for coins, supplies, and information on trades and liquidations. The File Transfer utility allows transferring data to other computer via phone links. $49. **Address:** Andent, Inc., 1000 North Ave., Waukegan, IL 60085 (Tel: 312-223-5077).

IBM-PC Communications. RELAY enables one IBM PC to link to another, act as a TTY, an APL terminal, or a 3270 device. It provides full error detection and correction while transferring data in both directions at the same time. Features include full support for autodial and autoanswer modems, simultaneous exchange of files and messages between PCs while printing and editing locally, split screen communication between PCs, directory of frequently used services, support for APL with a substitution character set, 3270 emulation on VM/370, full screen editor, and an unattended mode for sending and receiving files without an operator. $149. **Address:** VM Personal Computing, 60 E. 42nd St., NY, NY 10165 (Tel: 212-697-4747).

Casino Blackjack. Casino Blackjack Counter/Tutor for the TRS-80 Models I and III teaches play strategy as well as point counting. The program will suggest the best possible play for any hand. Five hands are shown with the computer playing the first two hands, the player the middle hand, and the computer the last two hands. All cards are played face up to facilitate point counting. Three dealing speeds are provided, and with each bet opportunity, the program will show the correct count is requested and make a recommendation on the size of the bet. The player can play against one to six decks. Requires a TRS-80 Model I or III, 32/48K disk system. $21.95. **Address:** Manhattan Software, PO Box 1063, Woodland Hills, CA 91365 (Tel: 213-453-6943).

Commodore 64 Programs. DIARY 64 keeps track of phone numbers, birthdays, appointments, etc., and files by dates or page number. $59.95. CHECKBOOK MANAGER has a capacity of 250 checks, 100 deposits, and 50 account charges. It has built-in password security. $39.95 for disk, $34.95 for cassette version. 64 MAILING LIST holds 250 names and addresses per file and features full screen editing, and sort. $34.95 for disk, $29.95 for cassette. VANILLA PLOT features 19 editing commands for Turtle Graphics to change directions and draw lines of any length. The Turtle has a pallette of 16 colors. Sound is also available. $29.95 for disk or cassette. **Address:** Computer Marketing Svcs., 300 W. Marlton Pike, Cherry Hill, NJ 08002 (Tel: 609-795-9480). ◇

Logic Design. Micro-Logic enables engineers to draw logic diagrams directly on a CRT screen. The net list required for simulation is automatically generated from the diagram, or may be directly typed in. A timing-level simulation can be performed to evaluate design before building hardware. The system will handle 500 to 2000 gates with all gates user-programmable as to delay, truth table, and input/output clocking. The system also handles macros of up to 16 pins enabling direct modelling of 16-pin MSI functions. Currently available for IBM-PC with Apple II coming soon. $450. **Address:** Spectrum Software, 690 W. Fremont Ave., Suite 11, Sunnyvale, CA 94087 (Tel: 408-738-4387).



No wonder they call it the SUPERFONE!

At Last—a Cordless Phone with TWICE the Range, Sound Fidelity to Rival Phones with Cords, and a Privacy Code System—All This in a Phone Less Than an Inch Thick!

The Super Fone is less than 1" thick. The base unit has a built-in speaker phone, a fully independent intercom and is 110 volt-220 volt switchable.

Until now, cordless phones have given you wonderful convenience. But they've had two problems:

1. The range is limited to 600 to 700 feet.
2. Some of them sound as though you're talking inside a barrel.

As cordless phones have become enormously popular, another problem has arisen: two people, living near each other, can have the same channel. Not only is there line confusion, but someone else can literally make a long distance call on your phone.

No more. Never again.

Range: 1500 Feet OR MORE!

The SuperFone 650 uses state-of-the-art electronics to bring you **the ultimate cordless phone.** Sound quality is superb — and it stays superb, 1500 feet or more from the base station. That's **more than twice the distance** of standard cordless phones.

Only SuperFone 650 has a secret code system to prevent interference and false operation of the phone. You choose from 512 possible "code" combinations. Both the base unit and the phone are **locked** onto that code, which you can change when you want to.

No other phone can interfere. No other unit can share the signal. No one else can hear or speak on your carrier-wave.

Enormous Range

We say the SuperFone 650 has a range of 1500 feet.

Notice we didn't say "up to" or "as far as" 1500 feet. There's no hedging, because this seems to be the **minimum,** not the maximum range.

Users report 1800 and 2000 feet. That's nearly half a mile. SuperFone 650 is a radiophone, not a toy, and that's why its signal doesn't break up or start hissing or crackling when you get half a block away.

You can tell when you heft it. It's a Little Giant. You can feel the power inside. What a marvel of electronic engineering it is! And it's tough, too. It fits into your shirt pocket, and you can bounce it around all day without damaging it.

Speakerphone, Intercom — Everything!

SuperFone 650 is The Everything Phone. Anything any phone can do, it can do.

First, the base station is a speaker phone. Touch a button and you can have a hands-free conference conversation in the room in which the base station sits.

Next, it's an intercom. You can page the handset from the base unit and have a private conversation. You have a **true wireless intercom,** not just a signal.

Third, you have a privacy button. Push that button and you'll still be able to hear anything the other party says, but he or she won't be able to hear you until you take the button off "hold."

Fourth, you have an automatic redial. Touch the key and the SuperFone will redial the last complete number.

What else? A **security switch** which makes it impossible for anyone to call out on the remote phone, without changing the ability to receive calls. A **volume control** for the speaker on the base unit. A **call button** to page the base from the cordless phone. THIS PHONE HAS EVERYTHING!

30-Second Installation

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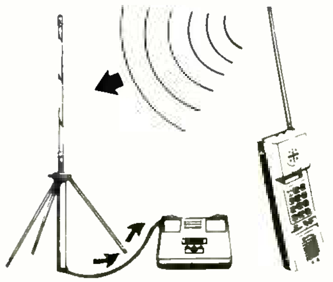

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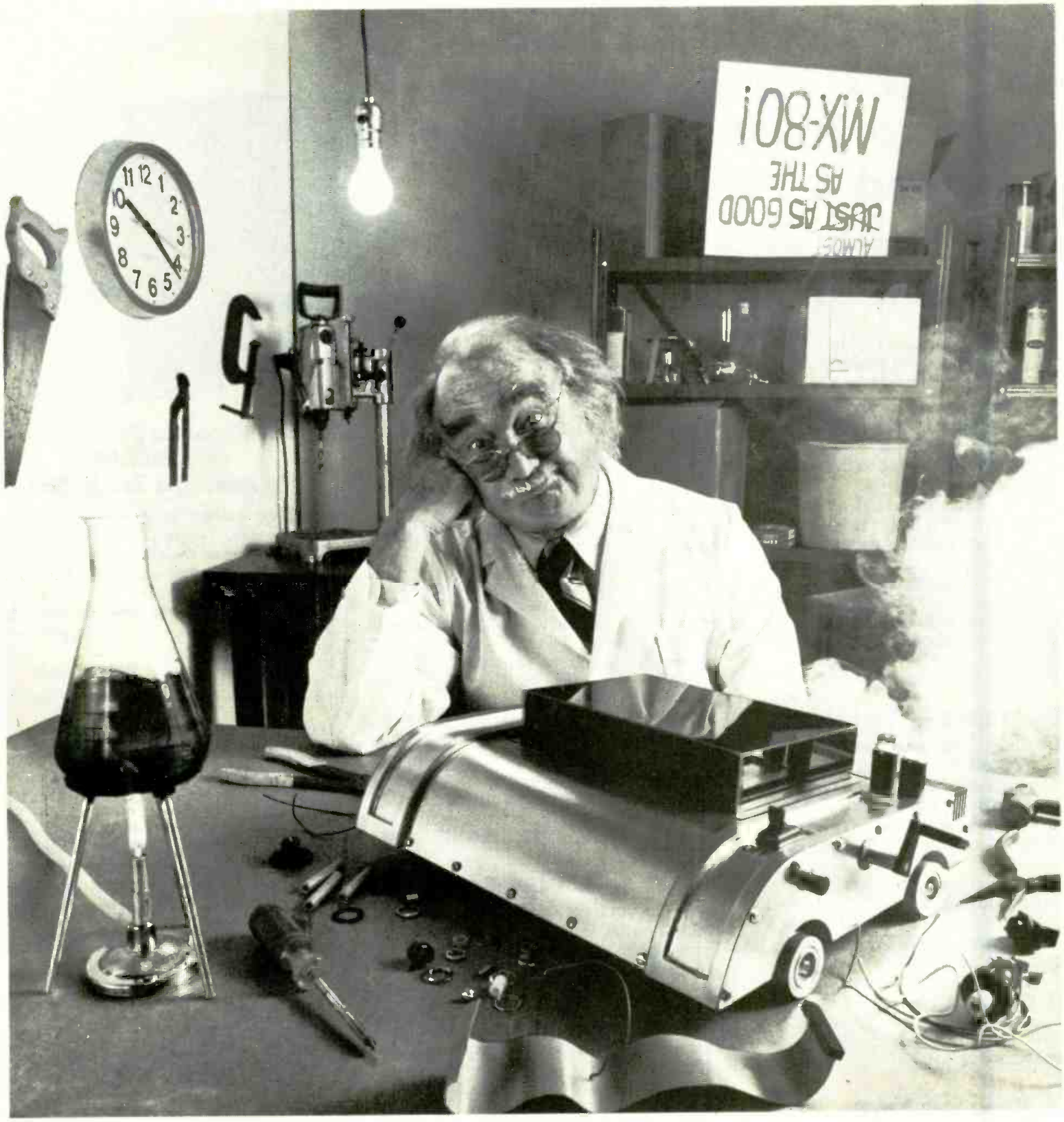

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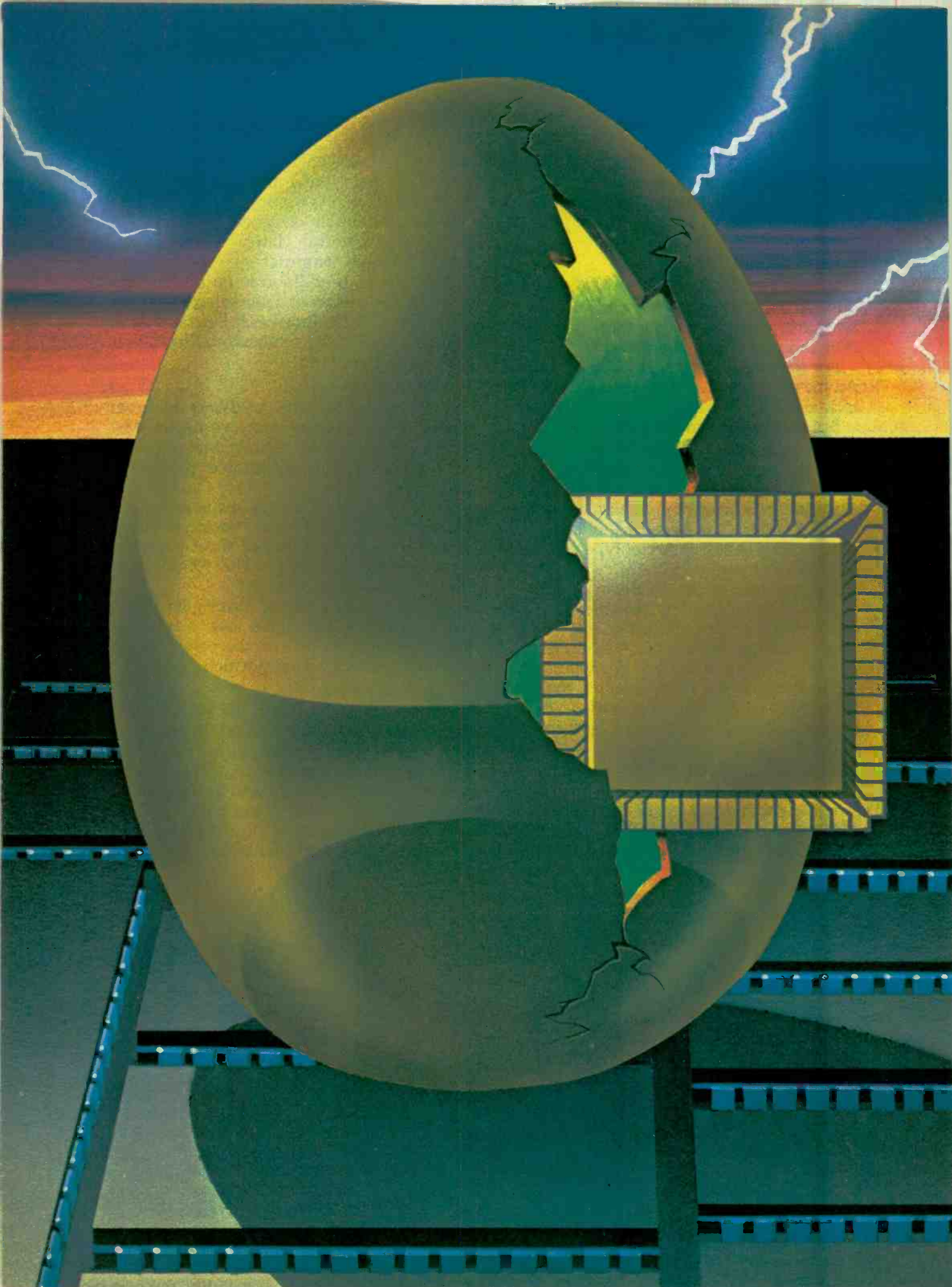
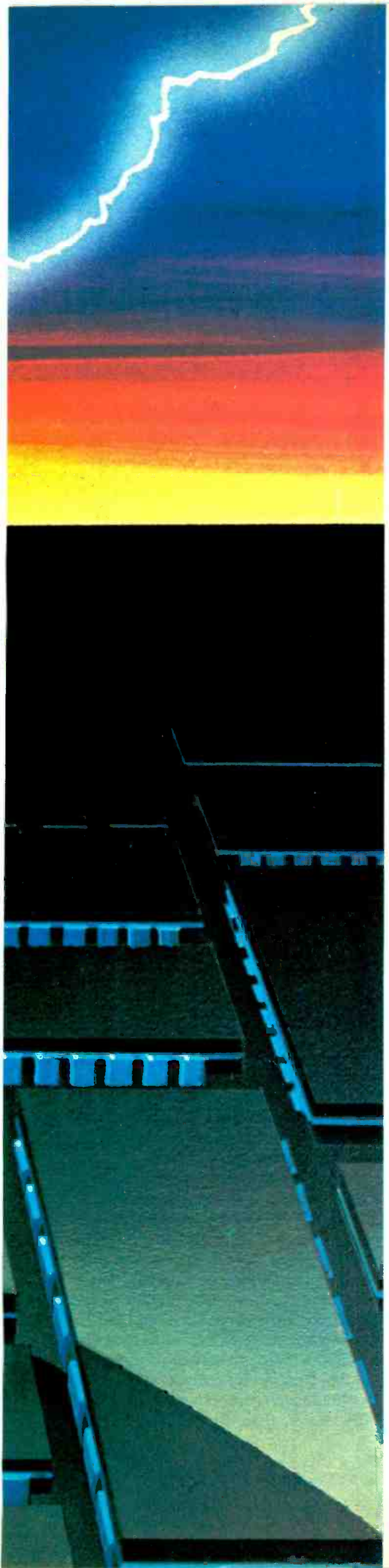




A Super Chip FOR NEXT-GENERATION PERSONAL COMPUTERS

Intel's 68-pin iAPX-188 combines an enhanced 8088 16-bit CPU and up to 20 support ICs in a single package for double the performance and much lower device and assembly costs

By Tony Zingale

MICROPROCESSORS represent a great advance in electronics owing to their small size, programmability, and low cost. Developing them is as much an art as it is a science since considerations extend beyond performance and reliability. Production cost, peripheral availability and cost, and software availability are important factors, too. The sum can determine the success of the CPU in the marketplace—how many computers will be designed around it.

Since the introduction of the microprocessor in the mid-1970s with Intel Corporation's 16-pin 4004 CPU, leading to the 40-pin bug-like package of the 8080 CPU and others, there has been a swift evolution in the design of these "computers on a chip." Zilog, for example, quickly followed with its Z80 CPU, which is much like an 8080 that combines a clock generator and a systems controller into one IC instead of having three separate devices. Other microprocessor makers followed suit with their designs, each playing "can you top this" with new products. This lead to the development of 16-bit CPUs—Zilog's Z-8000, Motorola's 68000, and Intel's 8088, among them. Their larger word size makes them more powerful than the 8-bit CPUs.

The beat goes on with the announcement of a next-generation CPU in Intel's advanced processor family—the iAPX 188. It shows great promise in becoming a very popular nucleus for personal and small-business computers for a host of reasons. With a square shape and 68-pin package, it's apparent that this is a different type of CPU than the ordinary one. Actually, the single chip incorporates a number of ICs, combining up to 20 equivalent chips that constitute essential microprocessor building blocks that are ordinarily separate support chips.

The CPU partition itself is really an enhanced 8088 microprocessor, the same one used in the IBM-PC and similar machines. Although the two chips are object-code compatible, 10 more instructions have been added. The logic within the iAPX 188 is shown in Fig. 1.

Physically, the iAPX 188 is not compatible with the 8088 since its JEDEC Type A, 68-pin, leadless package has 17 pins on each of its four sides, as shown in Fig. 2. It does directly address 1 megabyte of memory, is compatible with 8282/83/86/87, 8288 and 8289 bus support components, and requires a single 5-volt power supply.

Since the data path is only 8 bits wide, there is a saving in parts, and a reduction of board space of about ⅓ can be realized over a 16-bit approach. Direct peripheral interfacing is also easier since most reasonably priced peripherals handle data 8-bits at a time. With an 8-bit system requiring eight 64K-bit memory chips for each 64K-byte block, this is cheaper than going to 16-bit wide memory. Since the iAPX 188 (80188 is the part number) combines high-performance 16-bit internal architecture with an 8-bit bus interface, this allows 20-megabyte addressing and 64K-bytes of I/O addressability, which is becoming a "standard" in modern microcomputers. In performance, the 80188 can provide up to 65% to 95% of the performance of its 16-bit relatives while retaining the interface advantages of the 8-bit data bus.

Besides the CPU, several functions have been integrated on the 80188. One of these is the clock generator that provides an 8-MHz system clock. Other functions include two 16-bit programmable timer/counters for implementing baud-rate generation, real-time clocks, and delay counters, with a third counter (not externally connected) used to implement time delays and which can be used as a prescaler.

Also included are two high-speed, in-

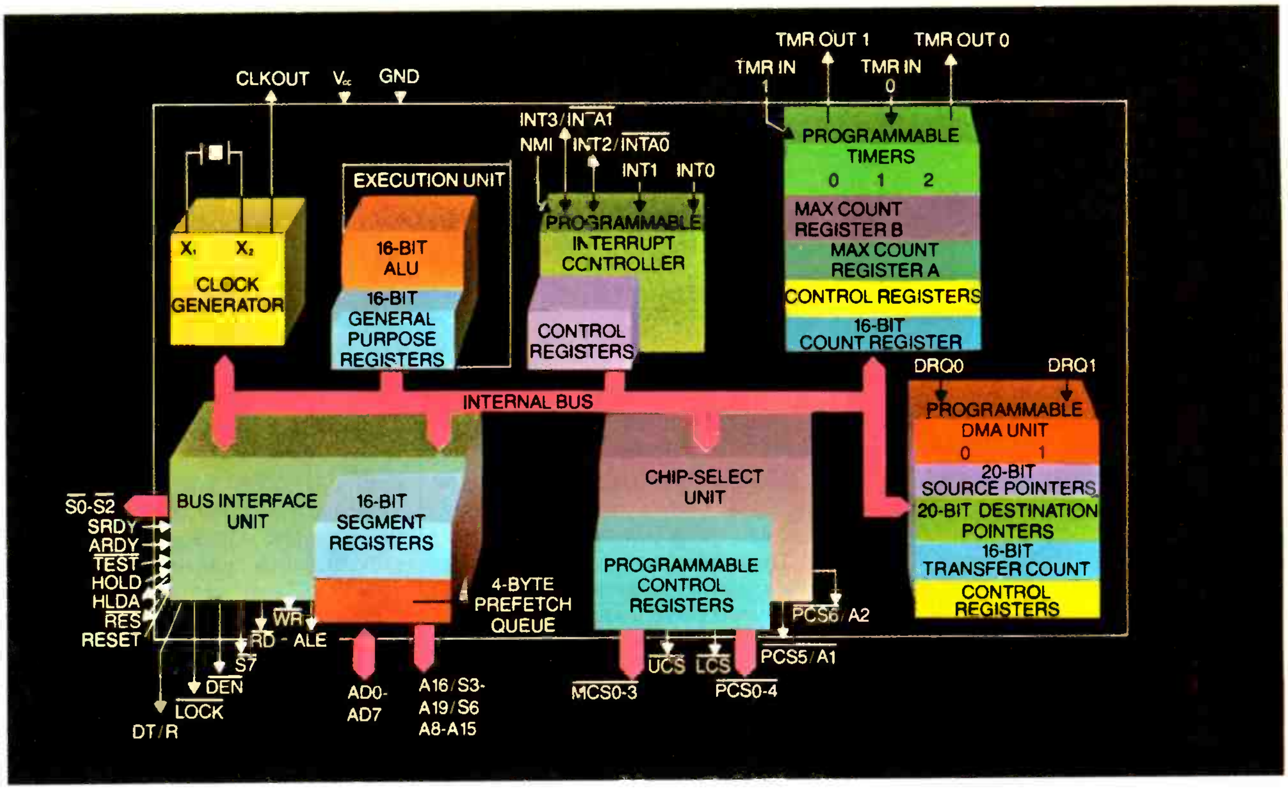
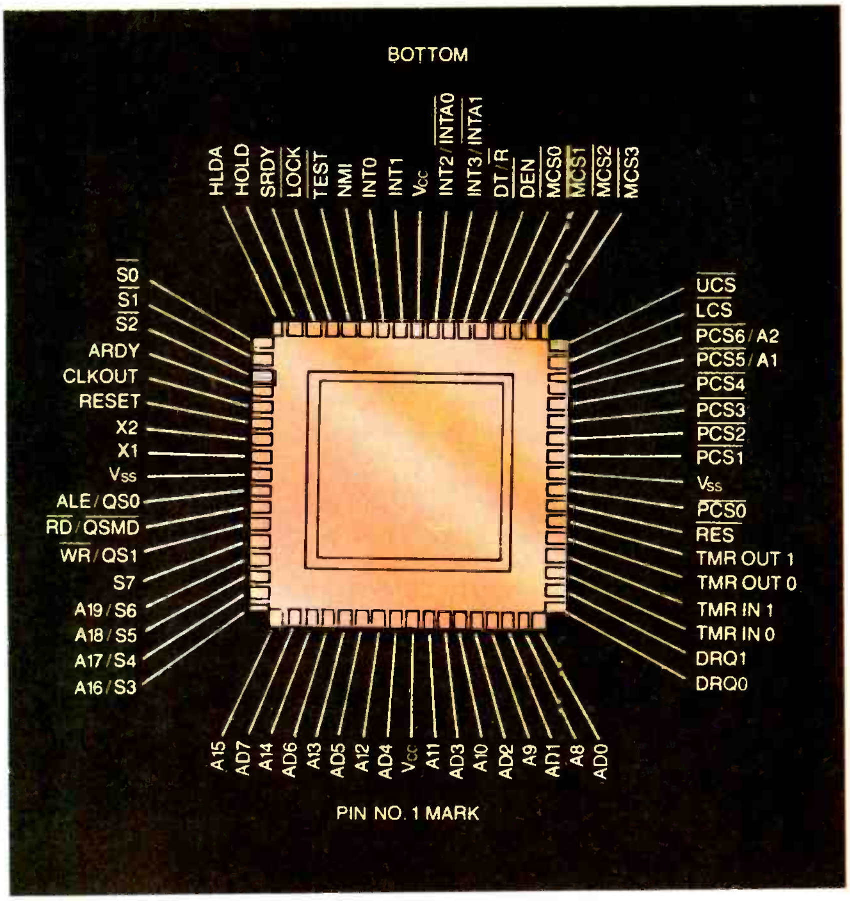


Fig. 1. Block diagram of the various parts of the iAPX 188.



dependently programmable DMA channels to provide data transfers between system memory and I/O devices. DMA transfers can occur between memory and I/O or within the same space (M-M, or I/O-I/O). Each DMA channel maintains two 20-bit source and destination pointers that can be incremented, decremented, or left unchanged after each transfer. Data transfers occur a byte at a time, and can be anywhere within the 1-megabyte addressable memory space. This allows a maximum transfer rate of 1 Mb/s. The user can specify several different modes of operation via the on-chip DMA channel control word.

A multi-level programmable interrupt controller that can resolve priority among up to five external interrupts plus interrupts from the five internal sources (timer, DMA, etc.) is also provided in the chip. Each interrupt has a programmable priority level and a preassigned interrupt vector type used to derive an address to a table in memory where the interrupt service routines are stored. This enhancement makes the iAPX 188 interrupt response time about 50% faster than the 8088. Multiple

Fig. 2. The 68-pin, leadless package has 17 pins on each side.

8259A's can be cascaded to provide up to 128 external interrupts.

Integrated programmable memory and peripheral chip-selects, plus a programmable ready generator, replace many of the conventional TTL devices required to interface system memory and I/O devices to the CPU. The wait-state generator is necessary so that the CPU can interface to memory and I/O devices of varying speeds. The result of the integrated logic eliminates external propagation delays, thus speeding up the data flow. Three memory ranges (lower, middle, upper) can be programmed to variable lengths (1K, 2K, 4K, . . . 256K) so that a variety of memory chip sizes can be used. Also, anywhere from zero to three wait states can be programmed so either high-speed or low-cost and slower memories can be used.

The added functionality of the 80188 (i.e., timers, DMA, interrupt controller, chip selects), uses on-chip 16-bit registers for each integrated device contained in a 256-byte control block. This logic is shown in Fig. 3. The control register block may be I/O or memory mapped based on initialization for a new control block pointer in the CPU. Except for these additions, the register architecture of the 80188 is identical to the 8086/8088.

A local bus controller provides the required address, data, and control signals to the local system bus. The pipelined architecture of the 80188 allows savings in memory cost since instructions are prefetched into a 4-byte execution queue, high performance can be maintained while using slower (thus less expensive) memory. Other cost savings come from the use of an 8-bit rather than a 16-bit external data bus. A typical iAPX 188 computer is shown in Fig. 4.

Since the iAPX 188 is software compatible with the 8086 and 8088 CPU's, compilers, operating systems, and application programs written for the 8086/8088 will run on systems using the new CPU. Current operating systems include Intel's iRMX 86/88; Digital Research's CP/M-86, and CP/NET; and Microsoft's MS-DOS and Xenix (a Unix implementation). All popular programming languages are available, including BASIC, Fortran, Pascal, Cobol,

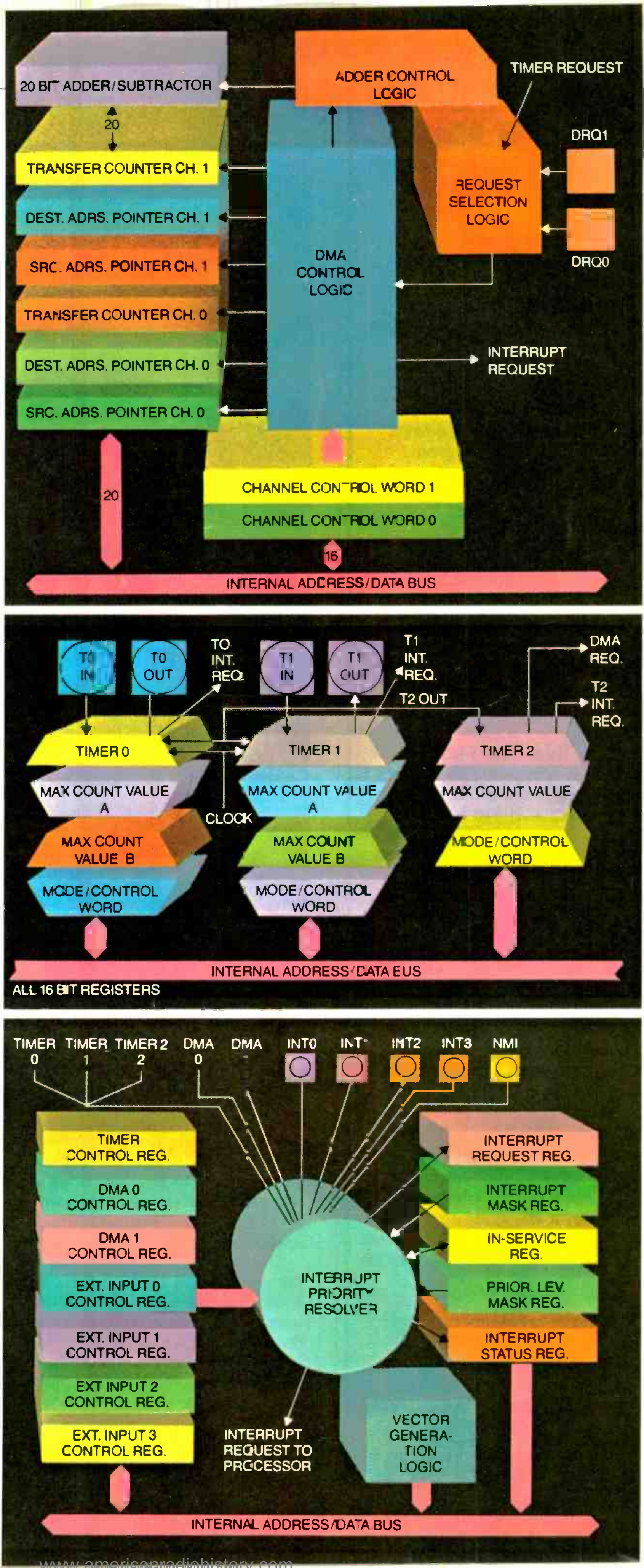


Fig. 3. Block diagrams of the DMA control logic (top), three timer circuits (center), and interrupt controller (bottom). On-chip 16-bit registers are used for each integrated device.

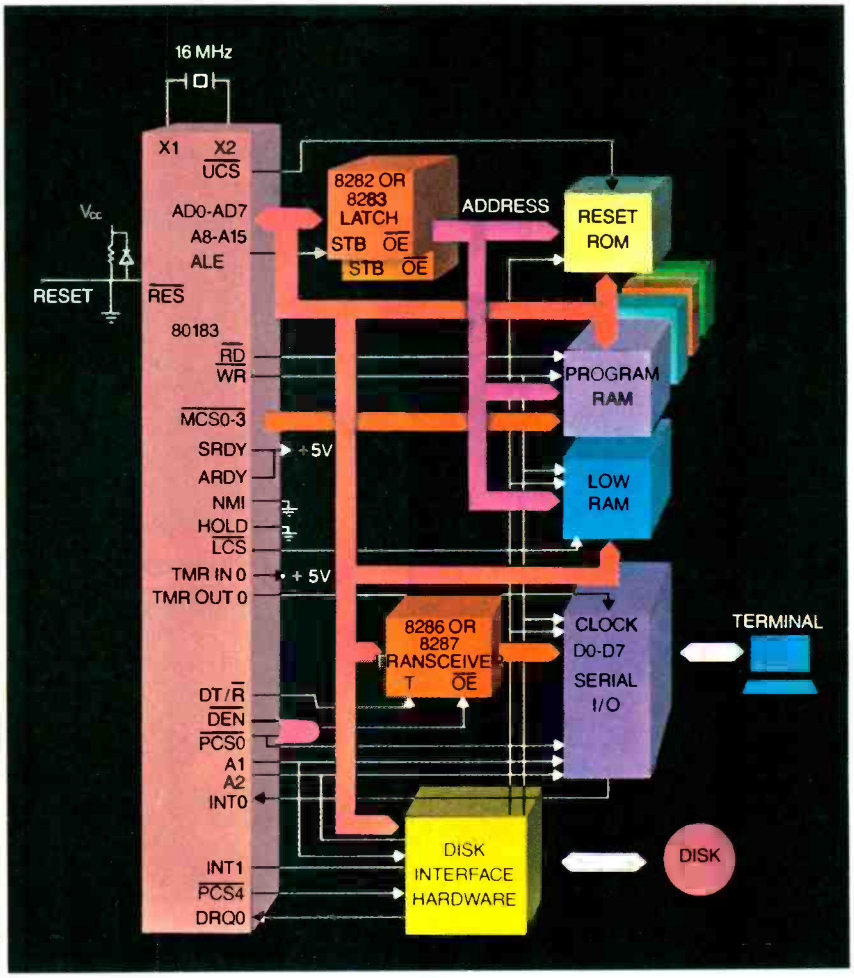


Fig. 4. Block diagram of a typical way in which the 80188 (iAPX 188) could be used in a computer.

PL/M, and C. And applications programs that can run on computers based on the iAPX 188 already abound.

As previously mentioned, new instruction types have been implemented on the new CPU. These include a block move, push or pop all registers, rotate/shift immediate, and multiply immediate. These new instructions not only increase the raw computing speed of the CPU, but they also apply to high-level languages and multitasking implementations.

The iAPX 188 delivers about twice the performance of the 5-MHz 8086/8088. This is attributed to some hardware enhancements. For instance, effective address (EA) calculation typically involving the addition of a segment register plus a displacement and some index value to a given segment is performed by an on-chip microcode sequence in the 8086/8088. In the 80188, this calculation is performed by a dedicated hardware adder in the Bus Interface Unit (BIU) of the CPU. Additionally, the 80188 executes many instructions in fewer clocks than the 8086/8088.

The use of the 8087 Numeric Processor Extension allows operations such as arithmetic, trigonometric, exponential, and logarithmic instructions to show an increase in speed of some two orders of magnitude. Other chips, such as the 82720 GDC, 82730 Text Coprocessor, and the 82586 Ethernet Controller are also compatible with the iAPX 188.

In sum, the iAPX 188 represents another evolutionary step forward in microprocessors. Its performance is said to double that of its 8088 cousin, while cost is half as much. Moreover, software compatibility with the 8088 is maintained. You can expect to see computers incorporating this chip in the very near future. The next move is up to competitive processor makers, who will likely follow with their new-generation CPUs. ◇

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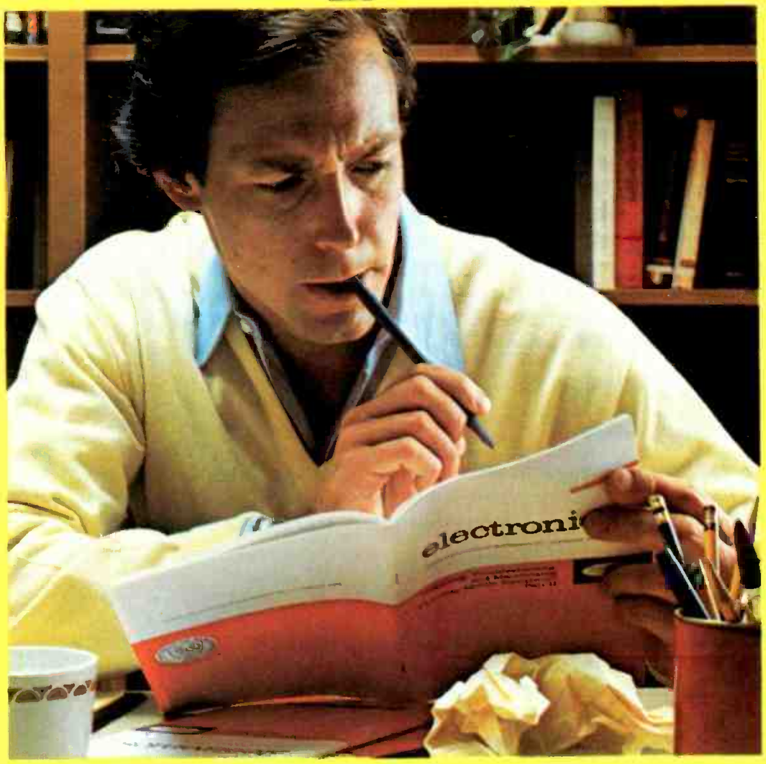

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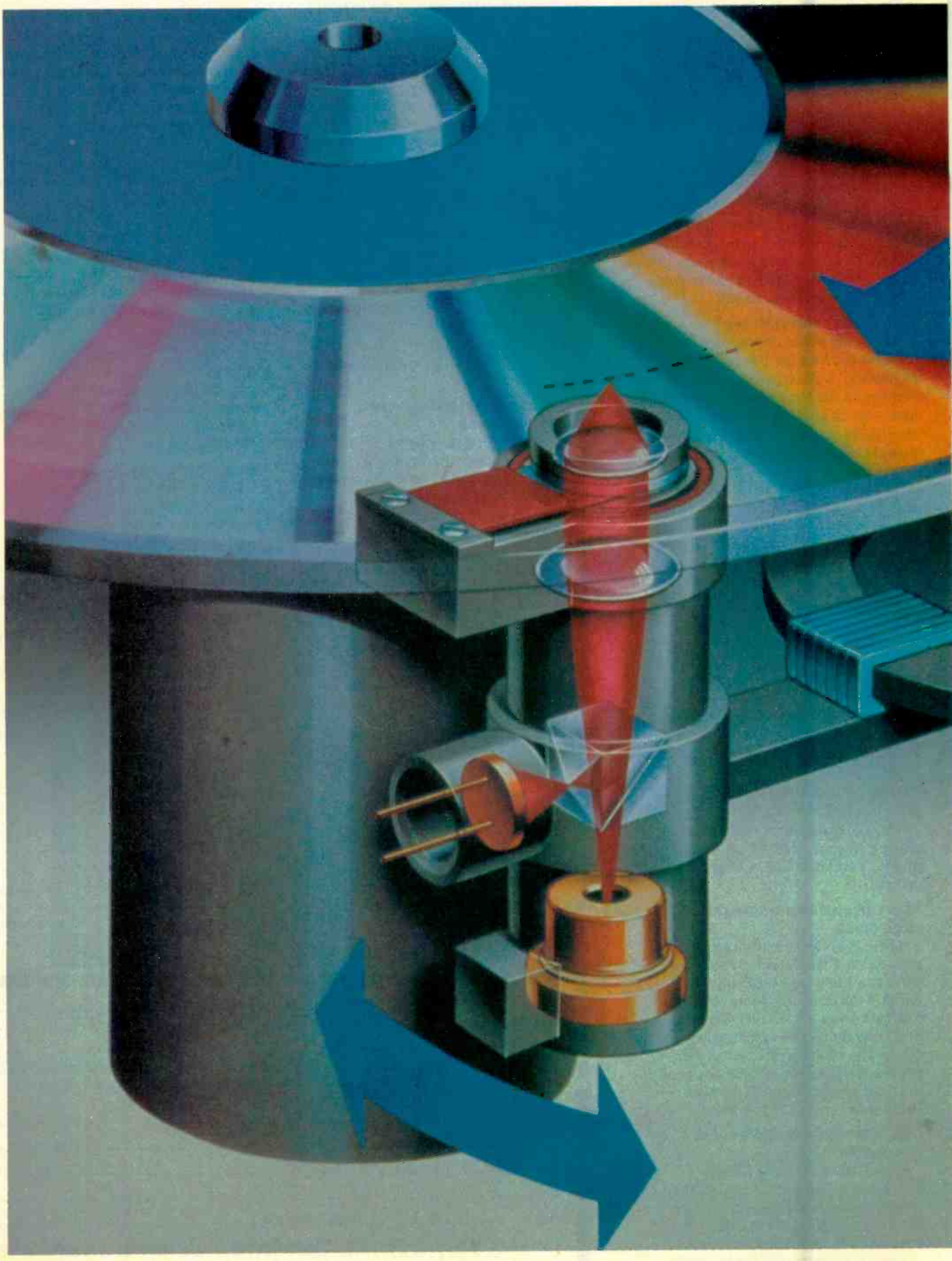

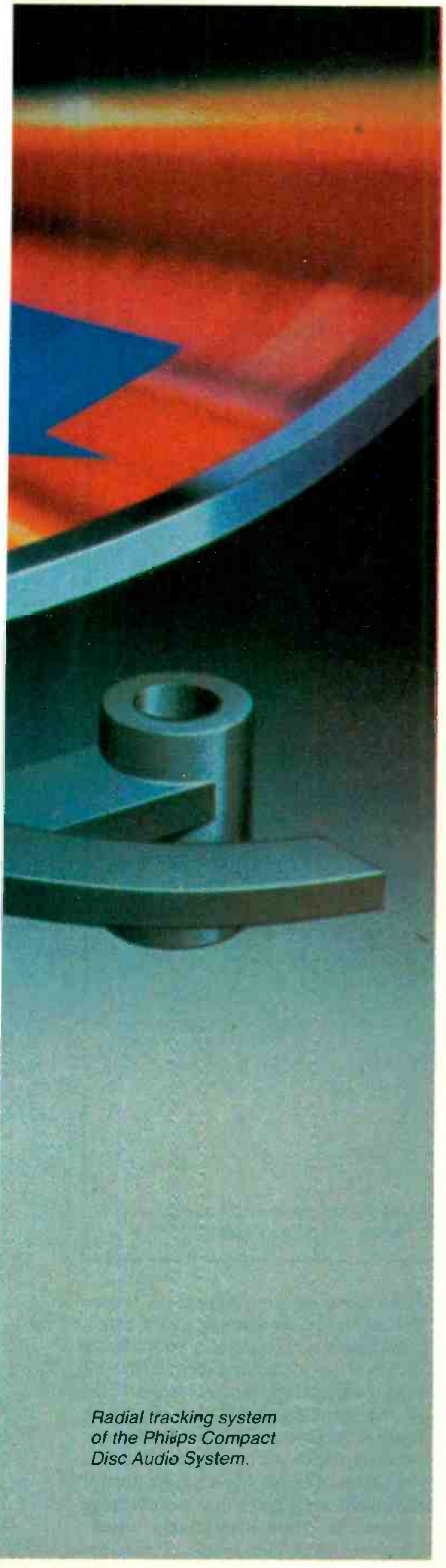

Radial tracking system of the Philips Compact Disc Audio System.

COMPACT DISC DIGITAL AUDIO SYSTEMS

How the new digital audio 4.7-inch playback record system works

By David Ranada

COMPACT Disc players—the hottest new products to appear on the audio scene in quite some time—are probably the most complex and sophisticated electronic devices for the home ever offered to the consumer. They are designed to play back, with extraordinarily high audio fidelity, up to 75 minutes of music recorded on mirror-finish 12-centimeter (4.7″) acrylic discs. The system does not wear out or damage the discs while it is playing them since only a light beam contacts the disc to read it out; that light comes from a semiconductor laser.

CD players combine aspects of a home computer's disc drives (in the player's disc-drive and laser-tracking servos), a specially programmed microprocessor (to handle a player's control functions), a digital signal processor (to decode and correct the digital-audio bit stream), and a high-quality, high-precision digital-to-analog conversion system (to change the digital audio data into normal audio signals of high sonic quality). How do all these systems interact to make a CD player work?

Digital Audio Basics. A digital-audio recording/playback system converts a smoothly changing, analog waveform into a series of binary numbers describing the waveform, records those numbers as pulses on a suitable medium (magnetic tape or the master disc for Compact Disc pressings), plays back those pulses, converts them into numbers, and finally reconverts the numbers into a smoothly varying analog waveform (Fig. 1). How can such a system provide the high audio quality claimed by advocates of digital audio? After all, typical Compact Disc player specifications claim a dynamic range of more than 90 dB, flat (±0.2 dB) frequency response to 20,000 Hz, distortion of less than 0.01%, and *no* wow or flutter.

The answer lies in the way the two basic operations of digital audio are performed. The first operation is called sampling. If the amplitude of a waveform—any waveform—is somehow captured or frozen at regular, closely spaced intervals, the waveform is said to be sampled. The waveform in Fig. 1A gets sampled in Fig. 1B, the samples being the points at the ends of the vertical lines. Mathematical models of this activity say that as long as samples are made at least twice as frequently as the highest frequency contained in the signal being sampled, *no information is lost.* From the information contained in the samples the waveform can be exactly reconstructed, as long as the waveform did not contain any frequencies greater than the *sampling rate.* The Compact Disc system's designers wanted it to have a frequency response extending to 20,000 Hz, so the audio signal for Compact Disc master tapes is sampled 44,100 times per second. The sampling rate is 44.1 kHz, more than twice the highest frequency desired by a slight margin.

Quantization—the second basic operation of digital audio—is shown in Fig. 1B and 1C. It is simply the *measurement* of the amplitude of the samples, the results of which are shown here in arbitrary numerical units in both decimal and binary representation. Binary representation is used by analog-to-digital converter (ADC) circuits in digital-audio equipment.

Note that the measurements are not infinitely precise; there is some "rounding off" to the closest integer value. Making an infinitely precise measurement would generate a number with an infinite number of digits (or bits); there has to be a practical limit imposed to the resolution of the measurement. This limitation creates noise and distortion in the reproduced signal, but the noise and distortion can be reduced to any level by increasing resolution of the ADCs.

In the Compact Disc system, audio is encoded with 16 bits of resolution, meaning that the ADCs used in Compact Disc mastering can distinguish changes in voltage levels of 1 in 2^{16}. This translates to 1 in 65,536 or the equivalent of 1″ in about 1 mile. With this degree of resolution, the signal-to-noise ratio or dynamic range of the CD system can be greater than 90 dB, the theoretical limit being a little better than 97 dB. Since quantization error is also responsible for nearly all the distortion in the digital audio process, it too is reduced to very low levels with 16-bit encoding.

The digital numbers from the ADC are converted into a pulse train (Fig. 1D) for recording on tape or on a Compact Disc master. Since it has only two possible values (high and low, corresponding to 1 and 0), this waveform is far more immune to distortion and noise in the recording and playback process than the original analog waveform. Distortions that can and do occur in the data-storage media (tape or optical disc) only rarely change the recorded pulse train enough to confuse the decoding circuitry as to whether a high or low value was intended.

In playback—this is where a CD player comes in—the original pulse waveform is recovered from the recorded waveform (Fig. 1E). After it is converted into the original numerical sequence (Fig. 1F) the series of digits is fed into a digital-to-analog converter (DAC) which changes them into discrete voltage levels (Fig. 1G). Because the numbers are clocked into the DAC at the same rate as they were generated at the ADC during the recording process, variations in the speed of the playback medium do not affect the reproduced waveform. Therefore, wow and flutter are eliminated!

An output-smoothing circuit removes the inaudible ultrasonic components that give the staircase waveform it's disjointed character. The filtered waveform makes up the output of the digital audio system, an output that is a very high-fidelity replica of the original input signal.

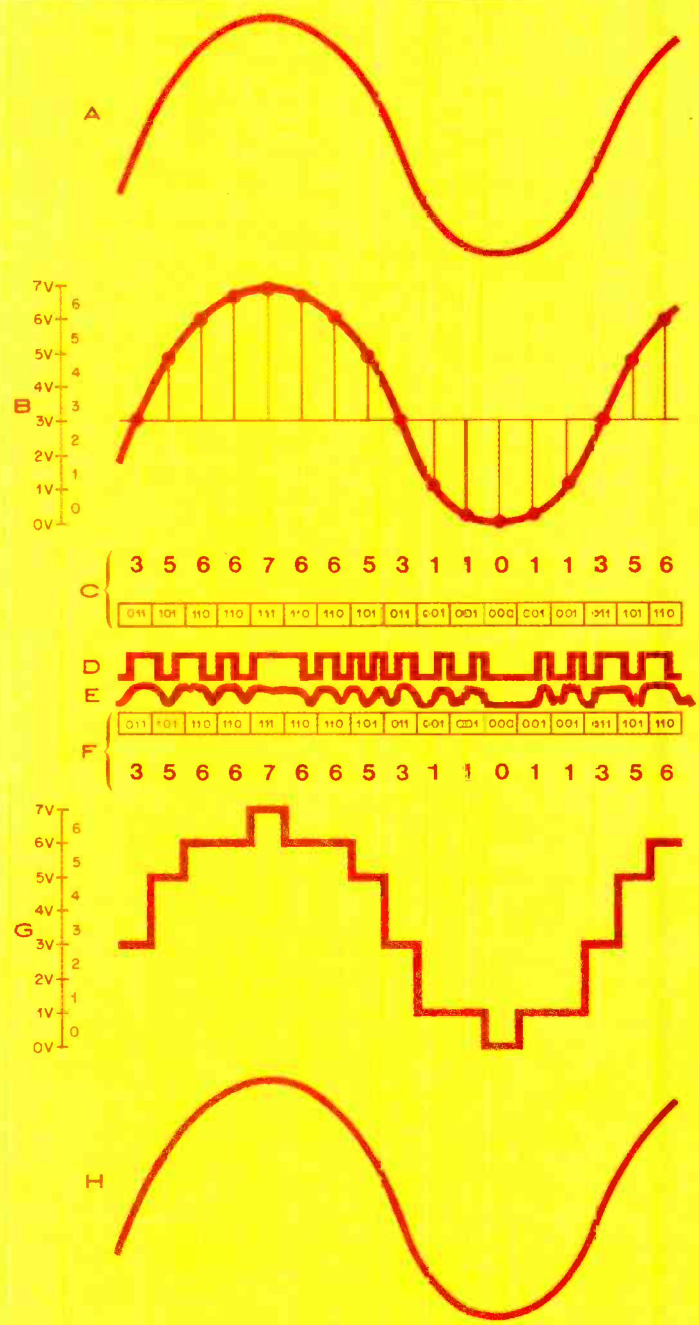

Fig. 1. Basic operations of digital audio: sampling (B); quatization (C); recover of data (E,F); and reconversion of data into an audio signal (GH).

The Compact Disc and Player. Before exploring some of the processing that goes on inside a Compact Disc player let's take a look at what a CD player has to play, the Compact Disc itself. Audio information is recorded on a CD pressing in a track of microscopic "pits" on the surface of a transparent acrylic disc 12 centimeters in diameter, as shown in an accompanying photo. These pits average slightly less than 1 micrometer in length; each revolution of the track is 1.6 micrometers away from the next. Data is contained in the *length* and *spacing* of the pits and the spaces ("lands") between them.

A cross-section of a CD pressing is shown in Fig. 2A. In it you can see that, though the pits (P) are made as indentations, they appear as "bumps" to the scanning laser beam. It comes up through the bottom of the disc, hits the aluminized signal surface (AL), and is reflected out again. Changes in the intensity of reflected light are detected (Fig. 2B) and converted to a digital bit stream (Fig. 2C). The pits are protected on one side by the bulk of the disc's plastic substrate (S), and on the other by a tough lacquer coating and a label (PR).

A typical mechanical arrangement of a Compact Disc player is shown in Fig. 3 and the illustration on page 40. It consists of an optical scanner, containing a semiconducter laser and a photodiode, mounted on a tracking device that allows the scanner to move across the face of the spinning disc. The disc spins counterclockwise in relation to the laser beam and the track of pits starts toward the center of the disc and moves toward the outside edge, both movements being opposite to those with analog (black-disc) records. The speed of rotation

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slows down between the start of a disc and its finish.

It starts out spinning at around 500 rpm and ends up spinning at about 200 rpm if the program extends close to the edge of the record. The speed is controlled by servo networks so that the track is always passing over the laser at between 1.2 and 1.4 meters per second. The steady decrease in rotation speed increases the amount of information that can be held on the disc. If the rotation rate were constant, the pits and alternating lands near the start of the disc would be unnecessarily large.

Data on Disc. It would be a stupendous and misleading oversimplification to say that digital-audio data gets recorded on a Compact Disc exactly as it emerged from the digital-audio master recorder. There is a good deal of digital signal manipulation on the audio data before it finds itself on the signal-surface of a Compact Disc. Most of this processing is undone by a CD player in its operations to recover the original digital-audio. Then why is all the processing necessary? The three main reasons are: to increase the playing time of a CD, to make it audibly immune to disc damage (scratches, fingerprints, small pressing defects), and to provide special digital control and data signals for advanced Compact Disc applications.

Figure 4, as complicated as it appears at first glance, summarizes all the main digital operations performed to a digital-audio signal on its way to the master Compact Disc. The digital data on a CD is gathered into units called frames and the diagram depicts the encoding process for one frame (which takes only about 136 microseconds to be scanned by a CD player's laser).

The digital-audio signal content of a CD frame consists of enough information to make up six sampling periods (Fig. 4A). Since there are 32 bits generated in one sampling period (16 bits per stereo audio channel every 22.68 microseconds) there are 32 × 6 = 192 audio-data bits per frame (Fig. 4B). Each 16-bit sample is broken down the middle into two 8-bit bytes, called *symbols* in CD terminology (Fig. 4C). One symbol contains the 8 most significant bits of the sample, the other contains the 8 least significant bits. This repartitioning of the data yields 24 symbols containing only digital-audio data per frame.

The first major signal-processing operation on the audio data during the encoding process is depicted in Fig. 4D and E. These two lines depict the functions that make the data stream immune to transmission errors due to disc defects or damage.

They start with the generation of redundant data that a CD player will use

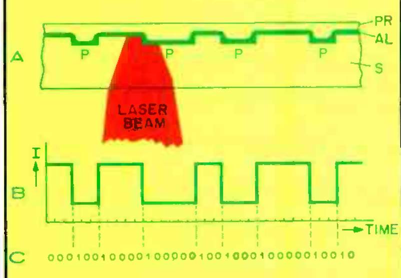

Fig. 2. A 1.2-mm thick Compact Disc (A) consists of three layers: an acrylic substrate (S), an aluminized reflecting "signal surface" (AL), and a lacquer coating and label (PR). The pits (P) are pressed from above but the laser beam scans from below. The reflected intensity of the beam varies as the pits pass by (B) and these variations hold the digital-audio data (C).

to detect and correct for any errors in the data stream as read by its laser (see box on page 45). Simply put, the redundant data is a mathematical summary of the digital-audio data contained in the frame and is a special form of parity-check code (for those of you familiar with digital data transmission). The first error-correction symbols to be generated are the four Q symbols which find their places in the middle of the frame.

Next comes interleaving, a process for making the recorded signal immune to disc scratches and other relatively large-scale defects (see accompanying box). Interleaving scrambles the symbols from a large number of frames preceding and following the one being encoded in the diagram. This scrambling (depicted by the arrows between Fig. 4D and E) is performed in a very strictly defined way, which moves originally consecutive symbols to distantly separated frames, and which moves symbols from distant frames into the one under construction. The Q-parity symbols also undergo this shuffling process. No data is left out or repeated—the number of digital-audio symbols per frame is still 24, the number of Q-parity symbols is still 4—its just that 28 previously consecutive symbols find themselves strewn over about 40 different frames in a very regular, and undoable pattern.

After interleaving, four P-parity error-detection/correction symbols are calculated from the 24 audio and 4 Q-parity symbols now in the frame. This additional parity data is tacked onto the end of the frame. The whole parity/interleaving scheme is called CIRC (Cross-Interleave Reed-Solomon Code).

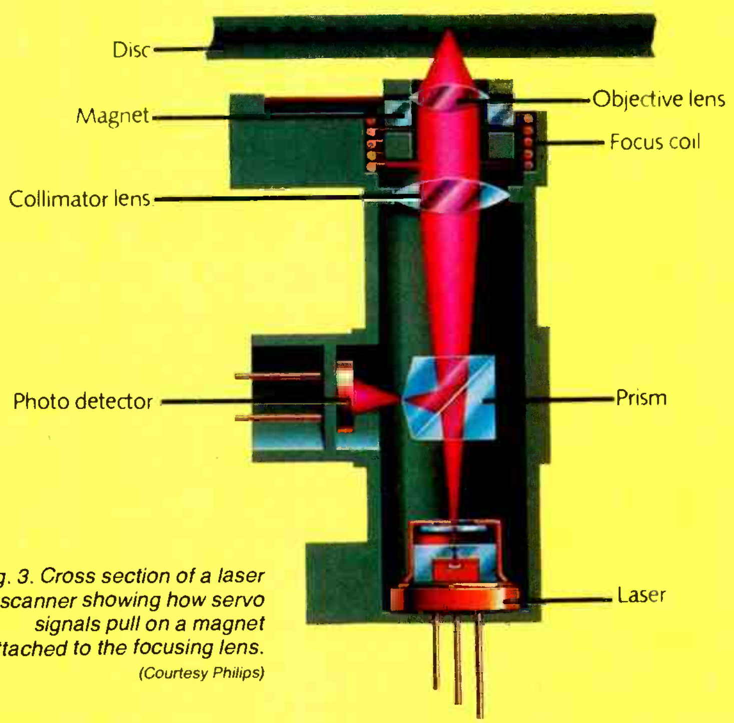

Fig. 3. Cross section of a laser scanner showing how servo signals pull on a magnet attached to the focusing lens.
(Courtesy Philips)

To the start of the frame is added one 8-bit symbol containing control and display (C&D) bits. At present this symbol is used only to hold data about the timings of each musical selection on a Compact Disc, and data signalling where each selection begins and ends. This information is used by a CD player to cue up individual selections.

Future applications of the C&D symbol include text data for lyrics; graphics data for computer-type displays on TV's and monitors; and ultimately video data in conjunction with a video frame-store system. The C&D symbol can also be made to carry a telephone-quality digitally encoded voice signal for sing- or play-along recordings. (Since the C&D symbols contain 8 bits and occur 7,350 times per second–once per frame—a voice signal with a signal-to-noise ratio of about 45 dB and a frequency range up to about 3,500 Hz can be carried.)

Players for all these advanced functions have not yet been issued. In fact, some or the most technically complex options, like computer graphics and video, are still in the planning stages.

Modulations. At this stage (Fig. 4E), the frame consists of 33 8-bit symbols of digital-audio (24 symbols), parity-check (8 symbols), and control/display data (1 symbol). This symbol sequence is then fed into a digital modulation circuit which converts, via a read-only-memory look-up table, each 8-bit symbol into a 14-bit word in a process called EFM (Eight-to-Fourteen Modulation). Essentially the 8-bit symbols modulate a bit pattern 14 bits wide (Fig. 4F and G). Why is this done?

The full answer to that question is rather complex, but it boils down to the fact that about 25 per cent *more* information can be stored on a Compact Disc if the 8-bit symbols are converted to 14-bit words with certain special properties. To the CD user this increase of "information density" means longer

ERROR CORRECTION

Analog stylus-in-a-groove recordings are very susceptible to all sorts of sonic degradations from defects in the manufacturing process or damage inflicted by the user. What record buyer hasn't had the unpleasant experience of a bad pressing or hasn't heard the noise added by fingerprints or scratches on an analog disc's surface. Digital audio offers salvation from these problems since specially encoded digital signals can be made immune to what are called "transmission errors." By the incorporation in the pit/land track on a CD of extra information which is mathematically redundant to the original digital-audio signal, a Compact Disc player can eliminate to a substantial degree the sonic side effects of even gross disc damage like scratches and fingerprints.

The theory of error-correction coding can get extremely involved, mathematically speaking, but the basic principles of how error correction is applied in the CD system can be illustrated by a simple analogy. Figure A illustrates what is called a magic square. As you might recall from grade-school arithmetic, a magic square is an array of numbers, the rows, columns, and diagonals of which all add up to the same number. In this case each row, column, or diagonal adds up to 15. If you were to transmit the numbers contained in the magic square along with the sum of any row or column, and if one of the numbers were to be incorrectly received, you would still be able to regenerate the magic square completely and exactly. Why? Because you know that each row or column or diagonal adds up to 15. If an incorrect number is received as in Fig. B, the rows, columns, and diagonals will not add up correctly. The offending number can be easily located and corrected. The location is at the intersection of the row and column which do not add up correctly; the correct value is that number which makes the sum come out correctly.

By transmitting the sum value along with the numbers in the magic square you were transmitting redundant information, a mathematical summary of the numbers contained in the square. The receiver is able, using this redundant information, to calculate and correct more than one transmission error even if one of the errors occurs with the sum value. Of course, correcting the sum value isn't helpful if all you are interested in is the magic square's numbers, but at least that this example shows that the transmission of redundant information makes the detection and correction of transmission errors much easier.

Figs. A and B. Magic squares with and without the correct numbers.

The Compact Disc system makes use of a similar, but much more complex, process to protect the digital-audio data from transmission errors. About 25 per cent of all the data encoded on a Compact Disc is mathematically redundant to the digital-audio information. These error-correction symbols are derived by binary computation in much the same way the sums for the magic square's rows and columns were obtained. Naturally the numerical data on a CD is not placed in magic squares—digitally encoded music doesn't create sequences of numbers that are easily fitted into magic squares. Instead, the CD encoding system creates unique patterns of bits which are hard to confuse with one another without being able to find and correct for errors.

No error correction system is perfect, however. Eventually enough errors can occur that exact reconstruction of the transmitted signal is impossible. In the magic square example, for instance, if four or more numbers were altered in transmission there would be no unique solution to the square. There may be several different arrays of numbers which will make up a valid magic square. Likewise with the Compact Disc system. Eventually there may be so many errors in the data stream, due to extensive disc damage, that exact correction of the digital-audio data cannot be performed. A CD player will then interpolate the correct data from valid data by taking an average of the number before the erroneous digits and the number after them.

In the CD system, if one out of every thousand data bits were incorrect (giving a bit error rate or BER of 10^{-3}), interpolation will be performed about 1,000 times per minute. A BER of 10^{-3} corresponds to a very well scratched disc. If only 1 out of every 10,000 bits is in error (BER$=10^{-4}$), a typical value for an undamaged CD pressing), the interpolation rate drops to about one 16-bit sample in every 10 hours of playing time.

There is a very small possibility that an undetected error will sneak through the CD error-correction system. With the magic square this would mean that several numbers were changed in such a way that the square is still "magic" but not the same one as transmitted. In digital audio, an undetected error can lead to a "click" in the reproduced sound. The CD error correction system will produce fewer than one click for every 750 hours of playing time with a disc having a BER of 10^{-3}. In practical terms this means that a reasonably well cared for Compact Disc pressing will never generate clicks or pops in playback. The listener is spared from these by the actions of the Compact Disc error-correction system on the data stream. ◇

playing times. Accompanying this increase of playing time, EFM decreases the CD system's sensitivity to disc and optical-system defects and production tolerance variations.

The signal created in a CD player's photodiode detector circuitry by the EFM sequence of pits and lands has two more important properties: it has low dc (0-Hz) content and it is "self-clocking". Low dc content is important because the servo systems which keep a CD player's laser "on track" utilize low-frequency control and feedback signals. Any dc content in the signal from the photodiode detector can throw off the tracking of the laser. (Think of a very long pit or land as having substantially higher dc content than rapidly alternating, small pits and lands.) EFM has very little 0-Hz in its waveforms since the spacing and lengths of pits and lands is strictly controlled.

A CD player must synchronize its operation with the data coming from the disc and must also synchronize the rotation rate of the disc with the operation of the CD-decoding circuits. EFM has self-clocking properties allowing a CD player to determine which bit belongs to which symbol during decoding.

While the 8-bit symbols are converted into 14-bit EFM words, three additional bits are added to each word. These "merging bits" are calculated to further reduce the dc content of the signal. Finally, the end of the frame is marked by a sync signal of 24-bits length together with three merging bits. In all, a frame which started out as 192 audio bits now contains 588 channel bits. These are recorded onto a Compact Disc so that a 1 in the channel-bit sequence turns into the *edge* of a pit. A CD player's decoder circuits really don't care if they are scanning pits or lands; the circuits are sensitive to pit edges. It makes no difference whether a logic "1" is encoded as a pit or a land.

Inside a CD Player. A Compact Disc player has to undo all the encoding steps just described in order to recover the original 16-bit digital audio samples. The process, very simply described, follows this sequence:

1. Light from the player's semiconductor laser is focussed through a prism/lens optical system onto the surface of the spinning disc.
2. The reflected laser beam returns through the same optical system but is diverted to a light-sensitive detector (a photodiode array).
3. The photodiode output, after amplification and filtering, is converted into a squared-off pulse train by the use of comparator circuitry.
4. The pulse train of zeros and ones (corresponding to Fig. 4H) is demodulated according to the rules of EFM into 8-bit symbols carrying audio data, parity-check information, and C&D data.
5. Data control/error-detection-correction/memory circuits de-interleave and correct the data using the CIRC decoding rules.
6. Sixteen-bit digital-audio samples are assembled from the error-corrected symbols and sent to the 16-bit digital-to-analog converters where they are converted into analog voltages.
7. The staircase-shaped DAC outputs are smoothed by sharp-cutoff lowpass filters and the resulting *analog* signals make up a CD player's audio output.

This brief summary pays short shrift to the complexity and sophistication of the operations and circuitry involved. Semiconductor lasers are not universally used components, let alone in mass-market consumer products like CD players. Steps 4 and 5 make use of complex LSI chips, without which the building of a practical and affordable CD player would be impossible. For example, the three Sony-developed chips performing steps 4 and 5 and used by them and several other companies in their first CD players contain the equivalent of about 7,500 gates, not including a 16 kilobit RAM necessary for the processing. Sixteen-bit DACs weren't even available in low-cost monolithic form five years ago.

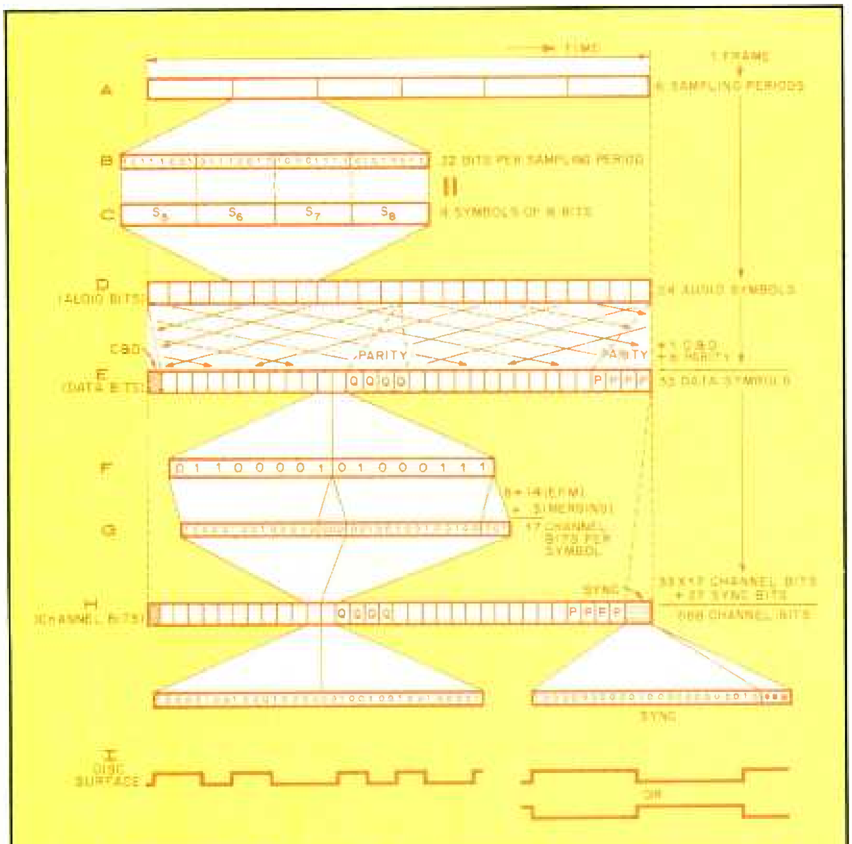

Fig. 4. Read from top to bottom, this chart summarizes the operations applied to a digital audio signal before it gets on a Compact Disc. Read from bottom up, it summarizes the CD player recovery process.

Tracking. That short list of CD-player functions also glosses over two of the most fascinating applications of servo-loop techniques: the turning of the disc and the tracking of the track of pits by the laser/optical system. These two operations are controlled by digital/analog/electromechanical servo loops of fascinating complexity. They are so intricate, in fact, that only a very broad description of them can be given here.

As mentioned before, the rotation rate of the disc is locked to the frame rate, which itself is determined by characteristics of the disc's data stream. Phase-lock techniques are used to keep the rate of disc rotation generally synchronized with the frame rate. Exact synchrony is not necessary because of

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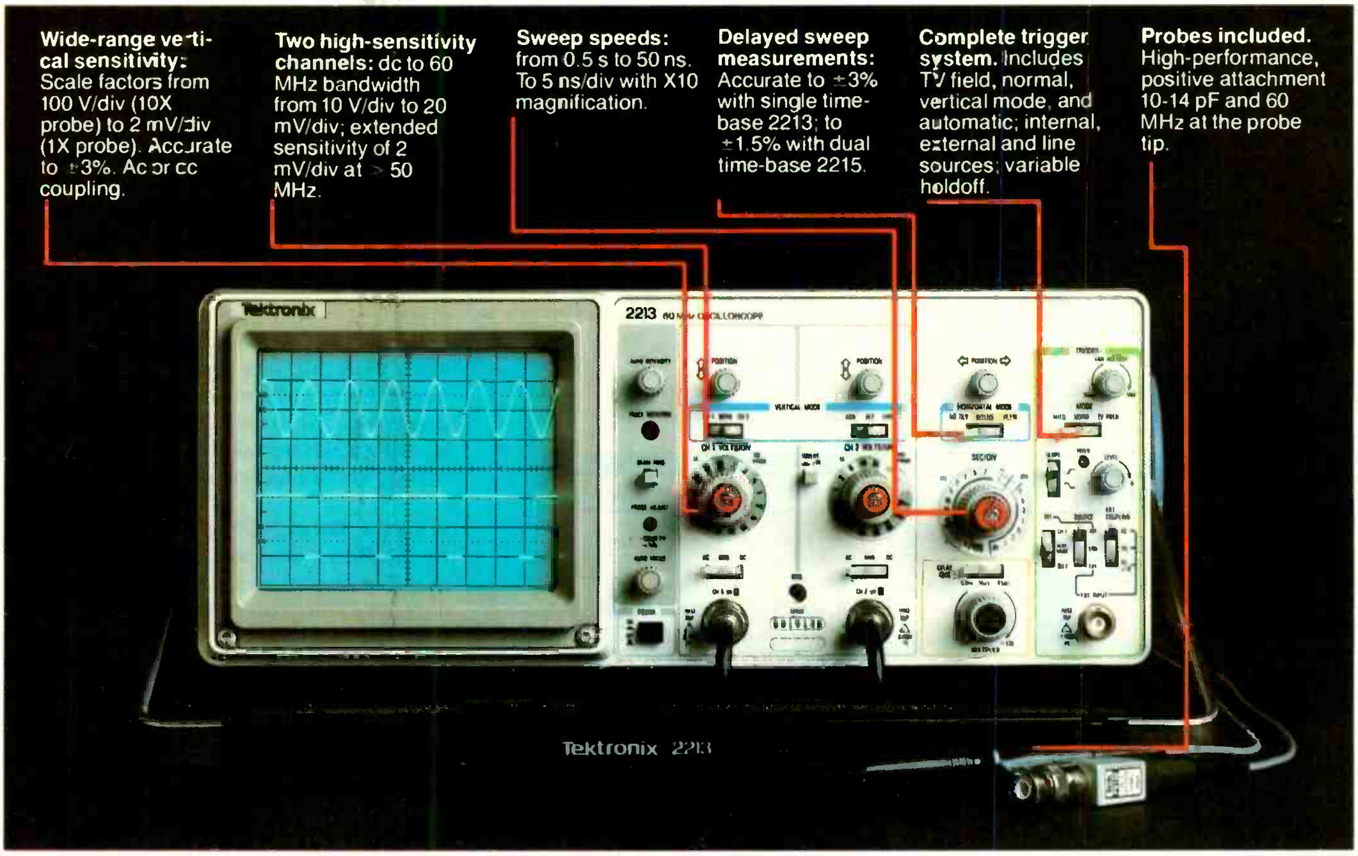

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the self-clocking nature of the data modulation scheme; EFM demodulation chips can determine where each bit belongs from the signal itself.

Servo-loop feedback techniques also keep the laser trained and focussed on the pit track. The precision of the servos systems that accomplish this is very high. Taking tracking as an example, the laser system must be guided over a spiral of pits with a pitch of only 1.6 micrometers. Disc eccentricity and player tolerance may cause the track to swing from side to side; the maximum permitted swing is 300 micrometers. Yet for accurate decoding, the tracking servo must allow the laser beam to follow the pits to with 0.01 micrometers and also must absorb the effects of vibrations and jolts applied to the player chassis.

When it comes to focussing the laser beam onto a CD's inner signal surface, the focus servo must be able to cope with disc warps of up to 1 millimeter. The focussing system, however, must maintain focus on the signal surface to tolerances 1,000 times smaller: ±1 micrometer.

A CD player performs such feats of electromechanical precision by monitoring the shape and/or intensity of the laser beam after it is reflected off the signal surface and back into the optical system. Deviations in the shape or intensity of the beam as detected by a photodiode array are used to move the optical system's objective lens nearer or farther from the disc surface to cope with focussing errors), or to move the optical system as a whole across the surface of the disc (to correct for tracking error).

What's Next. Even though the Philips/Sony Compact Disc is a tremendous engineering achievement, it is only part of the start of what will probably be a revolution in information-storage technology: the optical age. In its present form, a Compact Disc can hold about 16 *gigabits* of raw data. If the EFM modulation system is used to store computer data, a CD will hold about 9.14 gigabits or 1.14 gigabytes. If half of that capacity is used as redundant data for error detection and correction, one Compact Disc could hold about 570 megabytes of digital data, about 1,000 times the amount of a high-density floppy disc. (The error-correction system for the audio CD, as good as it is, still lets through too many interpolated and undetected errors to be tolerated in data-only applications, thus the very conservative assumption of 50 percent data redundancy.)

Since its small size increases production yields and lowers production costs over its larger (12") LaserVision videodisc counterpart, don't be surprised if the high information capacity of the CD system becomes a standard medium for mass distribution of software and data bases. The enormously larger data-carrying capacity of the 12" LaserVision system can even make it impractical for mass distribution purposes; who needs all that data anyway?

Software distribution won't be the only data application of the Compact

INTERLEAVING

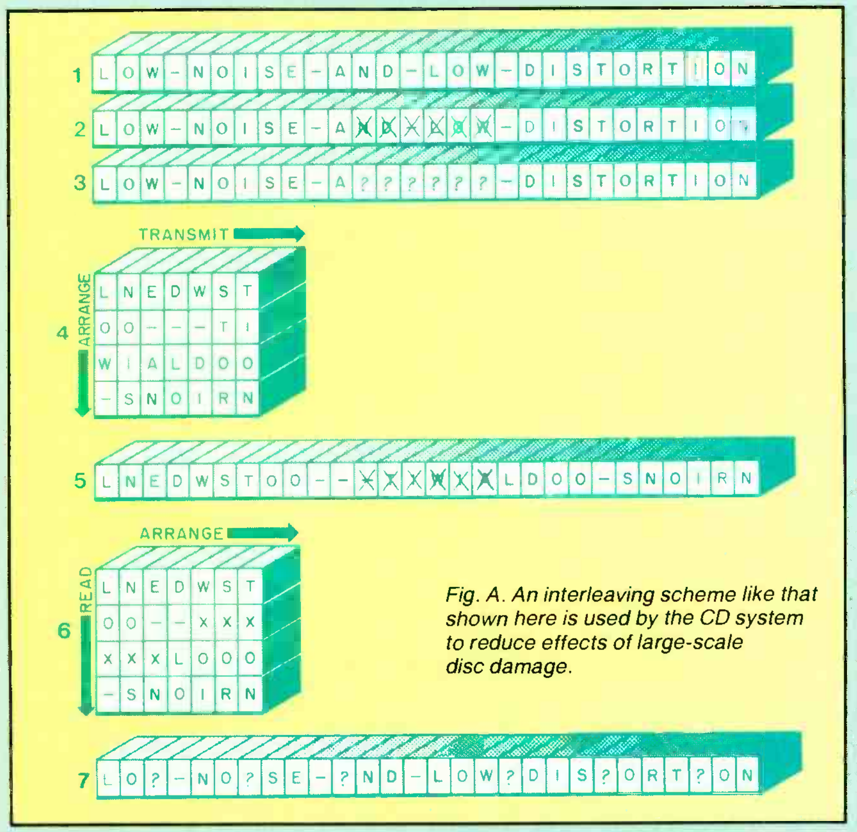

Fig. A. An interleaving scheme like that shown here is used by the CD system to reduce effects of large-scale disc damage.

Interleaving is a process used in the encoding of Compact Disc data that reduces the system's susceptibility to what are called "burst errors." These are errors in the data stream which occur to many bits in succession. They can result from interference to the scanning laser caused by relatively large disc damage (fingerprints, long scratches).

A simple example can easily demonstrate the effectiveness of interleaving (Fig. A). Suppose you transmitted the message LOW-DISTORTION-AND-LOW-NOISE, but a burst error of six characters occured during reception. The receiver would then have a hard time figuring out what was meant by LOW-NOISE-A?????-DISTORTION (Figure A1). You could have made the transmission more immune to the loss of several consecutive characters by first arranging them in columns, then transmitting them by rows (Figure A4). The transmitted signal is thus a regularly scrambled—interleaved—version of the original signal. If six successive characters are now obliterated, the receiver can deinterleave the message by rearranging it in rows and reading it out by columns (Fig. A5 and 6). The result is a much more intelligible signal; the burst error has been dispersed into separated "random" errors (Fig. A7).

Just as these random errors are much more easily handled by readers of English, they are more easily handled by a CD player's error-correction circuitry. In fact, readers of English supply a "context" to the received message to make it intelligible. Generally speaking, a CD player does the same thing with the redundant error-correction data placed on the disc. The redundant data provides a mathematically defined and standardized "context" in which to interpret random errors in the data stream.

In the CD encoding process interleaving is accomplished by writing the audio data into a digital memory and then reading it out in a different order—the equivalent to the row/column changeover in the example. A CD player performs the opposite operation in the de-interleaving process. ◇


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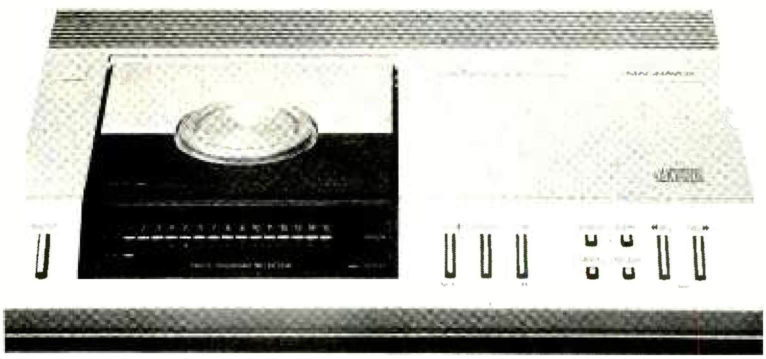
Disc system. Efforts are being made at a number of companies to come up with a practical, inexpensive method of *recording* on Compact Discs and optical videodiscs. Not only will home digital-audio disc recorders become possible with the development of such technology but home computers could easily use a recordable CD for storage of large amounts of information. Even an unerasable CD recording system could be useful.

At present, research efforts are being directed towards a suitable laser/recording substrate combination. The semiconductor lasers used in audio CD players are too weak to directly "write" on Compact Discs.

All that relates to developments five to ten years away from reaching commercial reality. Much closer to appearing on your electronics dealer's shelves is a digital signal processor for audio signals. Already, relatively slow microcomputers in typical home computers are being put to good use in audio via specialized Fast-Fourier-Transform measurement system (like the IQS system Julian Hirsch uses in testing audio equipment). Now under development are ultra-fast, special-purpose arithmetic processors which, under control of a microprocessor, can be made to perform such audio tricks as filtering, reverberation simulation, compression, expansion, click and pop removal, and sound synthesis and mixing *while an audio signal is still in digital form.* Among the many advantages that all-digital signal processing promises are no audible degradation in signal to noise ratio or distortion levels, the capability of extraordinarily complex realtime operations on an audio signal, and, last but certainly not least, software based processing.

Imagine an audio component looking much like a popular video-game console. Just plug in a cartridge and the system becomes a digital ambience synthesizer, or a digital multi-band equalizer, or a tick/pop remover for playing these old-fashioned stylus/groove recordings. Technologically such a system is possible today; a commercial system may see the light of day as soon as two years from now. By then CD players will be supplied with direct digital-audio data outputs so a direct link from recording studio to a home stereo system's power amplifier will be possible. The CD players and recordings available today are the start of our digital audio future, a future which promises extraordinary operating flexibility, convenience, and—above all—sound quality. ◇

A Hands-On Look at Magnavox's FD1000SL Compact Disc Player



MANUFACTURED by the parent company, Philips of Holland, the Magnavox Model FD1000SL is the simplest, most compact, and least expensive of the "first generation" of CD (Compact Disc) players to reach the United States market. It resembles a small, top-loading cassette deck, with a hinged clear-plastic compartment cover that swings up for loading and removing discs. The sloping upper-front portion of the case contains several pushbutton operating controls. The machine is enclosed in a satin-silver-colored polystyrene case that measures 12⅝" W x 10½" D x 2⅞" H and weighs approximately 11 lb. Suggested retail price is $800.

General Description. The CD is the long awaited "digital disc," about which we have heard so much in recent years. Analog programs are sampled at a 44.1-kHz rate and converted to 16-bit digital form. The digital information controls a laser beam that burns microscopic pits into a master disc, forming a spiral pattern somewhat like that of a conventional analog record.

In its final form, the compact disc is silver colored and measures 4¾" in diameter. Recording is on only one side, the flip side being used for the label. The recorded surface is protected by a tough transparent plastic coating, making the disc relatively immune to damage from normal handling. (Fingerprints, for example, have no effect on the sound quality of a digital disc.) And, since no mechanical contact is made with the laser-read disc during playback, it does not wear out or lose fidelity with repeated playings. Play is from the inside toward the perimeter. During play, the disc's rotating speed varies from 500 to 200 rpm to maintain an approximately constant linear scanning velocity of 1.2 to 1.4 meters per second.

The sonic performance of the compact disc is vastly superior to that of any medium previously available for home reproduction, surpassing even the most advanced professional analog tape recorders. Specifications of the Magnavox FD1000SL, typical of those for most CD players, include a frequency response of 20 to 20,000 Hz ±0.3 dB, dynamic range and signal-to-noise ratio that exceeds 90 dB, and harmonic distortion of less than 0.005% at maximum output. An almost literally zero flutter percentage is obtained, thanks to playback timing being controlled by a quartz crystal oscillator.

Within the player, a laser scans the pits on the revolving disc, and its reflection from or absorption by the disc (a function of the recorded pattern) is sensed by a photodiode and forms a series of digital words. The bit stream is converted to analog form by 16-bit D/A converters and filtered to remove all content beyond 20,000 Hz. Unlike most CD players that use physical filters, the FD1000SL employs digital filtering.

The operating controls are reminiscent of those on a cassette deck including PLAY, PAUSE, and STOP, as well as high speed FWD and REV SEARCH. Other smaller buttons control special programming features.

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When the machine's disc-compartment cover is raised by pressing a button at its front-left corner, a spindle is exposed onto which the disc is placed, recorded side down. The cover is then closed manually. Pressing PLAY causes the disc to spin for a few seconds, supplying information on the number of separate selections and their precise locations on the disc (similar to the action of a computer/disc catalog). Green LEDs, visible through the window on the front panel, light up to show the total number of programs, up to a maximum of 15. Normally, as the disc is played in sequence from the first selection, a second green LED lights below the track "catalog" to show which program is being played, advancing at each subsequent selection. At end of play, the unit shuts down.

The CD player may be programmed to play tracks in any sequence, by choosing either those tracks to be played, or those to be omitted from the playing sequence. This is done with the STORE and SELECT buttons, and the track indicator lights show which have been programmed and which is being heard at any moment. The high speed SEARCH buttons can be used to slew the laser pickup to any point on the disc and resume play from that point when the button is released. Although most music records have fewer than 15 tracks or programs, the FD1000SL is not limited to that number. However, it considers everything following the track 15 to be part of that program, and cannot be specifically programmed for higher numbered selections.

Laboratory Measurements. Tests of the Magnavox unit were made using special test discs from Philips and Sony. The frequency response (identical for both channels) was measured with the Philips 410 055-2 record, and was found to be flat within ±0.15 dB from 20 to 20,000 Hz, with the variation being in the form of small "ripples" between 4,000 and 20,000 Hz. Output from a "0 dB" 1000-Hz recording was 2.03 volts, and the A-weighted S/N (measured with an IVIE IE-30A Audio Analyzer), was 99.2 dB referred to that level. The harmonic distortion, playing the 1000-Hz test tones of the Sony YEDS 2 record, which are recorded at levels from 0 to −90 dB, was −95 dB (0.0018%) at 0 dB. Since the distortion components remain at about the same amplitude for all signal levels, the percentage increased at lower recorded levels. Eventually it was masked by system noise, but even at a −20 dB level the THD was −70 dB, or 0.03%.

Intermodulation distortion was also measured at levels of 0 and −20 dB, with readings of 0.004% and 0.039% respectively (for an SMPTE measurement with 60 and 7000 Hz tones at a 4:1 amplitude ratio.) Channel separation at 1000 Hz (averaged for the two directions of crosstalk) was 99 dB, and at 20,000 Hz it was 93.5 dB. As expected, the flutter was unmeasurable, reading the instrument residual of 0.001% on our flutter meter (the same reading was obtained using the meter's internal crystal controlled 3150-Hz signal).

We made limited measurements of the model's ability to withstand physical shock without mistracking. All CD players are susceptible to losing optical contact with the recorded track if they are jarred, and the Magnavox unit is no exception. However, it is at least the equal of a good record player in this respect, and has the advantage of being immune to acoustic feedback that can cause howling or simply a muddying of the sound when playing LP records.

"The total lack of noise, distortion, crosstalk, or flutter . . .transcends anything previously available . . "

An important consideration for a compact disc player is its ability to correct for bit errors, which are inevitable during playback. All available machines employ fairly elaborate error correction systems, typically designed to cope with interruptions of up to 3000 or more bits without loss of tracking or even a noticeable gap or noise in the program. To evaluate the effectiveness of these error correction circuits, we used a special Philips test disc on which a wedge-shaped portion of the information layer (recorded with music) is "damaged," so that the length of the dropout can be determined by reference to the disc portion being played. It also has dots of different sizes painted on the transparent protective layer to evaluate the effect of external dirt or scratches on information retrieval, as well as a simulated fingerprint formed of parallel-ruled lines. The Magnavox FD1000SL was outstanding in this test, being completely unaffected by any of the errors on the test disc.

User Comment. The Magnavox FD1000SL worked perfectly in extended-use tests, playing a number of commercial-music CD records and sampler discs. The programming system was flawless, with the sound beginning exactly at the start of each programmed selection. However, the movement of the pickup to the programmed position, or under the control of the REV and FWD SEARCH buttons, was very slow compared to other machines we have used. For example, if selection #15 was the first programmed for playing, the unit required more than 18 seconds to reach it from the starting point, compared to typical times of 1 to 6 seconds for other machines.

The Compact Disc is in its infancy, of course, and whatever opinions one might form on the basis of incomplete information or hearsay are likely to become modified in the future. Our reaction to it is overwhelmingly enthusiastic. The total lack of noise, distortion, crosstalk, or flutter results in a listening experience that transcends anything previously available to an audio enthusiast.

Not every digital recording is so outstanding (many come from analog masters, and cannot be better than the master tape), but the medium is everything that has been claimed for it. It will not replace the LP record for some time, if ever, but will supplement it much as tape has supplemented records for decades. Inevitably, the price of the CD players will come down to the level of any reasonably good turntable or cassette deck, and at that time anyone who is serious about good sound will have added digital disc capability to his music system.

It is important not to confuse the Compact Disc with the so-called "Digital Discs" that have been on the market for some time, and which are really conventional analog LP records made from digital master tapes. They are indeed likely to be superior to standard-type LPs. However, our experience suggests that a CD made from a good analog master tape is likely to be much better than an LP made from a good digital master. CD discs are expected to sell for $17 to $22 each, a premium price for a premium sound and long-lived fidelity. —*Julian D. Hirsch*

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The Terrific-80

RADIO SHACK'S NEW TRS-80 DESKTOPPER

WHEN the early TRS-80 Model I computers appeared, pioneering widely available, modestly priced personal computers, detractors jeered at the absence of lower-case letter, color video, and calculator keyboard, calling them by the name, "TRASH-80." Like "Yankee Doodle," the name stuck and became an affectionate one. The computer itself evolved through several modification improvements and enhanced versions to become one of the most popular computers ever built.

Recently, when I reported on my trip to Ft. Worth and the Radio Shack Model 100, I mentioned how I also saw, under wraps in the back office, the latest model in this successful series—the TRS-80 Model 4.

When I looked at the Model 4, my first thoughts were, "Oh, a white Model III, that's nice." When I began to use it, however, and understand its features and software, I kept saying "terrific, terrific!" So I want to offer a new and well deserved name, "TERRIFIC-80," for the newest and best of the marque.

It is not until you sit down at the keyboard, turn it on, and start to use the computer that the differences become apparent. The CRT display is 80 characters by 24 lines instead of the 64 characters by 16 lines of the Model III. Actually there are six video modes:

- White on black (normal)
- Black on white
- 64 characters by 16 lines (Model III mode)
- 32 characters by 16 lines (Model III mode)
- 80 characters by 24 lines (Model 4 mode)
- 40 characters by 24 lines (Model 4 mode)

The display can show the full ASCII character set and 64 graphics characters.

The keyboard of the Model 4 looks similar to that of the Model III. However, the former has several added keys that were sorely missed by users. One is a CAPS key, which provides the useful caps-lock function. The others are the CTRL (Control) key, which was missing on the Model III keyboard, and SHIFT keys located on either side of the bottom row. There are also three user-defined function keys marked F1, F2, and F3. These are used in application programs to provide single keystroke data entry.

The major physical differences between the new computer and the Model III are internal. In this case, *it's what you don't see that counts.*

The Model 4 contains 64K bytes of user memory, which can be upgraded to 128K bytes. The additional 64K bytes are used as memory pseudo-disk called Memdisk. The Model 4 can also be used with a Radio Shack hard-disk drive.

This Memdisk feature is a very interesting concept. It lets you add a solid-

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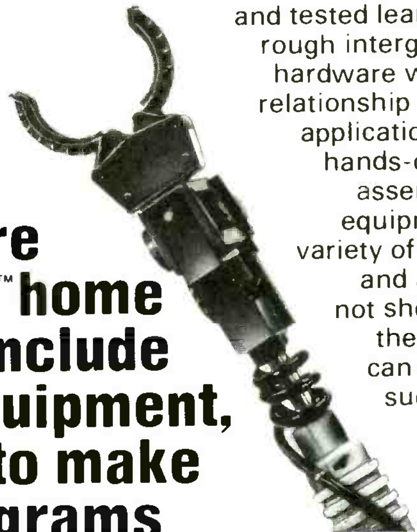

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state "disk" to the system, which keeps its files in memory. Files stored this way can be accessed, read, and written to with much more rapidity than ordinary disk files on a floppy. You can also use the Memdisk feature if you only have 64K of RAM, but its principal use is with the extra bank of memory that the Model 4 will support. All TRSDOS utilities treat the Memdisk files exactly like any other drive, so you can COPY, BACKUP, REMOVE, PURGE, ATTRIB (protect), and display the directory of the files on the Memdisk.

Like the Model III, the Model 4 comes with a parallel printer interface; however, there is an optional serial RS232C interface.

One of the new options of the Model 4 in the ability to use CP/M Plus, the latest version of the "universal operating system." This makes the entire library of CP/M-80, user controlled software available to TRS-80 Model 4 users.

Of course, the Model 4 uses the latest version of Radio Shack's operating system, TRSDOS, as it major system. This is TRSDOS 6.0. This version is substantially different than previous versions of TRSDOS. To TRS-80 experts it will look like an operating system that was written for Models I and III, called LDOS. The reason for this is that it is the latest edition of LDOS!

When Radio Shack first decided to release its disk system for the TRS-80 Model I, the decision was made to use a Radio Shack DOS rather than adopt one of the major disk operating systems available for licensing. A new system was written and released as TRSDOS 1.0, but it has bugs in it like all the new systems. These were corrected and the system was extended as it went through various updates.

Other companies came out with alternate operating systems for the TRS-80 computers, some of them compatible with TRSDOS and some not. Each gained some users. After a while, those TRS-80 owners who were considered expert came to respect LDOS from Logical Systems as a superior DOS. Radio Shack now sells it as an alternate for the Model III.

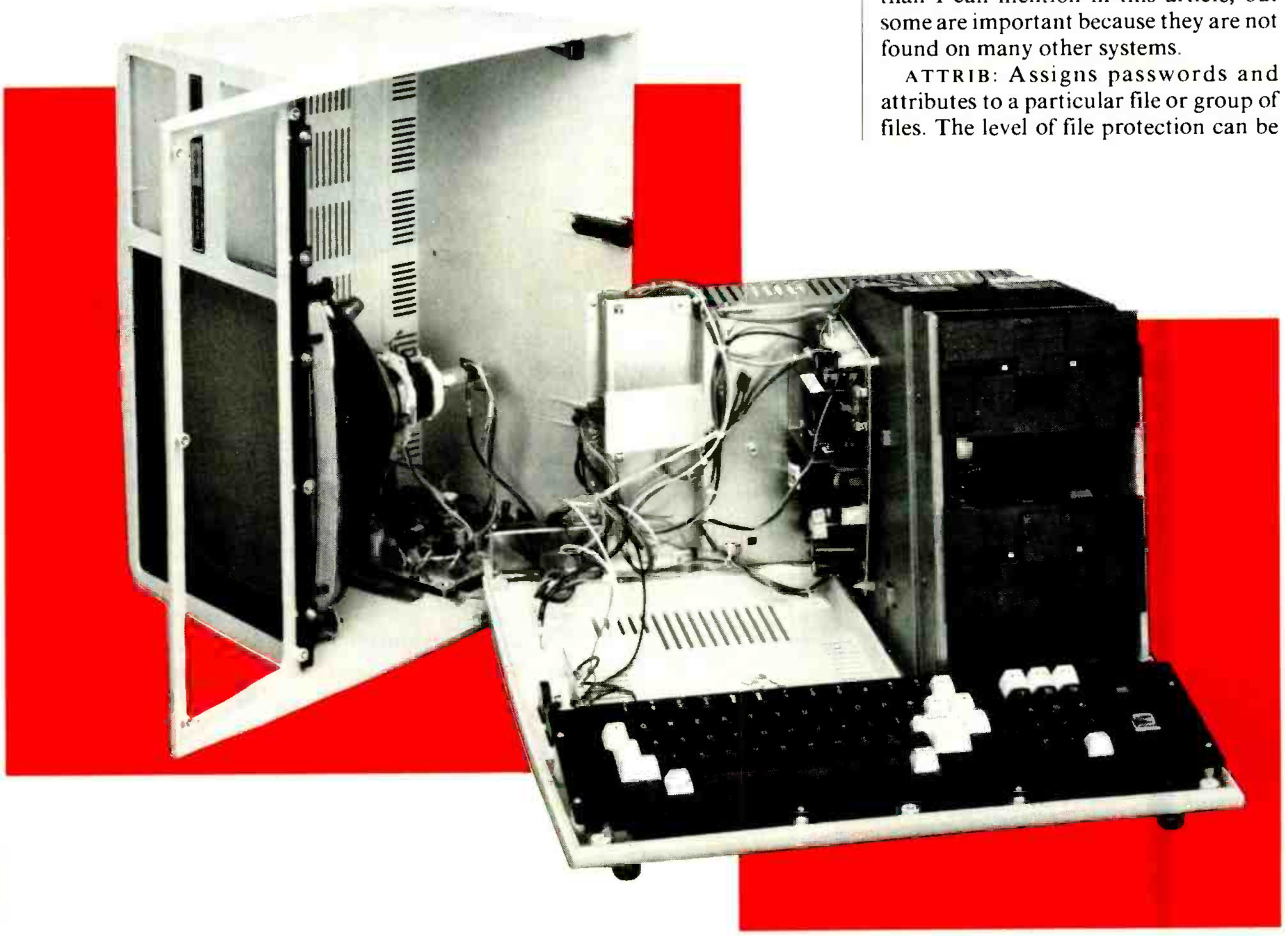
When it came to providing a new operating system for the Model IV, Radio Shack broke with its tradition and went to Logical Systems for a new version of TRSDOS that was based on LDOS. The result is TRSDOS Version 6.0, a really fine system. It has features that are found in very few personal computer operating systems.

Radio Shack has gone to a great deal of trouble to ensure compatibility with previous versions of TRSDOS and with LDOS. The version of TRSDOS used with the Model III is 1.3 and it is compatible with the Model 4. However, there are a few differences. An application program running under TRSDOS 1.3 prints larger and fewer characters on the screen than one running TRSDOS 6.0. This is because it is designed for the 64-character screen on the Model III. TRSDOS 1.3 commands work slightly differently than TRSDOS Version 6, but the differences are clearly explained in the manual.

The two versions of TRSDOS format disks differently. There is a conversion program on Version 6 called CONV to move files stored on a Version 1.3 diskette to a Version 6 diskette. This is not necessary in order to run Model III programs on Model 4.

TRSDOS 6.0 has many more features than I can mention in this article, but some are important because they are not found on many other systems.

ATTRIB: Assigns passwords and attributes to a particular file or group of files. The level of file protection can be



set to be restricted to a person who enters a password. Moreover, the protection can be set up in levels so that a password can only EXECUTE (Run) a program, READ a program, UPDATE a program, WRITE to a program, RENAME a file, or REMOVE a file. This kind of protection is usually only found on larger systems.

COMM: A built-in communications program that lets two computers talk to each other via a device, usually the RS232C serial communications. COMM lets the Model 4 be used as a terminal in communications and to transfer files to and from another computer. In addition it can be used to spool output from another computer to the printer. COMM also allows the computer to access Bulletin Board Systems Networks, and Electronic Mail Systems. While this type of thing is common, it is rarely built into an operating system. It is not only a money saver, but a great convenience that many users will appreciate.

The function keys F1 and F3 actually have many more possible functions

The Micro Color Computer

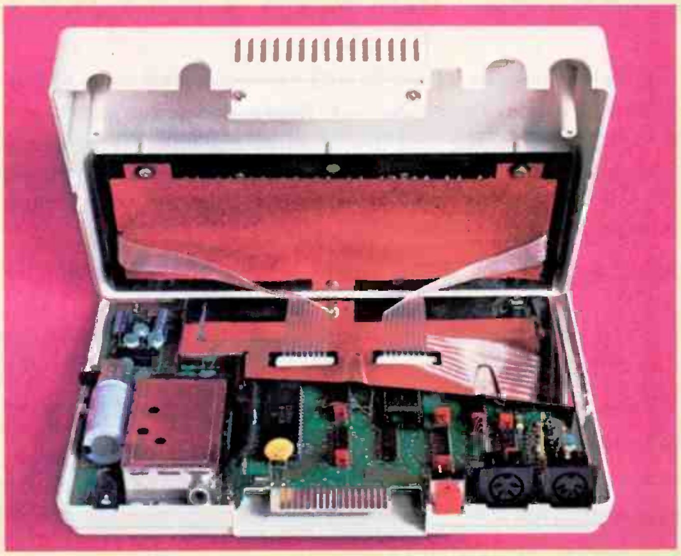
For a long time there has been a rumor that Radio Shack was about to come out with a new, low-cost, color computer. I asked about it during a recent trip to Fort Worth to see some other new models, but all I got from the Radio Shack people at that time was a smile.

One day shortly after I returned to home base, I got a phone call advising that I was about to receive a package "that I had asked about." I was as eager as a kid before Christmas, waiting for UPS to deliver that package. When it did arrive, I opened it with great expectation. Inside was a rare jewel, a little computer, 2" high by 8½" long by 7" wide, called the Model MC-10 "Micro Color Computer." It comes with an external power supply and a TV switch.

There is an excellent manual and a quick reference card to teach you how to run and program the little fellow. This is really a course in Micro Color BASIC, a dialect that is almost the same as TRS-80 Color Basic for the CoCo, the Shack's Color Computer. The keyboard has small keys (shaped somewhat like Chiclets), but they are large enough for most purposes. The keys cover the usual QWERTY characters, numerals and punctuation marks, plus cursor commands and graphics characters. There is a second shift level entered using the CONTROL key. With this level, you can perform single key BASIC commands inscribed above the keys. These include such commands as RUN, CONT, CLOAD, NEW, LIST, CLEAR, CLSD, PRINT, STOP, END, SET, RESET, READ, RESTORE, FOR, NEXT, STEP, INKEY$, INPUT, GOSUB, RETURN, IF, THEN, GOTO, SOUND, PEEK, and POKE. The trig functions and RND function are also available as single-key entries.

This is a color computer and can produce nine distinct colors. It can also produce sound under program control. In addition to the graphic characters, the MC-10 can use point graphics with a 64 by 32 grid. This is not very high resolution, but still good for such a small computer. It is like the dancing dog, which can not dance very well, but it is a wonder that he dances at all!

The MC-10 also has the capability of being connected to a tape recorder for data storage and through a serial port (DIN connector) to a serial printer. The Radio Shack TP-10 printer may be used. This is a 32-character, 4"-wide printer that's capable of printing all the MC-10 graphics characters. Further, the Radio Shack LP VII or LP VIII or the DMP-100, DMP-120, DMP-200, or DMP-400 printers may be used. You can also connect the MC-10 to the CG-115 or FP-215 Flatbed Plotters.



The MC-10 comes with only 3K of user memory, but there is a cover plate protecting a card edge connector that brings out an expansion bus.

I liked this small computer very much at the announced price of $119. ◇

through combinations of the CLEAR key and the function keys. This is used in the COMM program to control many communication application functions involved in "handshaking" between interconnected devices, COMM is the program that enables the Model 100 to download its information into the TRS-80 Model 4.

CONV: Converts the data files from a Model III diskette to a Model 4 diskette.

DEBUG: Enters, tests, and runs machine language programs for debugging. This is a very valuable function.

SPOOL: Establishes a FIFO (First-in, First-out) buffer for a device, usually a printer. It enables the computer to print data while other operations are performed on the computer.

FORMS: Another unusual and useful command in TRSDOS 6.0. It allows printing a form larger or smaller than a standard-size page. Another feature not often found in an operating system, but nice to have.

JCL: The TRSDOS Job Control Language is one of the most powerful features of the TRSDOS 6.0. It permits the writing of programs that perform a variety of functions such as FORMAT, and BACKUP and have TRSDOS run them when a single command is typed in. This makes the system much more "user friendly."

These features and many others cause people to applaud TRSDOS 6.0 as a major contribution to personal computing software. It not only provides a jumping-off place for new and better systems, it does it without obsoleting the large stock of TRS-80 programs already in the Library.

In addition to providing a selection of operating systems, Radio Shack has also provided a choice of langauges for every purpose. These include MBASIC, BASIC Compiler, and FORTRAN from Microsoft; CBASIC from Digital Research; Pascal from Alcor; Radio Shack Graphics BASIC (649 × 240 resolution); RM COBOL from Ryan McFarland; and an Assembly Language Development System including Macro Assembler.

Adding up the number of application programs, languages, and systems that are available for the Model 4 in TRSDOS 1.3, CP/M-80, and LDOS, this has to be one of the best-supported new computers ever released. In addition, Radio Shack has converted its line of business software into Model 4 format.

We say again, the Model 4 is really the TERRIFIC-80. —*Stan Veit*

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DATA CONVERTER FOR THE APPLE II

By Robert C. Nicklin

Part 2: Checkout, calibration, and use

LAST month, we discussed the principles of A/D and D/A conversion and described a converter for the Apple II. Here are the software and instructions needed to operate the converter.

Checkout & Calibration. Plug one end of a ribbon cable with DIP headers on each end into Port A at *SO4* on the interface adapter. Then, making sure the Apple computer is powered down, install the VIA in slot 5 of the computer. Plug the other end of the cable into a solderless-socket breadboard and use wire jumpers to connect D0 through D7 to ground at pin 11. Switch on the computer and wait for the prompt to appear on-screen. Measure the voltages at pins 50, 33, and 25 of the computer's bus connector; they should read +12, −12, and +5 V, respectively.

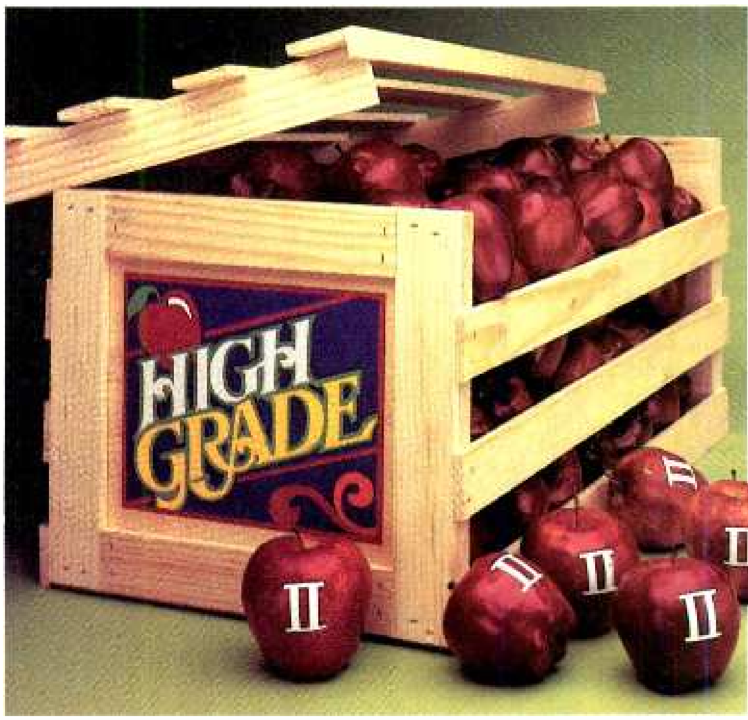
For the following discussion, the interface is assumed to be plugged into slot 5 of the computer and all data lines are grounded.

Enter and run Program 1 to test the input to Port A. Displayed on-screen should be a running column of 0s read in from Port A. One at a time, remove the data line jumpers from ground and note the change in status displayed on-screen. As each data line is ungrounded, it should display a 1 on the screen. If it doesn't, the interface adapter most likely isn't plugged into slot 5 of the computer and/or the program hasn't been correctly entered. If the problem still persists after making sure that the adapter is in slot 5 and the program has been properly entered, use a dual-trace oscilloscope to check the *IC7* delay circuit. For proper operation, the signal observed at pin 6 of *IC7* should be delayed by about 180 ns with respect to the signal at pin 1.

Remove the ground connections from D0 through D7 and load and run Program 2 to test the output. For Byte=0, there should be no voltage (0 volt) between each data line and ground; for Byte=255, each data line should be at +5 volts; for Byte=55, D0 through D7 should be 10101010, etc.

Load and run Program 3 to test control line CA2. Making measurements at *J6*, CA2 should be 0 V for PC=12 and +5 V for PC=14.

To test Port B, power down the computer and move the DIP cable to *SO3*. Repeat the above three tests, changing the POKE and PEEK addresses for DDRB and ORB as detailed in Table I. The PCR address doesn't change, but the values for PC change to 192 for 0 V and 224 for +5 V to operate CB2.



Having ascertained proper port and control operation, remove the ICs from the Data Converter assembly, power down the computer, and plug the 16-pin DIP cable into *SO3*, the Port B connector. Power up the computer and confirm that +12, −12, and +5 V are present at the appropriate IC socket pins. (Bear in mind that under these no-load conditions some non-power pins will measure high.) Having confirmed that the proper voltages are present at the appropriate pins, power down the computer, insert the ICs in their respective sockets (take care to observe proper orientation), and power up once again.

Connect a voltmeter to *J2* and ground the center connector of *J1* to begin testing the analog amplifier. Set the project's GAIN switch to 1 and adjust trimmer *R3* for a 0-V output. Set the GAIN switch to 500 and adjust *R3* for minimum positive output. To check calibration of the GAIN control, remove the short from across *J1* and replace it with a 10,000-ohm potentiometer connected across a D cell (use the wiper and one end lug of the pot to make connections to the converter circuit) to provide the dc signal input. Make up a table of input vs output for each of the six positions of the GAIN switch for use in making software corrections to compensate for nonlinearities in gain.

If you have access to an audio oscillator and an oscilloscope, feed sine waves into *J1* and monitor *J2* to observe that the amplifier has reasonably flat response from dc to 15 kHz.

Enter and run Program 4 to check D/A conversion. A voltmeter connected between DAC *J5* and ground should indicate 0 V when DB is 0 and 2.55 V when DB is 255.

Use Program 5 to generate a square wave whose pitch is controlled by the value of P for checking the audio amplifier. This square-wave signal can be observed at *J5* with a scope.

Program 6 sets DDRB=0 for all inputs for testing the digital I/O lines. D1 through D6 will float high while D0 and D7 are checked. The running display produced by this program will change according to whether D0 or D7 is shorted (see Table II).

A/D conversion is tested with Program 7. This simple diagnostic program is written in BASIC, which is slow enough to complete a conversion before being read. Results are continuously displayed on-screen. With *J1* grounded and the GAIN switch set to 1, the reading should be 0 on dc and about 127 on ac. Connect the pot/D-cell assembly to *J1* and slowly vary the setting of the pot (dc input level). The on-screen display should follow the changes. Make sure the −9-volt reference is present at pin 2 of *IC2*. A scope connected to TRIG *J6* should reveal CB2 going high for about one-third or one-quarter of the pulse cycle. Without this pulse, no A/D conversion is possible.

Set AC/DC switch *S2* to DC for ampli-

PROGRAM 1

```
100 REM     PROGRAM #1
120 REM     PORT A INPUT TEST
130 REM     6522 VIA IN SLOT 5
150 :
160 REM     SET PORT A DDRA
            FOR INPUT
170 D=0
180 POKE 49363, D
190 :
200 REM     READ ORA WHILE
            CHANGING
210 REM     JUMPERS FROM D0-D7
            TO GROUND
220 PRINT PEEK (49375)
230 :
240 FOR PAUSE = 1 TO 200: NEXT
250 GOTO 220
```

PROGRAM 2

```
100 REM     PROGRAM #2
120 REM     PORT A OUTPUT TEST
130 REM     6522 VIA IN SLOT 5
150 :
160 REM     SET PORT A DDRA
            FOR OUTPUT
170 D=255
180 POKE    49363,D
190 :
200 INPUT   "BYTE"; B
210 REM     OUTPUT BYTE TO
            PORT A
220 REM     TEST DO-D7 WITH
            VOLTMETER
230 POKE    49375, B
240 GOTO    200
```

PROGRAM 3

```
100 REM     PROGRAM #3
120 REM     PORT A CONTROL
125 REM     LINE CA2 TEST
130 REM     6522 VIA IN SLOT 5
150 :
160 REM     CA2 GOES LOW ON 12
170 REM     AND HIGH ON 14
180 :
190 INPUT   "PCR BYTE=?"; PB
200 POKE    49372, PB
210 GOTO    190
```

PROGRAM 4

```
100 REM     PROGRAM #4
120 REM     DAC TEST
130 REM     6522 VIA IN SLOT 5
150 :
160 REM     SET DDRB FOR OUT
170 POKE    49362,255
180 :
190 REM     SET CB2 HIGH SO DAC
200 REM     CHIP ENABLE IS LOW
210 POKE    49372,224
220 :
230 REM     OUTPUT DB TO DAC
            AR ORB
240 INPUT   "DAC BYTE=?";DB
250 POKE    49360,DB
260 GOTO    240
```

PROGRAM 5

```
100 REM     PROGRAM #5
120 REM     AUDIO AMP TEST
130 REM     6522 VIA IN SLOT 5
150 :
160 REM     SET DDRB FOR OUTPUT
170 POKE    49362,255
180 :
190 REM     SET CB2 HIGH SO DAC
200 REM     CHIP ENABLE IS LOW
210 POKE    49372,224
220 :
230 INPUT   "PAUSE BYTE=?";P
240 POKE    49360,0: GOSUB 290
250 POKE    49360,255: GOSUB 290
260 GOTO    240
270 END
290 FOR PAUSE = 0 TO P:
            NEXT: RETURN
```

PROGRAM 6

```
100 REM     PROGRAM #6
120 REM     DIGITAL I/O TEST
130 REM     6522 VIA IN SLOT 5
150 :
160 REM     SET DDRB FOR INPUT
170 POKE    49362,0
180 :
190 REM     GROUND D0 OR D7
            (4 WAYS)
200 PRINT   PEEK (49360)
210 GOTO    200
```

PROGRAM 7

```
100 REM     PROGRAM #7
120 REM     ADC TEST
130 REM     6522 VIA IN SLOT 5
150 :
160 REM     SET DDRB FOR INPUT
170 POKE    49362,0
180 :
190 REM     MAKE READ HIGH
            (WITH CB2)
200 REM     AND START
            CONVERSION
210 POKE    49372,224
220 :
230 REM     MAKE READ LOW
            (WITH CB2)
240 REM     PREPARE TO READ
            CONVERSION
250 POKE    49372,192
260 :
270 REM     READ ADC
280 PRINT   PEEK (49360)
290 :
300 GOTO    210
```

tude calibration. Apply the full potential from the D cell to *J1*. Assume this to be 1.46 V, the voltmeter will indicate 7.01 V with the GAIN switch set to 5. This means that gain is actually 4.80 (7.01/1.46), although the A/D converter actually "sees" 7.01 V. Measure reference voltage V_{REF} between *J3* and ground. Assume it to be 8.56 volts. With full scale for the converter being 255 for any V_{REF}, the A/D converter will produce 209 (7.01/8.56). Working backward, we find that V_{INPUT} = (A/D output/gain) $\times$ (V_{REF}/255). This means that conversion accuracy depends on voltmeter accuracy. Often, true V_{INPUT} isn't needed, since relative amplitude will be sufficient.

Frequency accuracy requires use of a frequency counter to set a square-wave generator to 1000 Hz (the actual frequency isn't important as long as it is known). Feed the square waves into *J1* and use Table III to run the A/D converter fast enough to digitize the waveform. The Apple monitor program can be used to "look at" the bytes in memory. Another way to do this is to use a short BASIC program written to PEEK the bytes onto the screen. In either case, count the number of bytes per complete cycle of the square wave and multiply by the frequency to obtain A/D conversion sampling rate. If the A/D timing bytes are changed, this frequency calibration can be performed and recorded for a range of digitizing rates.

Operation Under Assembly Language. For A/D or D/A at rates of less than 50 samples per second, such BASIC programs as those in Programs 1 through 7 are adequate. To realize rates up to 17,000 samples per second for A/D and output rates to 33,000 bytes per second with D/A, both converters must be operated with assembly-language programs. Table III is for A/D, while Table IV is for D/A code.

Operation of Table III code is similar to operation of Program 7. Port A DDRA is set for input with the A/D converter getting a high on its Read line via CA2 to initiate conversion. A loop of at least 20 μs allows the A/D section to convert the input signal. When the Read line goes low, via CA2, conversion

TABLE I—6522 VIA ADDRESSES, SLOT 5

Starting address	49360 ($CODO)
DDRA	49363
ORA	49375
DDRB	49362
ORB	49360
PCR	49372
ACR	49371

TABLE II—DIGITAL I/O TEST

D7	D6	D5	D4	D3	D2	D1	D0	Screen
0	1	1	1	1	1	1	0	126
0	1	1	1	1	1	1	1	127
1	1	1	1	1	1	1	0	254
1	1	1	1	1	1	1	1	255

TABLE III—ADC ASSEMBLY LANGUAGE

```
$9300   A9 00      START   LDA   $00
   02   A8                 TAY              INITIALIZE Y
   03   85 FE              STA   MEM        SET START OF DATA STORAGE—
   05   A9 88              LDA   $88        ALTER FROM BASIC
   07   85 FF              STA   MEM+
   09   A9 00              LDA   $00        MAKE PORT A ALL INPUTS
   0B   8D D3 C0           STA   DDRA
   0E   78 EA EA           SEI
   11   A9 0E      ADC     LDA   $0E        MAKE READ HIGH, START CONVERSION
   13   8D DC C0           STA   PCR
   16   A2 05              LDX   $05        GIVE ADC > 20 MICROSECONDS
   18   CA         WAIT1   DEX                 TO CONVERT
   19   D0 FD              BNE   WAIT1
   1B   A9 0C              LDA   $0C        MAKE READ LOW, PREPARE TO
   1D   8D DC C0           STA   PCR           READ ADC
   20   AD DF C0           LDA   ORA        READ ADC
   23   91 FE              STA   (MEM), Y   STORE DATA
   25   20 40 93           JSR   MSEC       DELAY BETWEEN SAMPLES
   28   C8                 INY
   29   D0 E6              BNE   ADC
   2B   E6 FF              INC   MEM+       PREPARE TO FILL NEXT MEMORY PAGE
   2D   A6 FF              LDX   MEM+       WITH DATA
   2F   E0 92              CPX   $92        CHECK FOR END OF MEMORY
   31   D0 DD              BNE   ADC
   33   58                 CLI
$9334   60                 RTS

$9340   A9 00      MSEC    LDA   $00        SET VIA TIMER 2 FOR ONE-SHOT
   42   8D DB C0           STA   ACR           TIME INTERVAL
   45   A9 E8              LDA   $E8        $03E8 GIVES ABOUT 1 msec
   47   8D D8 C0           STA   T2L           INTERVAL—POKE CHANGES
   4A   A9 03              LDA   $03              FROM BASIC
   4C   8D D9 C0           STA   T2H
   4F   A9 20              LDA   $20        TIMER 2 INTERRUPT FLAG MASK
   51   2C DD C0   WAIT2   BIT   IFR        IS FLAG SET?
   54   F0 FB              BEQ   WAIT2      IF NOT, THEN LOOP
   56   AD D8 C0           LDA   T2L        TIMED OUT—CLEAR FLAG
$9359   60                 RTS
```

TABLE IV—DAC ASSEMBLY LANGUAGE

```
$9200   A9 FF                LDA   $FF       SET UP PORT A FOR OUTPUT
   02   8D D3 CO             STA   DDRA         TO DAC
   05   A5 FE                LDA   FE        SAVE CONTENTS OF TWO ZERO PAGE
   07   48                   PHA                ADDRESSES USED FOR MEM AND MEM+
   08   A5 FF                LDA   FF              IN (IND), Y ADDRESSING
   0A   48                   PHA
   0B   EA                   NOP
   0C   A9 00       START    LDA   $00       INITIALIZE Y FOR (IND), Y MEMORY SCAN
   0E   A8                   TAY
   0F   85 FE                STA   MEM       START DATA READOUT AT $8800
   11   A9 88                LDA   $88
   13   85 FF                STA   MEM+
   15   EA                   NOP
   16   78                   SEI             MAKE DAC OUTPUT GLITCHLESS
   17   A9 0C                LDA   $0C       MAKE CA2 LOW TO TURN OFF DAC
   19   8D DC C0             STA   PCR
   1C   A9 0E                LDA   $0E       MAKE CA2 HIGH TO TRIGGER SCOPE
   1E   8D DC C0             STA   PCR          AND ENABLE DAC
   21   EA                   NOP
```

NOTE: CA2 GETS INVERTED BEFORE IT GETS TO DAC, BY 7416 HEX INVERTER

```
   22   B1 FE       DAC      LDY   (MEM),Y   DISPLAY MEMORY CONTENTS
   24   8D DF C0             STA   ORA          ON SCOPE
   27   20 50 92             JSR   DELAY
   2A   C8                   INY             DAC GETS ONE PAGE AT A TIME
   2B   D0 F5                BNE   DAC
   2D   E6 FF                INC   MEM+      MOVE TO NEXT PAGE
   2F   A6 FF                LDX   MEM+         TO CHECK FOR TOP LIMIT
   31   E0 92                CPX   $92
   33   D0 ED                BNE   DAC
   35   EA                   NOP
   36   58                   CLI
   37   C6 FD                DEC   NSCAN     HAVE N SCANS BEEN COMPLETED?
   39   A5 FD                LDA   NSCAN
   3B   D0 CF                BNE   START
   3D   EA                   NOP
   3E   68                   PLA
   3F   85 FF                STA   FF        REPLACE ZERO PAGE CONTENTS
   41   68                   PLA
   42   85 FE                STA   FE
$9244   60                   RTS
$9250   A2 02       DELAY    LDX   $N        DELAY BYTE
   52   CA                   DEX
   53   D0 FD                BNE
   55   60                   RTS
```

TABLE V—CLEAR MEMORY ASSEMBLY LANGUAGE

```
$9280   A0 00                LDY   $00       INITIALIZE Y FOR (MEM),Y
   82   A5 FE                LDA   FE        SAVE CONTENTS OF TWO ZERO PAGE
   84   48                   PHA                MEMORY LOCATIONS USED FOR
   85   A5 FF                LDA   FF           (IND), Y ADDRESSING OF
   87   48                   PHA                MEM AND MEM+
   88   A9 88                LDA   $88       START CLEARED AREA AT PAGE $88
   8A   85 FF                STA   MEM+
   8C   A9 00                LDA   $00
   8E   85 FE                STA   MEM
   90   A9 00                LDA   $00       BYTE TO FILL MEMORY
   92   91 FE       CLEAR    STA   (MEM),Y
   94   C8                   INY             FILL MEMORY
   95   D0 FB                BNE   CLEAR
   97   E6 FF                INC   MEM+
   99   A6 FF                LDX   MEM+
   9B   E0 92                CPX   $92
   9D   D0 F3                BNE   CLEAR
   9F   68                   PLA             REPLACE ZERO PAGE CONTENTS
   A0   85 FF                STA   FF
   A2   68                   PLA
   A3   85 FE                STA   FE
   A5   60                   RTS
```

TABLE VI—APPLE ADC LOCATIONS (SLOT 5 ASSUMED)

Address Hex	Decimal	Explanation	
$9300	37632	Start of ADC Assembly language program	
9306	37638	Set beginning of data storage pages $88-$91 (136-145)	
930C	37644	DDRA LOW $D3 (211)	DDRB LOW $D2 (210)
930D	37645	DDRA high $C0 (192)	DDRB HIGH $C0 (192)
9312	37650	READ HIGH (CA2 OR CB2)	START CONVERSION*
931C	37660	READ LOW	PREPARE TO READ CONVERSION*
9321	37665	ORA LOW $DF (223)	ORB LOW $D0 (208)
9322	37666	ORA HIGH $C0 (192)	ORB HIGH $C0 (192)
9330	37680	SET END OF DATA STORAGE MEMORY	
9346	37702	T2L BYTE	
934B	37707	T2H BYTE	
9359	37721	LAST OP CODE (90 BYTES)	

	low	high
CA2	$0C 12	$0E 14
CB2	$C0 192	$E0 224

TABLE VII—APPLE DAC LOCATIONS (SLOT 5 ASSUMED)

Address Hex	Decimal	Explanation	
$9200	37376	BEGINNING	
9203	37379	DDRA LOW BYTE (211)	DDRB LOW BYTE (210)
9204	37380	DDRA HIGH BYTE (192)	DDRB HIGH BYTE (192)
9212	37394	SET BEGINNING OF SCAN-PAGE 136 TO 145	
9218	37400	SET CA2 LOW (12)	SET CB2 LOW (192)
921D	37405	SET CA2 HIGH (14)	SET CB2 HIGH (224)
9225	37413	ORA LOW BYTE (223)	ORB LOW BYTE (208)
9226	37414	ORA HIGH BYTE (192)	ORB HIGH BYTE (192)
9232	37426	SET END OF SCAN (SCAN UP TO THIS PAGE)	
9251	37457	SCAN DELAY BYTE (0 TO 225)	
9257	37463	LAST OP CODE	
00FD	253	NUMBER OF SCANS BEFORE RETURN KEY IS CHECKED	

TABLE VIII—CLEAR MEMORY LOCATIONS (SLOT 5 ASSUMED)

Address Hex	Decimal	Explanation
$9280	37504	BEGINNING OF PROGRAM
9289	37513	SET HIGH BYTE, START OF CLEARED AREA
928D	37517	SET LOW BYTE, START OF CLEARED AREA
9291	37521	BYTE TO FILL MEMORY WITH
929C	37532	PAGE NUMBER FOR END OF CLEARED AREA —DON'T CLEAR BEYOND THIS (PAGE 146 MAXIMUM) —PAGE 146 ($92) MEANS $91FF IS LAST LOCATION THAT WILL BE CLEARED
92A5	37541	LAST BYTE OF PROGRAM

NOTE: $8800-$91FF ARE SET ASIDE FOR ADC, DAC. DATA STORAGE
$9200-$93FF ARE SET ASIDE FOR DAC, CLEAR MEMORY AND ADC ASSEMBLY LANGUAGE PROGRAMS

is latched so it can be read out from ORA. The sample is stored and a delay subroutine is called. The program determines if alotted memory is full; if it isn't, it sends a Read high for another conversion.

Operation of the D/A converter under the listing given in Table IV proceeds as in the BASIC listing in Program 7. Port A DDRA is set for output. A high on CA2 triggers a scope connected to *J6* and, after inversion by *IC4*, pulls low the D/A converter's Chip Enable line. A byte is then fetched from memory and sent to the D/A converter via ORA. The program then checks whether or not the memory specified has been scanned; if it hasn't, another byte is sent to ORA. After completing a set number of scans, the program returns to the routine that called it.

Table IV can be used to clear a specific block of memory before filling it with data from the A/D converter, or before storing the output from the D/A converter. Although memory clearing can be performed from BASIC, it's too slow for more than a 1K-byte block of memory used for repeated measurements.

Operation Under BASIC. The various assembly-language programs presented in this article are best used as subroutines called from a BASIC driver program. It's easy to set memory limits and data rates and change to the alternate port by POKEing new values into the assembly-language code. This permits use of the fast assembly-language routines without having to be familiar with assembly-language programming. The BASIC listings for Apple DAC, Apple ADC, and Clear Memory contain the three assembly-language programs discussed. Tables VI, VII, and VIII list the POKE values required to tailor the routines to your purposes.

These programs all assume you're using an Apple II Plus computer with 48K of user RAM and slot 5 in the computer. The memory map in Table IX reveals where everything is stored. If you're using a disk drive, you can keep the DOS from overwriting the machine-language program by booting the DOS, setting HIMEM:34815 and then loading the BASIC program. This protects operation by putting data storage and machine language above BASIC and below the DOS. Memory locations 34816 through 37375 are for data storage; 37376 through 37721 for the D/A, Clear, and A/D; and 37722 through 38399 for data or expansion.

The three assembly-language routines can be easily relocated, since except Apple ADC, they contain no absolute addresses. Because delay routine MSEC calls $9326 (memory location 37670) and $9327 (location 37671), Table III must be changed to fit the new location. If slot 5 in the computer isn't used, the correct VIA address for the slot must be POKEd.

Capturing Waveforms. The Waveform Program combines D/A, A/D, and Clear routines and illustrates use of the VIA and Data Converter. The purpose here is to capture an audio waveform and display it on the CRT screen of an oscilloscope.

Load the Waveform Program, connect a microphone to *J1* and a scope to *J2*, and set *S2* to AC. Sing a steady "o-o-o-h-h-h" tone into the mic and set the GAIN switch for a peak-to-peak signal level of less than 9 volts. Connect a lead from TRIG *J6* to the scope's trigger input and adjust the scope for a triggering. RUN the program while holding a note.

The computer will capture and display 1280 samples of the waveform. Since these samples are stored in memory, they can be SAVEd on disk, written to a printer, or plotted on a strip chart, or the waveform could be Fourier analyzed if desired.

With some minor changes in the BASIC program, 256 samples of each of 10 different waveforms could be captured and selectively analyzed. Alternatively, they could be plotted in HIRES with about a 25% loss in vertical resolution, on 192 vertical points for 256 from the A/D converter. ◇

TABLE IX—APPLE DATA CONVERTER MEMORY MAP

HEX		DECIMAL
$FFFF $C100	APPLE USES	65535 49408
$C0FF $C080	PERIPHERAL CARD I/O SPACE FOR 6522 VIA (8 SLOTS)	49407 49280
	APPLE USES	
$BFFF $9600	DOS	49151 38400
$95FF $935A	SPACE FOR MACHINE LANGUAGE PROGRAMS (MLP) OR CONVERTER DATA	38399 37722
$9359 $9300	ADC MLP	37721 37632
	80 BYTES FOR MLP	
$92A5 $9280	CLEAR MEMORY MLP	37541 37504
	40 BYTES FOR MLP	
$9257 $9200	DAC MLP	37463 37376
$91FF $8800	ADC/DAC DATA STORAGE (PAGES 136-145)	37375 34816
$87FF $6000	FOR BASIC PROGRAMS (SET HIMEM:34815)	34815 24576
$5FFF $2000	HIGH RESOLUTION GRAPHICS	24575 8192
$1FFF $0C00	FOR BASIC PROGRAMS	8191 3072
$0BFF $0000	APPLE USES	3071 0

Guidelines to Buying Impact-Type Printers

By Al Burawa

IT'S not surprising that a printer often heads one's list of most desirable computer peripherals. After all, most people want hard copies of their work.

For most applications, the choice of a printer comes down to an impact type rather than a thermal, ink-jet or other form of nonimpact design. So we will focus here on this most popular class of printers, which has two categories: fully-formed-character printers and impact dot-matrix printers.

Letter-Quality Printers. If you want print quality that is indistinguishable from that of a typewriter's characters, the popular daisy-wheel printer will likely come to mind, even though there are other methods used to achieve a similar goal. The daisy wheel is simply a flat wheel with individual-character spokes attached to it. When a key on a keyboard is pressed, it causes the wheel to rotate to the spoke that has the selected letter or number, and a hammer strikes the spoke so that the character hits a carbon ribbon against paper to make the printed impression.

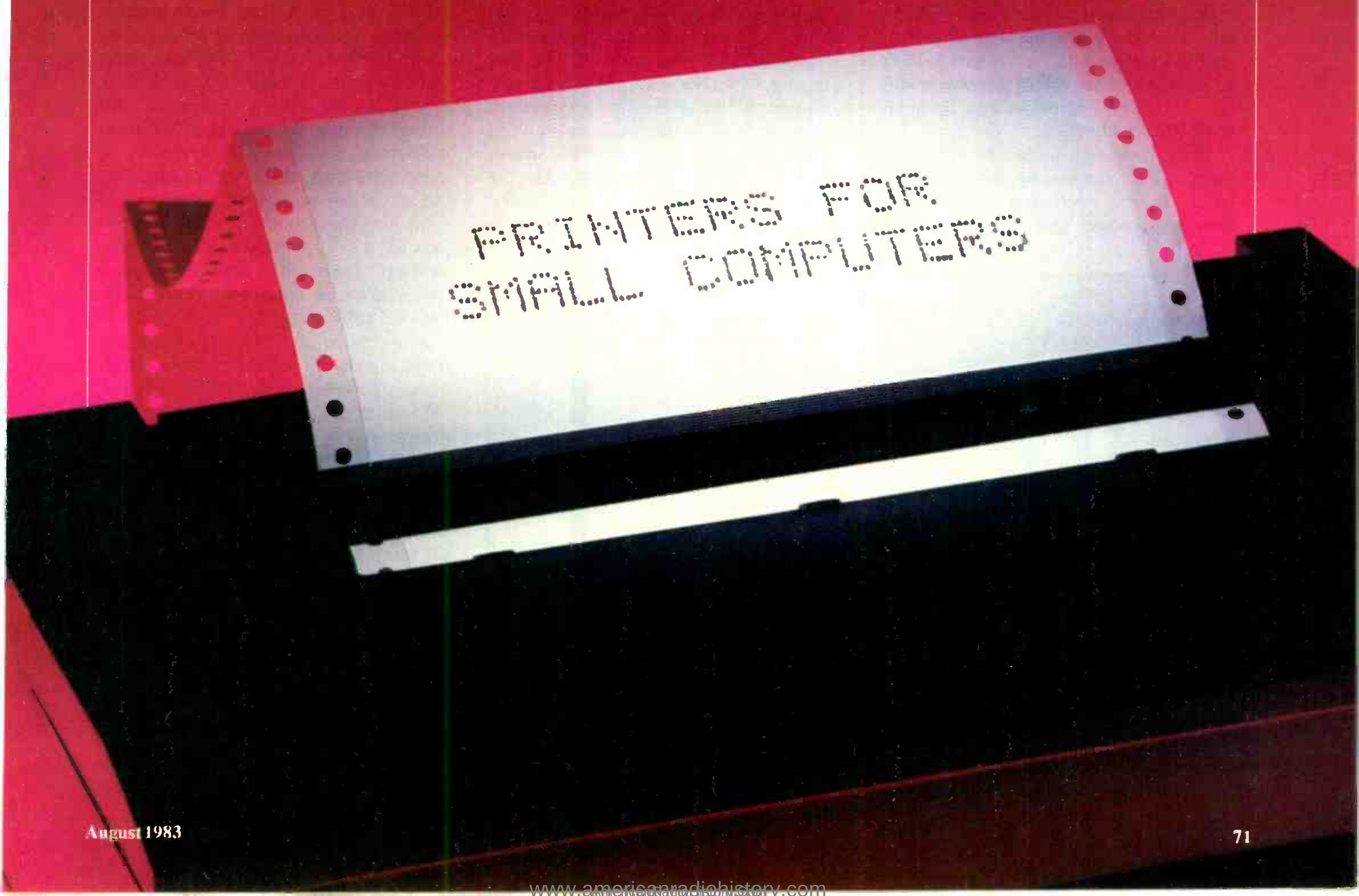
Should you wish to produce hundreds of letters, making them appear as if a secretary had typed each one individually, then a letter-quality printer is the way to go. The price you pay for this is higher cost and lower speed than dot-matrix printers—plus giving up special graphics.

Formed-letter printers such as Diablo, Qume, NEC, and similar models could have a suggested retail price in the neighborhood of $2500; though others, such as Smith-Corona's model is below the $1000 mark. Substantial discounts are commonly offerred, though. In contrast, the low end of impact dot-matrix printers is around $250. For typesetting speed, formed-character printers generally range from about 12 cps (characters per second) to 60 cps, whereas dot-matrix printers usually operate at speeds from 50 to 200 cps.

Formed-character printers provide sharp, continuous characters, like those you're now reading, in a variety of sizes and fonts (styles). The actual print element is very similar to that found in the standard office typewriter. In fact, a formed-character computer printer can be thought of as an electric typewriter minus keyboard. (Printing commands are generated by the computer, either directly from the computer's keyboard or from software.) And, as in typewriters, the elements that actually strike characters on paper are on metal or plastic "slugs" affixed to the ends of springy lever arms. In all, the daisy wheel has 96 slug/arm assemblies that radiate from a central hub, enough for the entire upper- and lower-case alphabetic, numeric, punctuation, and special ASCII character set.

An alternative to the daisy wheel is the print "thimble" element used in NEC Personal Computer Division's popular "Spinwriter" series of printers. Character slugs are arranged on the thimble's lever arms in much the same manner as on the daisy wheel, except that there are two characters per slug, one above the other. The lever arms are "folded" so that the entire assembly takes on the shape of a thimble. Alternate characters on each slug/arm assembly are accessed by a shift command similar to that used in typewriters.

To our knowledge, all print thimbles are made of highly durable plastic that's capable of delivering a useful life of several tens of millions of print impressions. Daisy-wheel print elements can be made of either metal or plastic, the latter with about the same useful life as for the thimble. Metal daisy wheels, costing several times more than plastic



units, are designed mainly for highly intensive use, where they'll be in operation the entire business day.

Although the formed-character printer isn't capable of providing the graphics capability available with even the lowest-level dot-matrix printer, it has one very appealing advantage. That is the ability to provide an almost unlimited variety of sizes and styles of type simply by changing from print element to print element. The variety is limited only by what's available in the marketplace.

Daisy-wheel and thimble formed-character printers operate in the same manner to strike characters onto paper. Since they're invariably impact mechanisms, both have their character slugs struck from behind by a "hammer" that forces character impressions onto the paper through an inked or carbon ribbon as previously cited. In the case of the thimble whose alternate character is to be struck, a shift operation occurs.

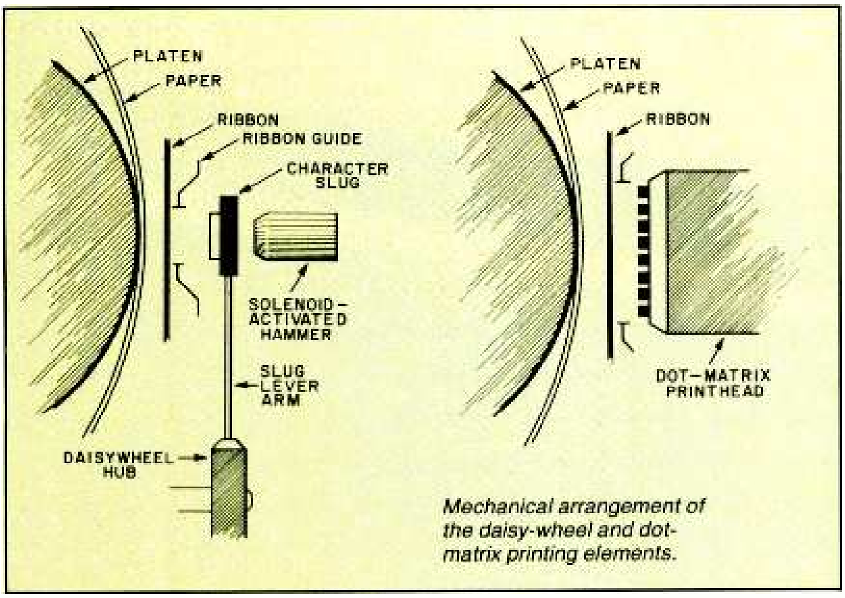
Formed-character printers generally feature full-page-width (80 columns on 8½"-wide paper), although many models are able to accommodate 14"-wide paper for printing up to 132 columns horizontally. Except in the lowest-priced models, selectable pitch is common. (Pitch defines the number of printable characters per horizontal inch—pica is 10, elite is 12, and micro is 15 to 17 characters per inch.) To obtain different pitches, printwheels or thimbles must be interchanged.

With formed-character printers, there is a choice among different fonts (print styles), including a variety of standard Roman, italic, and even bold faces. The fonts can even be mixed in a single letter or document, though the procedure can be time-consuming, since each change requires that the printwheel or thimble be changed.

Being able to change pitch and font is only part of the flexibility picture for formed-character printers. Using other options, available with hardware and/or software, you can give a report or letter a professional printed appearance, especially when variable pitch and font changes are used in conjunction with proportional spacing, left and right margin justification, and proper hyphenation. (In proportional spacing, characters are assigned only enough horizontal space for neat, legible printing. Lower-case characters *i*, *l*, and *1* are assigned narrower space than such standard-width characters as *a*, *b*, *c*, etc., while the extra-wide *M*, *W*, *m*, and *w* are assigned commensurately more space. Additionally, spaces between words can be varied to suit the demands of the justification and proportional-spacing parameters.) A finished printed document, then, could have an appearance very similar to the professionally printed copy on this page.

As a rule, formed-character serial printers churn out copy at a much slower speed than is possible with the typical dot-matrix printer because certain laws of physics must be observed. During printing, whenever a slug is to be struck to print a character, the appropriate slug must be spun into position between hammer and ribbon. Then the entire print mechanism, printwheel plus the mechanical hammer/carrier assembly, must be brought to a full stop and pause to permit settling. Only then can the hammer be activated to make the character impression. This entire procedure must be repeated for *each* character to be printed. Without the pauses between strikes, printed characters would smear, and the print element itself might be damaged.

Every pause to strike a character slug consumes time that reduces printing speed. The length of each pause is a function of the momentum of the movements in the entire printing mechanism as it sweeps horizontally across the paper in its track. More important, much time is consumed by having to rely on only the natural springiness of the print element's slug arm and the mass of the slug/arm assembly to return the character slug to its neutral position.



Mechanical arrangement of the daisy-wheel and dot-matrix printing elements.

Dot-Matrix Printers. In dot-matrix printing, an entirely different approach to character formation is used, almost totally unrelated to that used in the traditional typewriter and formed-character printer. The only similarity to the formed-character printer is that it strikes characters on paper by impact. (There's also a *thermal* dot-matrix approach that doesn't require impacting.)

To begin with, there's no multitude of print slugs used. Instead, the 96 or more printable characters are all produced by a wire or needle matrix of so many dots wide by so many high (5×7, 5×9, 9×9, or any other combination). Although the matrix might be specified as consisting of so many dots wide by so many dots high, this *doesn't* mean that the actual dot-matrix printhead has 35 print pins for a 5×7 matrix, 45 print pins for a 5×9 matrix, etc. Actually, modern dot-matrix printheads have only one or, at most, two vertical columns of print pins.

As a rule, for a dot-matrix printer, the fixed matrix for each printable alphabetic, numeric, punctuation, special, and block graphics character is programmed into one or more ROMs resident in the printer. A number of recently introduced dot-matrix printers offer a wide choice of characters, including several international character sets. For the bit-graphics mode in which each dot can be individually selected (instead of being preprogrammed into a ROM), a feature currently exclusive to dot-matrix printers, the vertical element of the matrix is fixed, but any number of dots can make up the horizontal element, such as $9 \times n$, where n can be any number up to the maximum that can be printed across the page. Text characters could also be generated in the graphics

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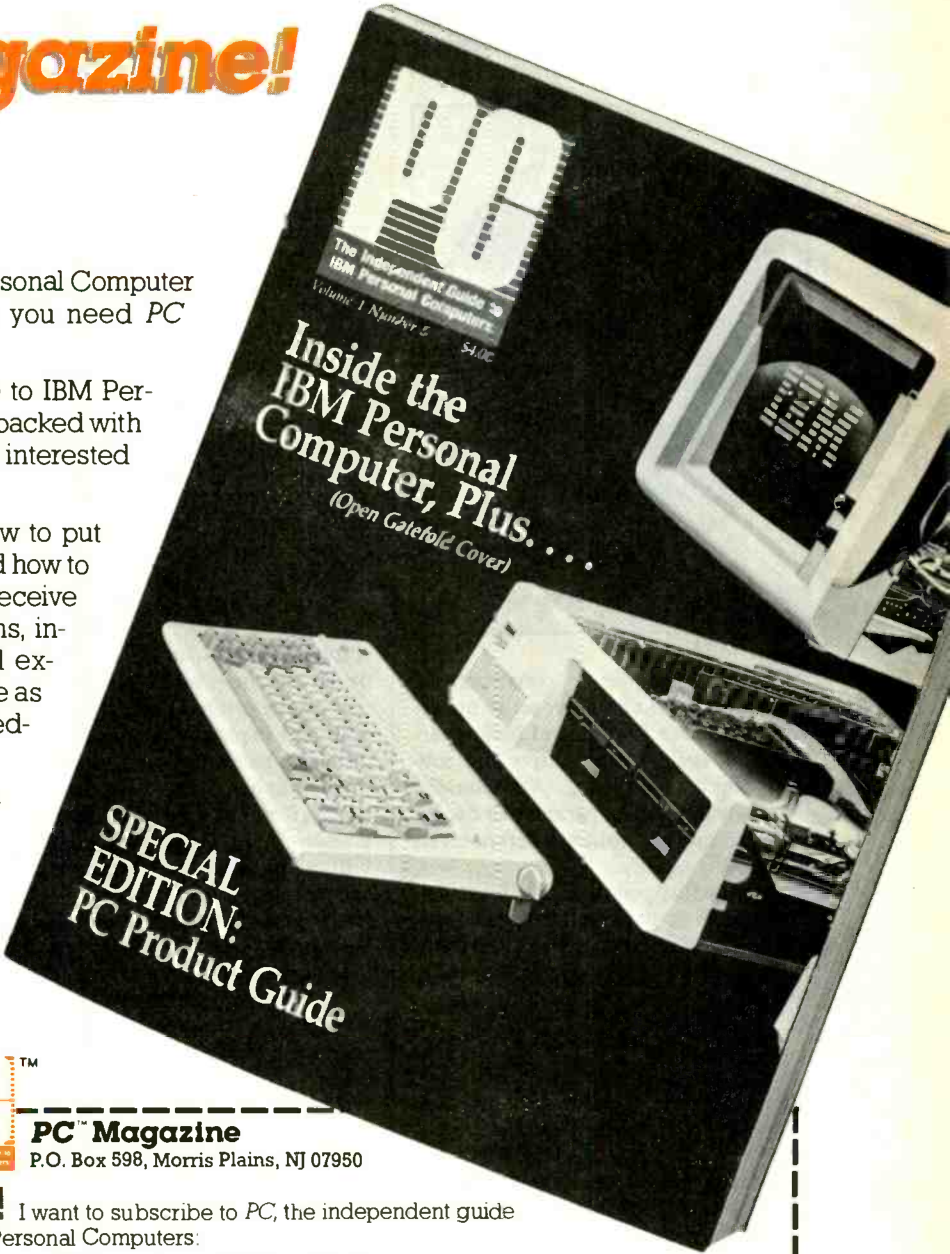

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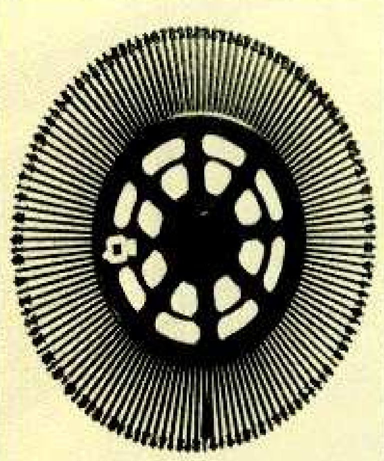
mode, but since each would have to be constructed as needed, this would be very time-consuming and would require slow single-direction printing.

Virtually any character, text or graphic, can be generated and printed in a matrix of dots, provided the matrix is large enough. In a 9 × 7 matrix, for example, it's possible to construct the standard ASCII character set in upper- and lower-case Roman and italic characters as well as superscripts and subscripts and underlining. Additionally, by controlling other parameters during printing, one can obtain different levels of legibility quality.


A Qume 130-char. daisy wheel.

Data-quality printing is the least legible, revealing gaps between the dots. However, data-quality printing is still extensively used in noncritical applications because its basic advantage is its high-speed throughput.

Moving up in legibility, we come to so-called "correspondence" quality dot-matrix printing. Here we find each character is more or less continuous, with no gaps between the dots. Correspondence-quality characters have an unfinished, slightly ragged appearance, though they're a vast improvement over data-quality characters. To obtain this level of quality, each character is struck more than once (usually twice to fill in the gaps) as the printhead sweeps across the paper. Consequently, printing in correspondence quality is slower than for data-quality printing by as much as 50%.

For maximum legibility, some of the latest dot-matrix printer models feature a mode called "near-letter-quality" (NLQ) printing. As the name implies, characters generated in this mode are generally continuous and therefore much less ragged in appearance than in the correspondence-quality mode. At first glance, they could almost be taken as having been generated by a formed-character printer, the only immediate giveaway being the unavoidable slight raggedness of descenders for the *g*, *y*, and *j*. As it's improved, this mode will probably become acceptable for even letter and report writing that have exclusively been the province of formed-character printers.

Combining near-letter-quality printing with the capability of mixing in graphics without having to change printers will further add to the appeal of the dot-matrix printer in the future. Of course, to obtain near-letter-quality printing, one must sacrifice something. In this case, it's printing speed, which may be as little as 25% of the speed obtainable with the same printer in the data-quality printing mode, since several passes are required to provide the desired printed dot density.

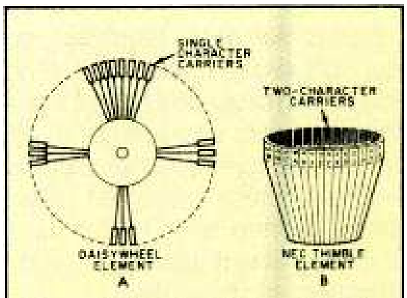
Aside from providing different levels of legibility, dot-matrix printers offer another feature that greatly adds to their appeal. That is the ability, under software control, to change pitch and density of the print. Typically, characters can be printed out condensed, normal, and expanded, representing three different pitches. Furthermore, in all three pitches, they can be double-struck, emphasized, or emphasized double-struck. Depending on the capabilities built into any given printer, you can have at your command a range of fonts/sizes/densities for type that can't be matched by any typewriter and few, if any, formed-character printers. Not all dot-matrix printers currently on the market offer this full range of facilities, of course. And even among those that do, one might offer these standard, while another might provide them as extra-cost options.

With dot-matrix printers, you have a much wider variety of types and models from which to choose. For a minimal investment of, say, $100 or less, you can choose a partial-page-width (20 to 40 columns horizontally) nonimpact *thermal* printer. This miniature model is an excellent companion for the compact battery-operated portable computer and, in some applications, for a desktop computer. However, if you plan to use your system for word processing or other serious applications, a full-page-width printer capable of printing 80 to 132 columns would be a much more practical choice.

Full-page-width dot-matrix printers can be obtained with a thermal printing mechanism but without most of the bells and whistles available in more expensive printers at relatively low cost. Bear in mind, however, that the specially treated paper for thermal printing may not be readily available in your area and that it's more costly than ordinary paper.

A full-size *impact*-type dot-matrix printer is preferable for all-around data/word processing and printing of computer graphics. This category has the broadest range of models available, at prices from as low as $250 on up to and beyond $2000. Almost all such printers feature the same or similar basic printing mechanism; so how much you pay for a given model will depend on what you're looking for in terms of speed, versatility, reliability, operating convenience, etc. As a rule, the faster, more versatile, and convenient a printer is to operate, the greater its cost.

A completely different design approach and different materials are used in the dot-matrix printing scheme. Consequently, many of the constraints imposed by formed-character printers are eliminated or dramatically reduced, making it possible for the dot-matrix printer to operate at much faster printing speeds than is possible with the typical formed-character printer.



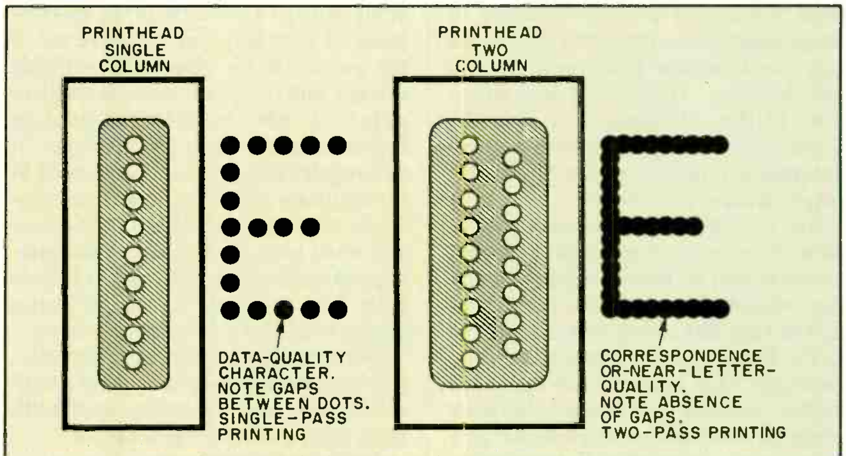
Formed-character printing elements.

To begin with, there are no spinning character slugs in the dot-matrix printer. Therefore, the only positioning motion is the horizontal sweep of the print head across the paper. Pauses occur only when a carriage-return/line-feed or line-feed-only operation is encountered in the drive data coming from the computer during the uninterrupted sweep. Very small and lightweight pins in the printhead are selectively "fired" and withdrawn at lightning speed to form letters. Even though the printhead is in motion, therefore, there's no time for the dots to smear as they're being printed.

Elimination of a spinning print element and pausing for settling time and striking, plus the fact that the print pins are *power* fired and retracted, make it possible for the dot-matrix printer to operate at speeds up to 400 cps in the most expensive models. For moderately priced printers, speed is more like 100 to 200 cps, which is two or more times faster than that available with very expensive formed-character printers. Even low-end economy-priced dot-matrix printers offer speeds in a range between 60 to 150 cps.

The speed specification for a dot-matrix printer can be misleading. Virtually all dot-matrix printers that have been introduced into the marketplace during the past few years are designed to operate at two or three speeds, depending on the print function activated. The fastest specified printing speed is for standard single-pass "data-quality" printing, in which dots are printed with blank space between the dots.

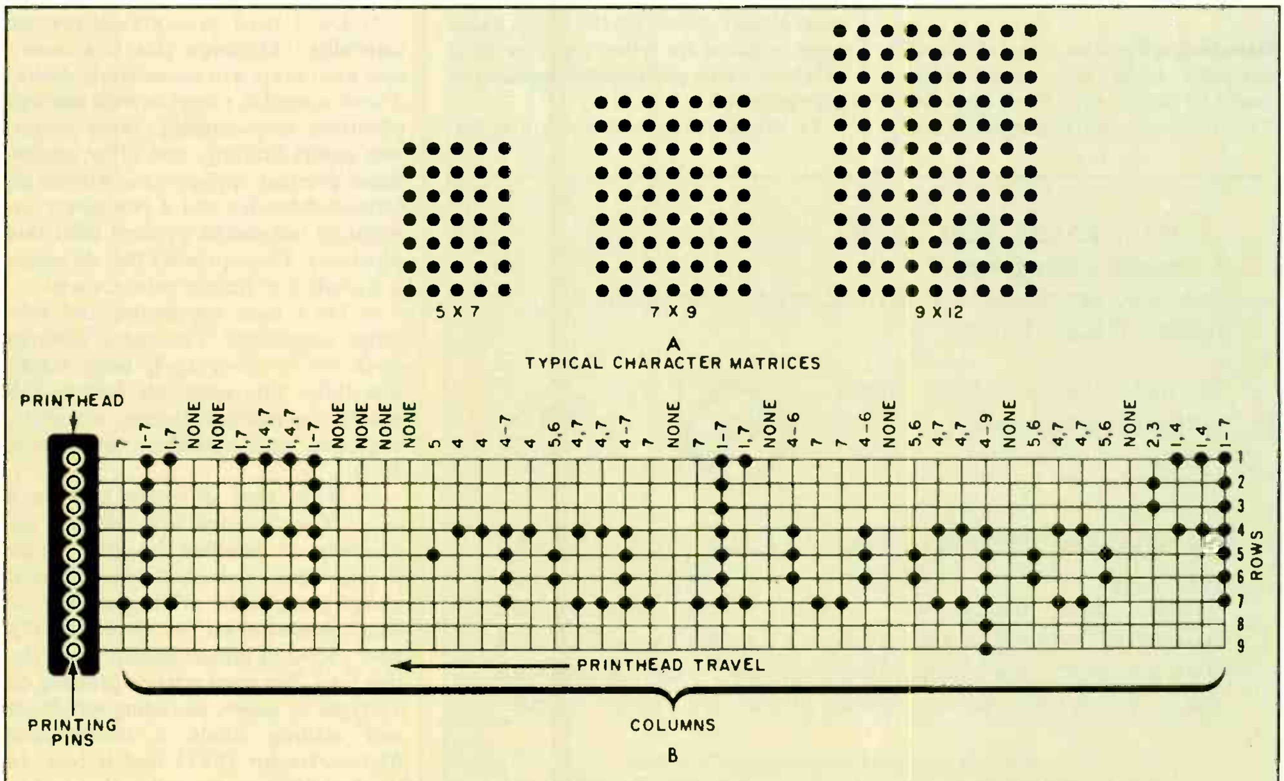
So-called "correspondence-quality" printing, introduced a few years ago to improve legibility, is achieved with two-pass (sometimes called "overstriking") printing, which fills the normally blank spaces between the dots with more dots to form more or less continuous characters, though actual printed characters will have a somewhat ragged, unfinished appearance. Operating a dot-matrix printer in the correspondence-quality mode usually halves the speed.



How better quality is obtained in dot matrix by two passes.

More recently, so-called "near-letter-quality" printing, in which printed characters have a more finished appearance, has been introduced. This level of printing quality can be achieved in either of two ways. In older model printers, it is obtained with a multiple-pass technique, each pass reducing the speed commensurately. For example, if four passes are required to achieve near-letter-quality printing in a 200-cps printer, speed will be only 50 cps. A more efficient technique is used in the newest printers, which have printheads with two separate columns of print pins that permit high-density-dot printing in the two-pass mode, only halving the speed obtained with data-quality printing.

Other factors govern how fast a printer can operate, too. For example, defeating the bidirectional printing capability, now more or less standard in new dot-matrix printer introductions, wastes time in returning the printhead from the right margin to the left margin. Also, you should be aware that printing graphics isn't as fast as alphanumerics, punctuation, and special characters.



Dot-matrix printhead has a single vertical column of printing pins that are selectively "fired."

Most dot-matrix printers operated in the graphics mode are slower than in the text mode because printing is in only one direction. There are a few exceptions to this, of course. For example, Centronics recently introduced a line of dot-matrix printers capable of printing graphics bidirectionally.)

The cost of a printer is directly related to the number of precision mechanical parts that go into its design. Oddly, the very complex electronic portions of printers are dirt cheap when compared to the high-precision metal and plastic elements. This accounts for the much higher demand for formed-character printers, which have a much higher precision-parts count than is required in the dot-matrix printer. Each of the mechanical elements in the formed-character printer must be machined to very close tolerances, at a very high cost.

In contrast, the dot-matrix printer is a relatively simple mechanical but complex electrical device. Its relatively few precision mechanical parts are contained in the printhead and linear head-positioning/track assembly. Considering that a much greater number of mechanical elements are used in the typical printing assembly of a formed-character printer than there are in an entire dot-matrix printer, it's not difficult to understand why the latter is so much less expensive.

Selecting a Printer. Your choice of a particular make and model printer should be based on an intelligent study of your current and future needs and a study of what's available in the marketplace. If your major or exclusive use of the printer is for generating mailable letters and/or professional-quality printing, plan on a letter-quality formed-character printer. However, if you require fast printing speed, such as for regularly typing hundreds or thousands of mailing labels at one time, or you must keep hard copies of accounting and financial records, or you wish to print out graphics, etc., your better choice would be a dot-matrix printer.

For strictly home use, the dot-matrix printer is perhaps best because of its relatively low cost, versatility, and sufficient print quality for general use.

Let's detail the important factors you must consider when it comes time to make your buy decision. Make up a master list as follows:

1) Do I need letter-quality printing or will data- or correspondence-quality printing suffice? If your needs are exclusively for letter and report writing, plan on a formed-character printer; otherwise, specify a dot-matrix printer. Bear in mind the differences in print quality obtainable at different price levels. If you need high-quality legibility, note this alongside your dot-matrix entry. Remember, too, that a number of recently introduced dot-matrix printers are capable of generating near-letter-quality printed characters that will almost always suffice for the high-quality copy required for letter/report writing in which a true professional appearance isn't essential.

2) What is my printing volume? Answer "light" if your printing needs are infrequent and usually limited to 10 pages or less per session. For strictly nonprofessional home use, figure your printing volume to be light. Answer "moderate" for normal daily business office use in which 100 to, say, 300 letters, memos, and envelopes are to be printed daily. Answer "heavy" for more intensive use, as in daily printing out of large volumes of mailing labels and in word processing, where the printer will be going for 35% or more of the time in an eight-hour day.

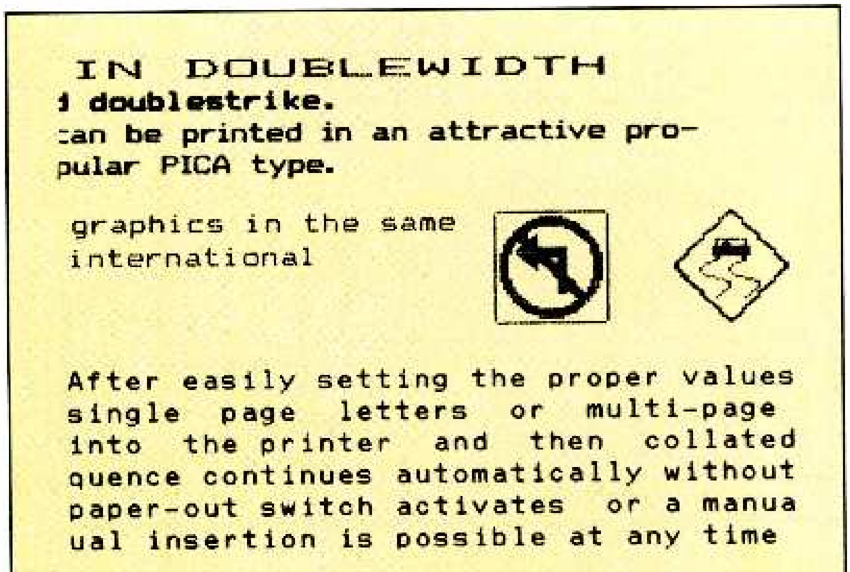
3) What printing speed do I need? For occasional light printing volume, any printer capable of churning out copy at even the slowest speeds will suffice. For moderate volume, be conservative and note 75 cps or more. For heavy volume, plan on a minimum of 150 cps.

4) Do I need variable pitch? If you do, don't think you *must* spring for an expensive formed-character printer. Most dot-matrix printers offer selectable expanded, normal, and condensed characters, without having to change the printhead. This feature will frequently be enough to fill your printing needs. Also, some of the new computers that feature bit-addressable graphics capability will allow you to custom design and program in one or more user-callable character sets on a compressed or expanded matrix format.

5) Do I need proportional-spacing capability? Although this is a nicety that most users will instinctively desire, it's not essential, except in such rare applications as publishing, fancy corporate report drafting, and other professional printing applications. Almost all formed-character and a few newly introduced dot-matrix printers offer this capability. Those printers that do usually include it at little or no extra cost.

6) Do I need superscript and subscript capability? The same remarks given for 5) above apply here, except that those who need this feature will usually be mathematicians, scientists, engineers, and publishers and report writers.

7) What kind of paper feed do I need? If you're going to be printing exclusively on pin-feed fan-fold printer paper, ordinary pin-feed will do. But if you're going to be printing mainly on single sheets (called "cut-sheet paper"), your choice of printer should have friction feed. For most reliable printing on all types of paper, including envelopes and mailing labels, a combination friction/tractor (F/T) feed is best. In the past, this was an option that had to be added to the basic printer, usually at



At top are print samples from an Epson FX printer. Below is a near-letter-quality sample from a Centronics Model 353.

high cost. However, more and more printer manufacturers are beginning to offer friction/tractor feed as a basic part of their products at no extra cost.

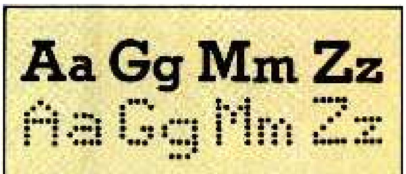
8) Do I need graphics capability? If your answer to this question is "yes," plan on restricting your choice to the dot-matrix printer category. Be aware that not all dot-matrix printers are capable of printing out everything that can be displayed on a computer's video display screen on a dot-for-dot basis. Some printers are able to print only the "block" graphics characters contained in preprogrammed ROMs inside the printers. Unless a manufacturer specifies that his product can print dot-addressable graphics, assume it can't.

9) Do I need alternate character sets? This question applies exclusively to dot-matrix printers, since all formed-character printers by nature of their interchangeable printwheels or thimbles are inherently capable of alternate character set selection. With dot-matrix printers, one doesn't pop out one head and replace it with another to obtain a different character set. Alternate character fonts must be obtained with the existing matrix head, using software, which may be in preprogrammed ROMs inside the machines themselves. Some of the newest dot-matrix printers on the market come standard with up to eight different character sets that can be selectively switched in and out as desired. Others have on-board sockets into which optional character-set ROMs can be plugged and called at will from software.

10) How much should I pay? This question usually tops the uninformed prospective buyer's list. In practical terms, it should be way down on the list, as it is here, because the answer will be based on the answers to all the preceding questions. It would be extremely foolhardy—and expensive—to let budgetary considerations overshadow your needs. Don't plunge in and choose an inexpensive printer that isn't capable of meeting all your current needs, much less leave room for growth, or an expensive full-featured printer with features you'll never use. Such a move will prove costly in the long run, since it won't be long before you have to trade up anyway. By the same token, buying a very fast full-featured printer with lots of bells and whistles you'll never use will prove costly right at the dealer's counter.

The best advice we can give for choosing a printer is: Select what you need. If you require a model that's too costly for your present budget, it's better to wait a few months, socking away a few extra bucks until you have enough to buy the model that best suits your needs, than to make a hasty purchase that won't satisfy you.

For the business office, keep in mind that it's not necessary to buy a printer for each computing station, since it's a rarity for every station to require printouts at the same time. In fact, under ordinary data- and word-processing circumstances, a printer will be idle more than 75% of the time! Therefore, you can plan your printer purchases with station sharing in mind. You have two choices here. The simpler choice is to reserve one of the several stations for basically print-only operations. The alternative is to have two or more computing stations *share* one printer, without having to install special—and expensive—multiple-user hardware and software. This latter approach is implemented by installing an optional switching box between the printer and sharing stations. Most such switching accessories offer print buffers, standard or optionally, to ensure efficient word/data processing.



Formed and dot-matrix letters.

With the first approach, the computer/printer station might be idle for long periods of time. The second approach is more practical because all stations can be active simultaneously for processing, and there's no need to have operator shuffling from one station to another.

Other Considerations. Printers connect into a computer in either of two ways: parallel (Centronics) or serial feed (RS232C). In most cases, the parallel interface is built into the printer, while the serial interface electronics is optional even though the printer has a plug-in facility on the back marked accordingly. Perversely, most computers come with a serial port, but require an optional parallel port to be added. Accordingly, the user will often have to spend extra money to get his printer up and running. Bit-parallel interfaces transfer data a word at a time, while bit-serial runs bits one character at a time. Consequently, a parallel-interface setup is a speedier one.

Most printers contain 1K to 2K of RAM buffer memory to store incoming data that's being received too fast for the printer to handle. Buffer memory can be expanded, of course, either by an external printer buffer or, in some cases, with an internal board, if you regularly dump a lot of copy from the computer to the printer.

All printers aren't alike, though most share many similar features. For example, low-cost impact dot-matrix printers often feature 5×7 dot matrix. If it has a lower-case facility, the letters won't produce true descenders, so that the bottom of, say, the letter "g" will be in line with the bottom part of, say, the letter "b." Perhaps this is good enough for you, given the savings in money, but you should know what you're going to get in return.

Is the paper drive a friction or tractor type? The former uses roll paper that's less costly, while the latter will enable you to print accurately and automatically on a given sheet of fan-fold paper or on mailing labels. Some printers come with both facilities at no additional charge.

Among other considerations are: the paper width the printer can handle, number of copies it can make, paper "out" alarm, addressable tabbing, overall dimensions, compressed and expanded print, and dot-addressable graphics provisions.

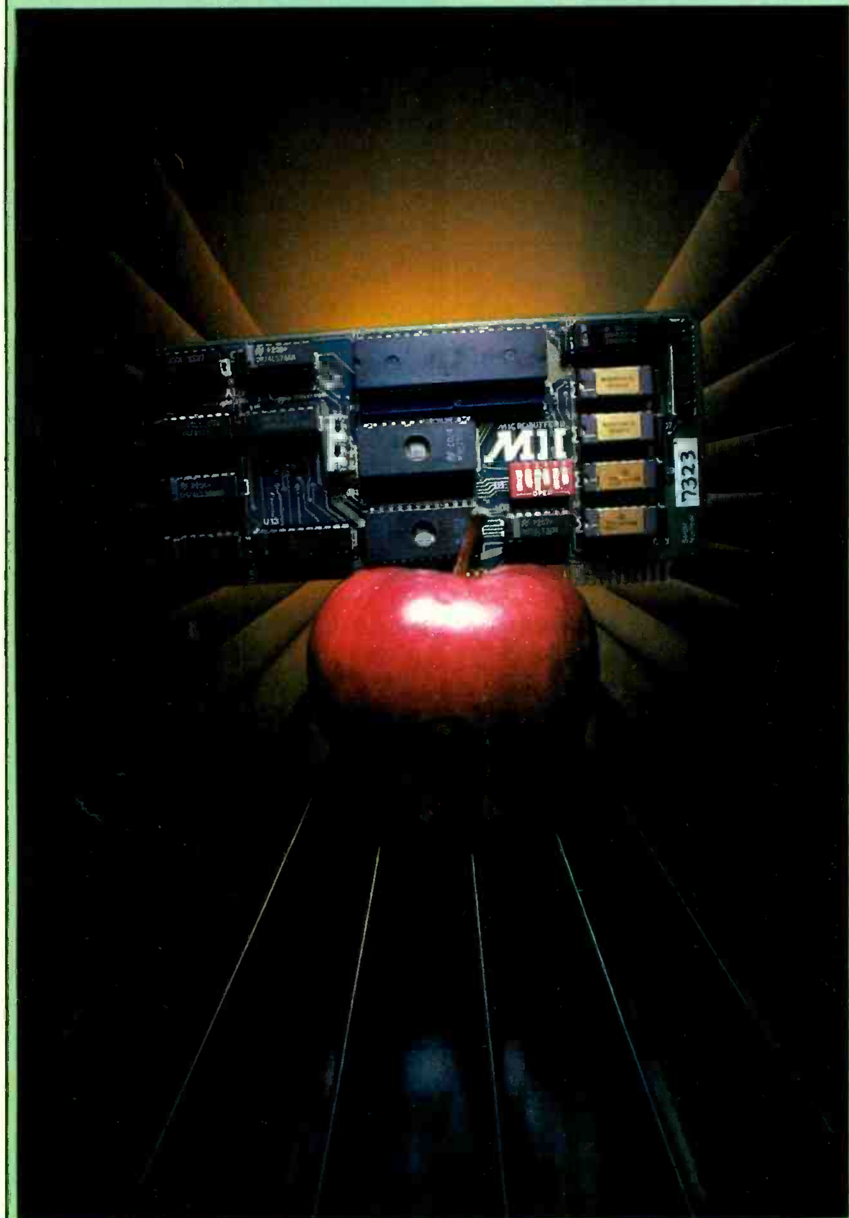
No matter how sophisticated a printer you decide to buy, you'll need the proper software to take advantage of its specific features. In fact, if you're putting together a sophisticated word-processing system, review your needs with an eye to both printer and driving software.

If you select a printer that offers true underlining, superscripting and subscripting, proportional spacing, etc., capabilities, get a software package that will allow you to access these features. Don't forget that any feature you add to a basic printer or package will add to its cost, however; so plan your purchases accordingly. If you buy more printer than you need, you'll be throwing away money that can be better spent on something else you might want or need for your system.

Good high-level word-processing packages, such as Word Star and Magic Wand, will almost always permit you to take advantage of virtually every feature built into modern printers. Basic low-cost packages, however, may not. Before you buy a software package for your computer/printer system, carefully study its description to determine if it fills your needs. The several hundred

Microbuffer II Printer Interface for Apple II

By Alexander Marx



Printer operations are light years slower than any computer's flow of data. So when a computer is spitting out large amounts of data to a typical dot-matrix or daisy-wheel printer, you're forced to wait until everything is printed before you can work at the console again.

What a waste of time for both you and a sporadically idling CPU! What's the solution? It's simple: take some memory, an inexpensive microprocessor, some support logic, and make the whole thing look like a fast printer to the computer. The computer can now dump the data to this external memory at 4000 plus cps (characters per second) and the additional microprocessor can then send them to the printer at the slower rate. Put the whole thing in a box and you have yourself a printer buffer!

The clever people at Practical Peripherals (31245 La Baya Drive, Westlake Village, CA 91362) have done just that, and they have a line of buffers to fill every need. For the Apple II computer they have come up with the Microbuffer II, which at $259 comes with 16K of onboard memory that is user-expandable to 32K. It also has an onboard microprocessor and an EPROM that contains the software to handle the buffering as well as some rather clever features. The whole thing is a plug-in card about twice as long as a normal Apple printer card.

The card tested was for a parallel "Centronics" interface. Even though it is a parallel interface it looks like a serial interface to the Apple. This is to maintain compatibility with both Pascal and CP/M. The card is installed like a normal Apple card. I placed it in slot 1 (although it can be used in any slot except 0). The card has a detachable cable with the standard parallel connector on one end and a standard Apple multipin connector on the other.

The card is transparent in operation if you don't want to do anything fancy. You notice the difference that the buffer makes right away: a standard screen full of data loads into the card in about two seconds as opposed to about a minute without the buffer. The card responds to the conventional commands. These

dollars asked for the software to provide professional printing capabilities will be well worth the investment since, in the long run, it can actually save you money in more efficient and flexible processing. Conversely, if you don't need all the sophistication built into professional-grade software, find a package that suits your requirements. Such packages are usually sold at considerable savings over individual items.

Finally, like so much computer hardware, printer prices appear to be at an all-time low. Leading Edge's "Gorilla/Banana" impact dot-matrix printer, for example, has a suggested retail price of only $249.95. Models that have been around for a while are being sold with considerable discounts. An Epson MX-80, the machine that brought logic-seeking to moderately priced printers, can be bought for less than $500, while Smith-Corona's TP-1 letter-quality daisy-wheel printer is being sold for below are prefixed by sending a Control I [CHR$(9) in BASIC], followed by one or more parameters. For example, to go from printing 40 to 80 columns, you would first turn the card on with the normal PR#1 and then enter a Control I followed by an 80N.

With 16K of memory, you can dump about 11 pages of text to the buffer. If you upgrade or purchase the 32K version, you will double the amount of storage. Once the buffer fills up and if you have more data to send, the system slows down to the normal crawl. As the card sends one line to the printer from the bottom of the buffer, a new line from the computer is entered at the top of the buffer.

You may wonder about the use of the card at this point since the system is bogged down waiting for the printer, just like the old days. But don't forget that the buffer is still full. At some point the computer will send all the data and be free once again, while the buffer continues to churn out the 16K or 32K that was filled. It may not be as fast as having unlimited buffer area, but it still saves a good one-third to one-half of the normal printing time. As I rarely print large documents, I get by very nicely with the 32K. Without reaching the buffer limit, you can save close to 90% of your printing time.

So much for the "dumb" mode of operation. If the card just buffered the printing it would be well worth the cost. But since you have a microprocessor on the card already, you may as well give it some smarts. This card has 25 text formatting and printer control commands, as well as eight graphics commands for dumping the Apple HiRes graphic screens to the printer.

Some of the text formatting and printer control commands are: send a linefeed after carriage return, set a left margin, set the print width, clear the buffer, and verify the operation of the card (self check). Among the more interesting commands is one to format BASIC listings so that each one of multiple statements on a line is displayed on its own line, indented from the margin. This is very useful if you do any programming or would like to follow someone else's work. It takes a little time to get used to the format but, once you do, it makes life a lot easier.

Another useful command is a screen dump. This will dump the 40-column Apple text screen to the printer. You can print the whole screen or specify a starting line, in which case it will print from that line to the bottom. The manual specifies that this command is useful for printing a Visicalc window, but I couldn't figure out how to interrupt Visicalc so I could send the command code. The manual doesn't elaborate either. It's a shame that they allude to something and yet don't explain at all how to achieve the desired effect.

The HiRes graphic dump commands are a nice bonus. They allow you to dump HiRes Apple graphics to your printer, provided it can handle dot-addressable graphics. You must specify what printer you have when you purchase the card as each printer requires a different EPROM.

The graphic dump commands give you many options including printing double sized, rotating the image 90 degrees, inverting the image so black is white and white is black, and emphasized so that twice as many dots are printed giving a darker image. The card will print both the primary HiRes page (HGR) or the secondary HiRes page (HGR2). It even allows printing mixed HiRes and Text screen. An additional feature is the Chart Recorder Mode. This allows two pictures to be printed contiguously, resulting in a larger picture. This can allow for greater detail by using both of the Apple HiRes screens and joining them at print time.

The Microbuffer II is an excellent product. It serves its purpose as a buffer simply and elegantly. It follows the standard Apple commands for ease of use. It also offers many features not normally found in a printer card. If you have ever shopped for a printer card, you soon realize that there is too much variety in the marketplace. Some cards offer straight printing with no bells and whistles, some offer buffering, some offer graphics dump routines and little else, some offer bells and whistles but are not compatible with anything.

The Microbuffer II offers the cake and the icing, too. In fact, I used the card for a long time as a straight buffer without having to modify any of my programs. I was oblivious to the other wonderful features. Now I use it more extensively, especially for formatting BASIC listings, with the left margin set where the text is comfortably centered on the page. No more moving the tractor feed to accommodate my word processor's spacing, while my BASIC listings are printing on the feed holes! And the graphics dumps are wonderful, convenient and versatile.

There are a few annoying things about the card, the worst being the manual. It is far from complete. It gives you enough to get started, but leaves you on your own for the rest. I am still trying to dump my Visicalc screens because it said I could, but I am not going to spend an hour trying to find out. The other complaint is a lack of a larger technical section. It has the standard "for machine language programmers, the following information will be useful," but what if I want to go deeper? For example, what if I wanted to access the graphic dump routines directly? At least, if you don't want to release source code, give entry points or even tips and examples.

For the dollar, though, I dont' think you could do better than this card. The combination of functions with the relative ease of use and compatibility make it unbeatable.

If you don't have an Apple II, but would still like buffered printing, one of Practical Peripherals' inline buffers may be the answer. These buffers go between the computer and printer and direct the flow from there. They offer several models in both serial and parallel interface and up to 256K of memory. That's about 175 pages of text! There's even a model that will fit inside the Epson printers.

So, if you are tired of waiting for your printer while you're computing, consider a buffer. And if you're considering a buffer, check out the Practical Peripherals' line. ◇

$600. And if these are beyond your budget, there's still no excuse for not having hard copy at your disposal because you can go the thermal printer route, such as with Star Micronics' new STX-80 80-column printer for under $200 suggested retail. Moreover, new models are available that boast more features than ever, such as faster printing speed and they are available in most locations, at surprisingly moderate prices.

Some unusual concepts are around, too. These include, among others, Qume's "personality" modules for its daisy-wheel printers that simplify mating it with the most popular computers, Riteman's 2⅞"-high 10"-wide-carriage impact dot-matrix printer that fits into an attache case, and Max and Mannesmann Tally's battleship-construction impact dot-matrix machines that allows one to set up a variety of characteristics from its front panel and store it in non-volatile memory. ◇

The Soul of CP/M

PART 4

This series of articles is condensed from a forthcoming book, Soul of CP/M, by Mitchell Waite and Robert Lafore*

SINCE beginning this series, we've been working our way deeper and deeper into what we call the "soul" of CP/M—the hidden part not usually visible to the casual user of this operating system. Now we're going to penetrate to the most hidden part of CP/M, the BIOS (Basic Input/Output System)! You could call BIOS the innermost soul of CP/M.

What is the BIOS? For BDOS to be able to execute its duties, it must at some point communicate with the actual physical devices (disk drives, video screen, keyboard, printer, etc.) connected to the computer. Since these peripherals can be from a variety of manufacturers and operate in different ways, subroutines that drive them must be different for each piece of this equipment. This collection of the subroutines is what constitutes the BIOS. Each of these driver subroutines "drives" a particular peripheral device. When you change from one kind of printer to another, you must modify the printer driver in BIOS to be able to "speak" to the new printer.

Although the BIOS is at the innermost core in CP/M (Fig. 17), it has a direct connection with the outside world. In fact, it's the *only* part of CP/M that can actually communicate with physical devices.

Now that you know where BIOS resides and what it does, let's explore how to modify a driver routine so that your CP/M can operate with a different printer. The techniques involved will also work for adding or changing other peripherals. Changes to the disk drives are considerably more complicated and should probably be left to the dealer unless you're a very ambitious (experienced) programmer.

Because every system uses different

hardware, every BIOS will be different. We can't, therefore, tell you *exactly* how to modify your specific BIOS, but we can show you an example that can be used as a guide for modifying your BIOS to suit your system's needs.

There are three steps involved in writing a new BIOS driver: (1) learning your way around BIOS—you must be able to find the existing driver so you can see what it looks like, how it relates to the rest of BIOS, and where to put the new driver; (2) writing the new driver routine and then testing it; (3) inserting the new driver into the BIOS file and writing the new BIOS to the system tracks of your disk.

What You Need. There are two things you need before you can modify your BIOS. The first is the ASM file of the BIOS, usually supplied with CP/M, which contains the 8080 code that communicates with I/O devices. This file is usually called something like IOBIOS.ASM, GBBIOS.ASM, or some similar name with BIOS in it. If the file contains the I/O for the disk system, it will be very long—20 or more printed pages. If this section is left out, the printout will be fairly short—six pages or so.

The BIOS.ASM file is what you're going to modify, using a word-processing program to alter a section of it.

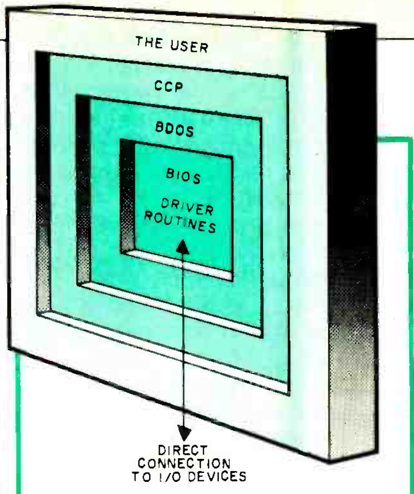


Fig. 17. BIOS, at the real center of CP/M, still connects to the world.

```
                 ;TITLE      ++ BIOS FOR D10 WITH CP/M 2.2  Rev2.7 ++
                 ;.......................................................
                 ;          BIOS FOR IMSAI D10-C CONTROLLER WITH CP/M 2.2
                 ;.......................................................
                 ;          BIOS VERSION 2.7:SINGLE DENSITY, 128 B/S
                 ;                           DOUBLE DENSITY, 256 B/S
                 ;                           DOUBLE DENSITY, 1024 B/S
                 ;.......................................................
0000 =           FALSE      EQU        0
FFFF =           TRUE       EQU        NOT FALSE
0038 =           MSIZE      EQU        56      ;MEMORY SIZE IN K-BYTES
0036 =           SSIZE      EQU        MSIZE-2 ;2K FOR CP/M,BIOS AND BUFF
001B =           REVNUM     EQU        27      ;BIOS REV #
0016 =           CPMREV     EQU        22      ;CP/M REV #
                 ;      "BIAS" IS ADDRESS OFFSET FROM 3400H FOR MEMORY
                 ;      SYSTEMS OTHER THAN 16K (REFERRED TO AS "B"
                 ;      THROUGHOUT THE TEXT).
8800 =           BIAS       EQU        (SSIZE-20)*1024  ;ADDR OFFSET FROM
                 ;                                       3400 (20K SYSTEM)
BC00 =           CCP        EQU        3400H+BIAS       ;BASE OF CCP
C406 =           BDOS       EQU        CCP+806H         ;BASE OF BDOS
D200 =           BIOS       EQU        CCP+1600H        ;BASE OF BIOS

                 ;          I/O DEFINITION EQUATES
                 ;.......................................................
                 ;          USEFUL THINGS TO KNOW
                 ;          MPU-B STATUS PORT
                 ;                 (TERMINAL/TRANSMITTER REFERENCE)

                 ;          0 = TxRDY             TRANSMITTER READY
                 ;          1 = RxRDY             RECEIVER READY
                 ;          2 = TxE               TRANSMITTER EMPTY
                 ;          3 = PE                PARITY ERROR
                 ;          4 = OE                OVERRUN ERROR
                 ;          5 = FE                FRAMING ERROR
                 ;          6 = SYNDET            SYNC DETECT
                 ;          7 = DSR               DATA SET READY

                 ;CONSOLE STATUS PORT (IN HEX)  -  15 = PARALLEL
                 ;                                13 OR 4 = SERIAL
                 ;                                3 = SYSTEM
                 ;CONSOLE DATA PORT (IN HEX)    -  14 = PARALLEL
                 ;                                12 OR 4 = SERIAL
                 ;                                2 = SYSTEM
0003 =           CRTST      EQU     3H        ;CRT STATUS PORT
0002 =           CRTDATA    EQU     2H        ;CRT DATA PORT
0015 =           IKBST      EQU     15H       ;IKB1 STATUS PORT
0014 =           IKBDATA    EQU     14H       ;IKB1 DATA PORT
F803 =           VIODATA    EQU     OF803H    ;VIO DATA PORT
0002 =           RXRDY      EQU     02H       ;CONSOLE STATUS
                 ;                               READY BIT (RxRDY)
0003 =           IOBYTE     EQU     0003H     ;INTEL I/O BYTE
F800 =           VIOINIT    EQU     0F800H    ;VIO INIT ENTRY POINT
FFFD =           VIOID      EQU     0FFFDH    ;POINTER TO VIO ID
0023 =           PRTS       EQU     23H       ;PRINTER STATUS PORT
0022 =           PRT        EQU     22H       ;PRINTER DATA PORT

                 ;      USER CUSTOMIZED I/O DEVICES.                     ;
                 ;        DO NOT REARRANGE JMP TABLE.                    ;
                 ;.......................................................
DE70                        ORG     BIOS+0C70H
DE70 C3F8DE  INITIO:        JMP     INITVC
DE73 C3BFDE  LIST:          JMP     LISTIO
DE76 C3B3DE  LISTST:        JMP     LISTSTIO
DE79 C388DE  CONST:         JMP     CONSTIO
DE7C C39BDE  CONIN:         JMP     CONINIO
DE7F C3A7DE  CONOUT:        JMP     CONOUTIO
DE82 C3CBDE  PUNCH:         JMP     CONOUTIO
DE85 C3D7DE  READER:        JMP     READERIO
```

```
                 ;          CONSOLE STATUS - CON:
                 CONSTIO:
DE88  CD8FDE                CALL CONS         ;GETS STAT OF SPECIFIC DEVICE
DE8B  C8                    RZ                ;IF NOT READY RETURN 0 IN A
DE8C  3EFF                  MVI A,0FFH        ;ELSE RETURN FF
DE8E  C9                    RET               ;Z FLAG SET CORRESPONDINGLY

DE8F  CDE3DE CONS:          CALL DISPATCH
DE92  01                    DB       1        ;USE IOBYTE BITS 1-0
DE93  45DF                  DW CRTSTAT        ;00 - TTY: (CRT STATUS)
DE95  45DF                  DW CRTSTAT        ;01 - CRT:      "
DE97  45DF                  DW CRTSTAT        ;10 - BAT:      "
DE99  5FDF                  DW IKBSTAT        ;11 - UC1: (IKB1 STATUS)

                 ;          CONSOLE IN - CON:
                 CONINIO:
DE9B  CDE3DE                CALL DISPATCH
DE9E  01                    DB       1        ;USE IOBYTE BITS 1-0
DE9F  4ADF                  DW CRTIN          ;00 - TTY: (CRT INPUT)
DEA1  4ADF                  DW CRTIN          ;01 - CRT:      "
DEA3  4ADF                  DW CRTIN          ;10 - BAT:      "
DEA5  64DF                  DW IKBIN          ;11 - UC1: (IKB1 INPUT)

                 ;          CONSOLE OUT - CON:
CONOUTIO:
DEA7  CDE3DE                CALL DISPATCH
DEAA  01                    DB       1             ;USE IOBYTE BITS 1-0
DEAB  55DF                  DW CRTOUT              ;00 - TTY: (CRT OUTPUT)
DEAD  55DF                  DW CRTOUT              ;01 - CRT: (CRT OUTPUT)
DEAF  55DF                  DW CRTOUT              ;10 - BAT: (CRT OUTPUT)
DEBI  6FDF                  DW VIOOUT              ;11 - UC1: (VIO OUTPUT)

                 ;          LIST STATUS - LST:
LISTSTIO:
DEB3  CDE3DE                CALL DISPATCH
DEB6  03                    DB       3             ;USE IOBYTE BITS 7-6
DEB7  42DF                  DW LISTSTC             ;00 - TTY: (CRT OUTPUT)
DEB9  42DF                  DW LISTSTC             ;01 - CRT: (CRT OUTPUT)
DEBB  42DF                  DW LISTSTC             ;10 - LPT: (LINE PTR
                                                     OUTPUT)
DEBD  42DF                  DW LISTSTC             ;11 - UL1: (VIO OUTPUT)

                 ;          LIST OUT - LST:
LISTIO:
DEBF  CDE3DE                CALL DISPATCH
DEC2  03                    DB       3             ;USE IOBYTE BITS 7-6
DEC3  55DF                  DW CRTOUT              ;00 - TTY: (CRT OUTPUT)
DEC5  55DF                  DW CRTOUT              ;01 - CRT: (CRT OUTPUT)
DEC7  35DF                  DW LPTOUT              ;10 - LPT: (LINE PTR
                                                     OUTPUT)
DEB9  6FDF                  DW VIOOUT              ;11 - UL1: (VIDEO
                                                     OUTPUT)

                 ;          PUNCH OUT - PUN:
PUNCHIO:
DECB  CDE3DE                CALL DISPATCH
DECE  05                    DB       5             ;USE IOBYTE BITS 5-4
DECF  55DF                  DW CRTOUT              ;00 - TTY: (CRT OUTPUT)
DED1  73DF                  DW PUNOUT              ;01 - PTP: (H. S. PUNCH
                                                     OUTPUT)
DED3  6FDF                  DW VIOOUT              ;10 - UP1: (VIO OUTPUT)
DED5  55DF                  DW CRTOUT              ;11 - UP2: (CRT OUTPUT)

                 ;          READER IN - RDR:
READERIO:
DED7  CDE3DE                CALL DISPATCH
DEDA  07                    DB       7             ;USE IOBYTE BITS 3-2
DEDB  4ADF                  DW CRTIN               ;00 - TTY: (CRT INPUT)
DEDD  74DF                  DW RDRIN               ;01 - PTR: (H. S. READER
                                                     INPUT)
DEDF  4ADF                  DW CRTIN               ;10 - UR1: (CRT INPUT)
DEE1  4ADF                  DW CRTIN               ;11 - UR2: (CRT INPUT)
```

Fig. 18. BIOS for DIO with CP/M 2.2, Rev. 2.7.

You'll then reassemble it with ASM and write it back onto the system tracks of your disk.

The second thing you'll need is the specifications table for your UART (universal asynchronous receiver/transmitter) or serial I/O board. The UART IC is installed on the serial board and allows the computer to communicate in serial mode with external devices. The spec sheet for the UART will tell you what numbers to output to what "port" in the UART to send signals to various I/O devices.

Some versions of the BIOS.ASM file include information on the UART at the beginning of the listing, making it possible to modify your BIOS without the actual spec sheet—provided the UART is already installed and operating and your listing has this information. It's also easier if you have a device already operating which is similar to the one you plan to install.

If you already have a printer running and want to change to another printer, you may not need the spec sheet or comments in the listing. You can use the existing driver as a model. Of course, if you don't have a printer, you'll need the spec sheet.

Sample BIOS. Bear in mind that the particular BIOS we'll be describing in Fig. 18 is only one example of the hundreds of possible versions in circulation. Yours may be somewhat different, but it should be similar enough that you can follow in your BIOS the steps we'll describe here. Reading your BIOS listing will make the most sense if you assemble it with ASM and then refer to the PRN listing, since often the hex values given are important.

BIOS Introduces Itself. When called from disk, BIOS introduces itself, as shown in the beginning of the BIOS listing in Fig. 18. BIOS starts out by describing itself, where it comes from, and what it's for. Our example comes from

```
              DISPATCH:
DEE3 E3                 XTHL               ;SAVE CALLER'S H, GET
                                            TABLE ADD
DEE4 56                 MOV D,M            ;SHIFT COUNT
DEE5 23                 INX H              ;POINT TABLE
DEE6 3A0300             LDA IOBYTE         ;GET IO ASSIGNMENTS
                                            BYTE
DEE9 07       DSHFT:    RLC
DEEA 15                 DCR D
DEEB C2E9DE             JNZ DSHFT          ;SHIFT TO POSITION
                                            BITS
DEEE E606               ANI 06H            ;MASK BITS
DEF0 5F                 MOV E,A            ;D ALREADY CLEAR
DEF1 19                 DAD  D             ;INDEX INTO TABLE
DEF2 7E                 MOV  A,M
DEF3 23                 INX H              ;TABLE WORD TO HL
DEF4 66                 MOV  H,M
DEF5 6F                 MOV L,A
DEF6 E3                 XTHL     ;PUT ADDR OF ROUTINE. GET CALLER'S
                                  H
DEF7 C9                 RET      ;GO TO ROUTINE

              ;**************************************************
              ;    INIT USER I/O IE. CONSOLE ,PUNCH AND LIST DEV.
              ;**************************************************
              INITVC:
              ;         INIT UART (RECOMMENDED CMDS BY IMSAI)
DEF8 AF                 XRA      A
DEF9 D303               OUT      CRTST
DEFB D303               OUT      CRTST
DEFD D303               OUT      CRTST
DEFF D323               OUT      PRTS
DF01 D323               OUT      PRTS
DF03 D323               OUT      PRTS
DF05 3E40               MVI      A,40H          ;RST 8251
DF07 D303               OUT      CRTST
DF09 D323               OUT      PRTS
DF0B 3EAE               MVI      A,0AEH         ;MODE
DF0D D303               OUT      CRTST
DF0F D323               OUT      PRTS
DF11 3E27               MVI      A,27H          ;CMD
DF13 D303               OUT      CRTST
DF15 D323               OUT      PRTS

DF17 21FDFF             LXI      H,VIOID        ;VIO ID 1 ADDR
DF1A 3E56               MVI      A,'V'          ;1ST ID
DF1C BE                 CMP      M              ;SAME?
DF1D C22FDF   JNZ       NOVIO
DF20 23                 INX      H              ;VIO ID 2 ADDR
DF21 3E49               MVI      A,'I'          ;2ND ID
DF23 BE                 CMP      M              ;SAME?
DF24 C22FDF   JNZ       NOVIO
DF27 CD00F8             CALL     VIOINIT        ;INIT VIO
DF2A 3E97               MVI      A,97H          ;VIO AS OUTPUT
DF2C C331DF   JMP       INITIO1
DF2F 3E94     NOVIO:    MVI      A,94H          ;CRT AS OUTPUT
              INITIO1:
DF31 320300             STA      IOBYTE
DF34 C9                 RET

              ;**************************************************
              ;     LIST CHARACTER IN C
              ;**************************************************
DF35 DB23     LPTOUT:   IN       PRTS      ;CHECK STATUS PORT
DF37 E685               ANI      85H       ;CHECK BOTH READY
                                            BITS
DF39 EE85               XRI      85H
DF3B C235DF             JNZ      LPTOUT
DF3E 79                 MOV      A,C
DF3F D322               OUT      PRT
DF41 C9                 RET      ;USER PRINTER IO
```

```
              ;*****************************************************
              ;     RETURN LIST STATUS (FF IF READY, ELSE 0)
              ;*****************************************************
DF42 3EFF     LISTSTC:  MVI      A,0FFH
DF44 C9                 RET
              ;*****************************************************
              ;     CONSOLE STATUS RETURNED IN A.
              ;*****************************************************
              CRTSTAT:
DF45 DB03               IN       CRTST     ;STATUS PORT
DF47 E602               ANI      RXRDY     ;TEST RxRDY
DF49 C9                 RET                ;Z=1,   CHAR   NOT
                                             READY
              ;*****************************************************
              ;     CONSOLE IN RETURNS THE CHARACTER IN A
              ;*****************************************************
              CRTIN:
DF4A CD45DF             CALL     CRTSTAT
DF4D CA4ADF             JZ       CRTIN     ;GET RxRDY
DF50 DB02               IN       CRTDATA   ;GET CHAR
DF52 E67F               ANI      7FH       ;STRIP PARITY
DF54 C9                 RET
              ;*****************************************************
              ;     CRTOUT SENDS THE CHARACTER IN C TO OUTPUT
              ;*****************************************************
              CRTOUT:
DF55 DB03               IN       CRTST     ;GET STATUS
DF57 0F                 RRC                ;TxRDY?
DF58 D255DF             JNC      CRTOUT    ;REPEAT, NOT READY
DF5B 79                 MOV      A,C       ;CHAR TO ACCUM
DF5C D302               OUT      CRTDATA   ;CHAR TO PORT
DF5E C9                 RET
              ;*****************************************************
              ;     IKB1 STATUS RETURNED IN A.
              ;*****************************************************
              IKBSTAT:
DF5F DB15               IN       IKBST     ;STATUS PORT
DF61 E602               ANI      RXRDY     ;TEST RxRDY
DF63 C9                 RET                ;Z=1,   CHAR   NOT
                                             READY
              ;*****************************************************
              ;     IKB1 IN RETURNS THE CHARACTER IN A
              ;*****************************************************
              IKBIN:
DF64 CD5FDF             CALL     IKBSTAT
DF67 CA64DF             JZ       IKBIN     ;GET RxRDY
DF6A DB14               IN       IKBDATA   ;GET CHAR
DF6C E67F               ANI      7FH       ;STRIP PARITY
DF6E C9                 RET
              ;*****************************************************
              ;     VIOOUT SENDS THE CHARACTER IN C TO VIO
              ;*****************************************************
              VIOOUT:
DF6F 79                 MOV      A,C
DF70 C303F8             JMP      VIODATA   ;VIO   RETURNS   TO
                                             CALLER
              ;*****************************************************
              ;     PUNCH CHARACTER IN REGISTER C
              ;*****************************************************
              PUNOUT:
DF73 C9                 RET                ;NULL ROUTINE
              ;*****************************************************
              ;     READ CHARACTER INTO A FROM READER DEVICE
              ;*****************************************************
              RDRIN:
DF74 3E1A.              MVI      A,1AH     ;ENTER END OF FILE
                                            (REPLACE LATER)
DF76 E67F               ANI      7FH       REMEMBER TO
                                             STRIP PARITY BIT
DF78 C9                 RET
DF79                    END
```

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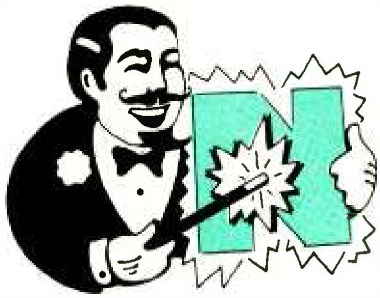
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60

WW Components, is for the Imsai 8080 computer, and is Version 2.7.

Address Location Arithmetic. All BIOS listings contain some calculations at the outset that define and set up the beginning address of BIOS in memory. Addresses are usually calculated according to a set of rules laid down by Digital Research. They start out by specifying the memory size with which BIOS is working, which is 56K in our example in Fig. 18. If your BIOS has other statements in it at this point, such as various options that must be set to true or false, ignore them; they won't influence this discussion.



The magic "N"

In Fig. 18, we see that MSIZE (computer's memory size) is set at 56 (28H). All BIOS.ASM files should have such an equate (EQU). If you want to change your BIOS to work with a machine with a different memory size, the first thing you would do is change this number to a value that will permit you to take advantage of maximum available memory.

The next important number is for BIAS. (In other listings, it may have a different name, such as IOBIAS.) This number specifies the distance in memory between where the CP/M system is on your system and where it is on a CP/M disk as it comes from the factory. A brand new system is configured for 20K of memory and then moved up to the top of memory, where it will reside in a particular computer. BIAS is related to a certain "magic" number, which we call N.

BIAS is then used to define the starting locations of the major parts of the CP/M system (CCP, BDOS, and BIOS). Location 3400 is the "standard" starting point for the bottom of CCP in a 20K system. CCP is 806H bytes long in our listing, since BDOS starts at CCP + 806H. CCP and BDOS together are 1600H bytes long; so in our 56K system, at least, BIOS starts at D200H.

I/O Equates and More. In the next section of the listing, headed "I/O Definition Equates," BIOS tells us something about the UART, namely the meaning of each bit when we read the status of an I/O device. Following this is a series of equates, which are places where certain variables and addresses in BIOS are given values. The CRT status port (CRTST) is at 03H, keyboard data port is at 14H, etc. Notice especially the printer status (PRTST) and printer data (PRT) ports. We'll be using the numbers they're equated to (23H and 22H) when we write our printer driver.

ORG Statement & Jump Table. In the next section of the listing, "User Customized I/O Devices," we finally get to the ORG statement, which is the beginning of our program. Usually, this location is defined in terms of various other locations that are, in turn, defined in terms of the computer's memory size, among other things. In this case, ORG is at the beginning of BIOS because all disk system drivers are located there, between D200H and D200H + 0C70H. Our listing is really only a small portion of BIOS, since it contains no disk information.

If we add instructions to BIOS and reassemble it to insert our new driver, the starting addresses of all drivers following the one we changed will be different. How will BDOS find them? The answer is that it makes use of a clever programming tool called a "jump table."

A jump table is merely a number of jumps at the beginning of the listing. Each jump goes to one of the driver routines. Since these jumps are part of the listing we're going to reassemble, the values in their address fields will change when we reassemble the file. So BIOS doesn't care about the locations of the driver routines themselves, only where the jump table is located. The jump table is always at the beginning of the listing. BIOS calls one of the locations in the jump table, and the jump takes BDOS to the proper driver.

Notice, however, that BDOS assumes the jumps in the table will always be in the same order. When it calls on the second jump in the table, it expects to find the jump to LISTIO, *not* some other driver. This is why the listing has the caution "Do not rearrange jump table" in it.

IOBYTE. Now we can actually start to follow a trail through the listing to our destination. The second jump in the table is to LISTIO, the list device. CP/M permits different physical devices to be assigned to different logical devices—console (CON:), reader (RDR:), punch (PUN:), and list (LST:). There are also various physical devices like TTY:, CRT:, and LPT:. You can change the assignments of physical to logical devices by using STAT. When you do this, STAT changes the IOBYTE at location 3 in memory.

Now, when BIOS gets a call to the LIST routine, it doesn't know what physical device it's intended for until it checks the IOBYTE. Based on what it finds there, it will go to either the driver for the printer or to some other driver. That's why LISTIO and LISTSTIO (the latter being list status I/O) are a different form of jump table, rather than driver routines (see "List Out - LST" entry under "User Customized I/O Devices" in Fig. 18).

This section first calls the DISPATCH routine, which looks at the IOBYTE and determines which of the four routines to go to for the four possible physical I/O devices. Because the line printer is usually assigned to the LST: device, DISPATCH determines this from the IOBYTE and jumps to the address in the third DW statement in this routine—LPTOUT (line printer output).

In some BIOS versions, the IOBYTE isn't used and this section of code is omitted. This is true of the BIOS example provided in the "CP/M Alteration Guide" supplied by Digital Research. In other versions, it's implemented in a different manner.

Refer now to the section of Fig. 18 titled "List Character In C," which takes us to LPTOUT. We've found the instructions that tell the UART to accept a character and send it on to the printer. This is the routine we're going to modify. For a change, it doesn't call another routine. So we've reached the end of the line. Printer status (PRTS) at 23H and printer (PRT) at 22H are the "ports" we're going to access with IN and OUT instructions.

IN and OUT Instructions. These are the chief means by which the 8080 microprocessor communicates with the outside world. IN gets data from a port and puts it in register A, while OUT sends data from register A to a data port. Of the 256 possible data ports, the appropriate one is specified by the two-digit hex number (or label equated to it) in the address field.

Data ports and their addresses are *not* the same as memory and its addresses. Data ports consist of a separate group of registers. Since there are only 256 of them, the ports are addressed by two-digit numbers. Thus, the 5A in the instruction "IN 5A" refers to a data port, not to memory address 5A.

The byte read into register A can be either data, such as an A character (41H) read from the keyboard, or a "status byte" whose purpose is to inform your program about the status of a UART or I/O device. The values of a status byte must be known from the operator's manual for the UART or I/O device.

OUT takes an 8-bit byte *from* register A and puts it into the port specified in the operand field of the instruction. This byte can be either data to be transferred to an output device, such as the character A to be printed on the CRT screen, or a "function byte" that tells the UART or I/O device what to do. The values to be used in a function byte must be known from the operator's manual for the UART or I/O device.

XRI Instruction. This instruction performs an exclusive-OR of the one-byte data in the instructions with the data in register A. This instruction is useful for testing bit patterns because it immediately tells you if all bits in a certain bit configuration are set to 1. Simply XRI the bit pattern you want to examine with the bit pattern in register A. If all the bits you specify are set, but nothing else is, the result will be zero. For example, if register A contains 07H and you XRI it with 85H, you'll have:

register A	0000 0111
constant	1000 0101
result	1000 0010.

The result is not zero. However, if register A contains 85H, you'll get:

register A	1000 0101
constant	1000 0101
result	0000 0000.

Note that the result is now zero.

The first thing we do in LPOUT is read the status of the printer port to see if the printer is ready to receive data. We do this with an IN instruction to the port that holds the printer status (23H), which returns a byte that looks like that shown in Fig. 19.

Now, what we want to see when the printer is ready to receive a character is that DSR, TxE, and TxRDY bits are set. The other bits can be anything at all. We first mask off the other bits with an ANI instruction, using 85H (1000 0101 binary). As a result, only bits 7, 2, and 0 can have a value other than zero; these bits can either be zero or one. The values of all of the other bits *must* be zero.

Next, we want to make sure that bits 7, 2, and 0 are indeed zero. So we XRI register A with 85H again. If the result is not zero, we go back to check again with the JNZ instruction.

Once all bits are properly set in the status word, we're ready to receive data. The data byte has been in register C all along (your program put it there before doing a call to BDOS). So we move it to register A and then OUT it to printer port 22H. Then we return.

I/O Initialization. Usually, the particular UART you're using must be initialized before it can function properly. Thus, there's a section of code in BIOS that's activated every time you do a warm or cold boot. This routine is shown in Fig. 18 under the heading "Init User I/O IE. Console, Punch and List Dev."

Different UARTs require different kinds of initialization. You can find out what yours requires from its spec sheet. In our example, the UART must be told "0, 0, 0, 40, AE, 27" before it can do anything. Examining the listing, you'll note that every time an OUTCRTST is executed, the value in register A is sent to the CRT status register (3H). Also, every time an OUT PRTS is executed, the value is sent to the printer status port (23H). Hence, the sequence of numbers referred to above is sent to both the CRT and printer ports of the UART.

If you're changing from one printer to another, you probably won't have to add anything to this initialization process. But if you add a driver that wasn't originally there, you'll have to add code in this section to initialize the new ports in your UART.

Modifying a Printer Driver. To create a new driver for your BIOS, you must first determine the kind of driver program to write. You must know what kind of printer you have and which communication "protocol" it uses. Protocol is another term for procedure. In this case, it means the procedure by which the printer tells the computer it's ready to accept data for printing.

With some printers, you can simply wait until they're ready, throw a character at them, wait for ready again, throw another character, and repeat until you're done. Such a printer will print each character just fine. The printers made by Epson are typical examples of such "standard serial" or "teletype-like" printers. Other more complex printers, such as the daisy-wheel models, require one of two advanced protocols: "xon/xoff" or "etx/ack." The NEC printer, for example, requires etx/ack, while the Diablo 630 likes xon/xoff. These protocols are designed to allow a printer to work with more than one character at a time.

XON/XOFF Protocol. You've probably used xon/xoff without even knowing it. Xon/xoff is the same as the "control-s/control-q" (ctrl-s/ctrl-q) CP/M uses to freeze and unfreeze the scrolling of the display on the CRT screen. In CP/M, ctrl-s freezes the display; striking any key thereafter generates a ctrl-q that unfreezes scrolling. Ctrl-s means xoff (turn off transmission), while control-q means xon (turn on transmission).

A printer uses xon/xoff when it has a built-in "buffer" that can hold a certain number of characters (1024, for example) for printing. The buffer allows the computer to send characters to the printer at a fairly fast rate and then hold them while the slower printer mechanism prints them out. While the buffer in the printer is emptying, the computer can be used for more processing, such as editing a file, during the print operation, without slowing down your text editor. You should notice a delay in processing only when the printer calls for more characters to fill its buffer.

This operation is as follows. After your printer driver sends each character, it reads a status word from the printer and looks to see if the printer is sending back a ctrl-s. If it detects a ctrl-s, it tells the driver to stop sending because the buffer is full and to suspend transmission of characters until the buffer is once again empty. If no ctrl-s is sent back, the computer will continue to

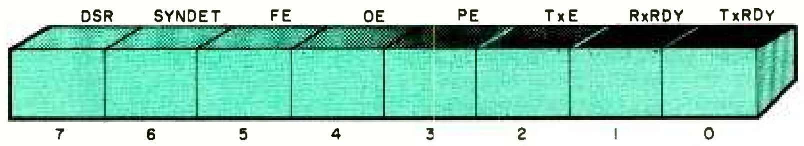


Fig. 19. The printer port is read to see if it can receive data.

send characters to the printer until one is detected. Upon detection of a ctrl-s, the computer goes into a wait loop and waits for a ctrl-q, the signal that buffer is empty, to come from the printer.

ETX/ACK Protocol. This protocol is similar to xon/xoff, except that it's implemented differently. In this case, a block of characters (usually 128) is sent to the printer, followed by an etx character (03H = ctrl-c), which translates to "end of text." After the entire block of characters has been printed out, the printer sends an ack (06H = ctrl-f), which means "acknowledged; last transmission received."

Writing a Sample Driver. When we explored the BIOS listing, we found a driver for the simplest kind of printer—a teletype-like device with no advanced protocol. We're now going to write a driver for a printer that uses xon/xoff. Our example will assume a Diablo 630 daisy wheel printer connected to our CP/M system through a serial board that's running at 1200 baud and uses an Intel 8251 UART.

Look back at the driver in the last section. When it wants to know if it can send a character, it checks to see if three bits are sent: 7 for data set ready (DSR), 2 for transmitter empty (TxE), and 0 for transmitter ready (TxRDY), as shown in Fig. 20.

Using xon/xoff is somewhat more complicated. We must ask the UART two questions. First, is it ready to receive a character from BIOS and, second, does it have a character ready to give *to* BIOS. In the first case, we ask the UART whether bits 0 and 2 are set. In the second case, we want to know whether bit 1 (RxRDY) is set.

With xon/xoff, there are two things that can occur when a program calls the driver to send a character to the printer. In either case, a character gets sent to the UART to transmit it to the printer. Then, either (1) the UART will *not* have sent an xoff, in which case control will return to the calling program so that it can get another character; or (2) the UART *will* have sent an xoff, in which case the driver won't return to the calling program but will wait until xon is received before it goes on.

The listing for the new driver is shown in Fig. 21. We're assuming here that we don't have to do anything else to initialize the UART. If we did, we'd have to add the appropriate instructions to the initialization part of the program. From the comment given in Fig. 21, you shouldn't have any trouble following operation of the driver.

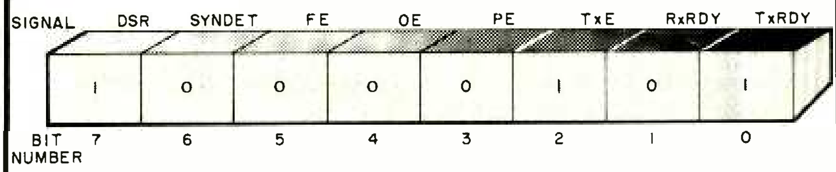


Fig. 20. The driver wants to know if it can send a character.

Testing the Driver. Inserting the new driver into the BIOS and writing it on the system tracks of a diskette is somewhat involved. What we need is a way to test our driver routine without going through this process. Here's how:

1) We put the driver routine at 100H, just like any other program, using DDT and the *a* command. (It can also be assembled with ASM.)

2) We put a "jmp 100" instruction at the start of the printer driver routine in the BIOS.

We'll assume at this point that you've written an appropriate driver routine of your own. It may not be perfect, but it's ready for a preliminary test. Hence, as we describe how to test our routine, you can follow the same steps with your routine.

First, you must know where to put the jmp 100 instruction. This isn't difficult if you've assembled your existing BIOS into a PRN file. Simply look through the listing for the printer driver routine and make a note of the address where it starts (DF35H in our 56K system, as you can see from the last section

```
;**********************************************************************
;               LIST CHARACTER INC
;**********************************************************************

;   New xon/xoff printer driver.
;   (was just a RET return instruction.)

LPTOUT: in      prts        ;input 8251 status
        ani     05h         ;AND 8251 for ready to send
        xri     05h         ;exclusive-OR to get zero
                             flag
        jnz     lptout      ;loop until UART register is
                             ready
        mov     a,c         ;get list character from C to
                             A
        out     prt         ;output to UART data register
                             and send
        in      prts        ;is UART ready with a
                             character?
        ani     02h         ;does receiver have a charac-
                             ter ready?
        xri     02h         ;mask
        rnz                 ;if not zero then continue
                             normally
        in      prt         ;yes - get the character
        cpi     13h         ;is it a ctrl-s freeze (xoff)?
        rnz                 ;no - skip it
lpt1:   in      prts        ;it was a ctrl-s, so now wait
                             for a
                            ;ctrl-q to return
        ani     02h
        xri     02h
        jnz     lpt1

        in      prs         ;character is ready
        cpi     11h         ;is it a crtl-q (xon)?
        jnz     lpt1        ;no, so loop until it is; i.e.
                             let
                            ;printer buffer empty
        ret                 ;finally a ctrl-q; return for
                             next character
```

Fig. 21. Listing for the new driver.

of our BIOS listing given in Fig. 18).

You can write your driver with a word-processing program, assigning the file the name NEWDRIVE.ASM, assemble it to get a HEX file, and call it from DDT by the assigned file name. Alternatively, you can type it in directly from DDT using the *a* command. In either case ORG it at 100H.

At this point, your printer shouldn't be operating, since you haven't toggled it on with a ctrl-p. Use the *a* command to insert a jmp 100 at the start of the driver routine in BIOS. For our particular BIOS, it would be:

```
-adf35
DF35 jmp 100
DF38 .
-
```

Note that you're modifying the very BIOS with which you're operating. If you do something wrong, the system

Finding a new address.

may die; so save your files before you get in too deep.

Now comes the moment of truth. Toggle on the printer with a ctrl-p and hit RETURN a few times. The printer should respond. Now type something and hit return. Whatever you type should be printed out, including the return. If something other than what you typed or nothing at all is printed, either your driver is defective or your jmp 100 is in the wrong place.

Installing the New Driver. Once you've gotten your driver to work in this nonstandard location, it's time to install it in your CP/M system. However, before you can complete this process, you must learn about the MOVCPM and SYSGEN utilities in CP/M and that magic number N.

MOVCPM. This amazing program actually contains CCP and BDOS, which is most of the CP/M operating system. It may also have part of the BIOS in it. If the people who configured your system didn't put the disk part of BIOS in the BIOS.ASM file, they put it in MOVCPM. What MOVCPM may not have in it are the drivers for the other I/O peripherals, which are probably in the BIOS.ASM file. MOVCPM may have these routines in it, but they may not work on your equipment or they may merely be skeletal drivers that won't work on any system.

When you call MOVCPM, it loads three things into memory: MOVCPM itself; CCP, BDOS, and maybe part of BIOS in the form of a COM file; and a bit map that tells it which bytes of the COM file must be "relocated" and which don't.

MOVCPM can't put the COM file in high memory, where CP/M normally goes, since the system we're operating with is already there. Remember, you can't make major changes to the same sections of code that constitute your operating system without getting into trouble. So MOVCPM keeps this version of CP/M in low memory, starting at location 900H, which leaves just enough room for the program and the bit map below it. This version of CP/M is called the system *image*, which means that the instructions of code look just like the actual operating version of CP/M in high memory but are in the wrong place to actually execute properly (see Fig. 22).

When you call MOVCPM from CP/M, you must specify the memory size of your computer, such as 64K, and tell it whether you want the CP/M image to be moved to high memory and execute. This is something you almost never want, since the CP/M image is probably incomplete and won't work, resulting in a "crashed" system if you attempt to execute it. If you *don't* want this to happen, you can type an asterisk after the size: "A>movcpm 56 *" in which the "56" means that you want to generate a 56K CP/M system and the "*" specifies that the image is to remain in low memory, where it's not to be relocated or executed.

You can also use an asterisk in the memory field if you want to simply use all available memory: "A>movcpm * *" (takes 64K in a 64K system, 48K in a 48K system, etc.). In our particular case, we can't do this because the upper 8K in our computer, although present, is used for special video drivers. (The routine determines how much memory the computer has by testing higher and higher addresses to see if it can put something into and read it out of each location. When it no longer can, that's the top of memory.)

In moving this image of CP/M to high memory, MOVCPM starts off with all 8080 instructions written as if they were in a 20K system. It then determines the difference ("bias") between a 20K system and the size we specified, like 56K. Finally, it uses the bit map to change only those bytes that represent addresses in the code (the last two bytes of a jmp instruction, for instance). That's it. The resulting new image sits in low memory waiting for the next thing we want to do with it. Even though the addresses are changed—as if the bios were in high memory—it isn't actually moved there.

Now we save this image, using the SAVE utility. MOVCPM is very helpful

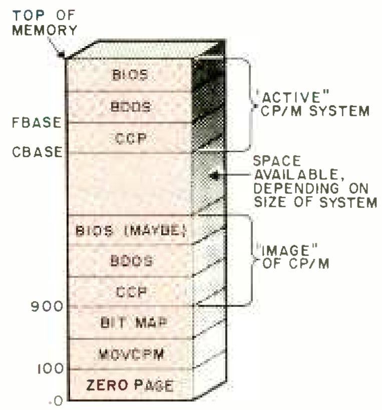


Fig. 22. The system image of CP/M.

here because it tells us just what to type:

```
A>movcpm 56 *
CONSTRUCTING 56K CP/M
  vers 2.2
READY FOR "SYSGEN" OR
"SAVE 45 CPM56.COM"
A>
```

At the A> prompt, we type "save 45 cpm56.com". The image is 45 256-byte "pages" long, and MOVCPM suggests that we call the file "CPM56.COM".

Urge to Merge. Once we have the CPM56.COM file of the CP/M image safely stored on disk, we merge the BIOS.ASM file, which we've modified by putting our new driver into it, into CPM56.COM. To do this, we use a special technique in DDT and the magic number, N. Then we take the resulting complete image and write it onto the system tracks of a formatted, blank disk, using SYSGEN. We'll call this file "CPM56n.COM," where *n* is "new."

The Magic Number N. N is simply the difference between where MOVCPM puts the CP/M image and where CP/M actually goes in high memory, as shown in Fig. 23. Notice here how the CP/M image placed in low memory by MOVCPM is related to the CP/M image that will be placed on the system tracks of the new disk. This new image will occupy exactly the same addresses as the CP/M currently running in high memory, except for the changes made to BIOS by the new driver.

CCP is located at 980H in the system image but will be at BC00H in our 56K system when actually installed and running; BDOS is located at 1186H in the image but will be at C406 when running, etc. You can see that all these pairs of numbers are related by the same constant, which can be found by subtracting any two of them.

Finding Addresses. To find the magic number N, we must know at least one pair of addresses—one in the MOVCPM image in low memory, the other in running CP/M in high memory. A good one to work with is CBASE, which is the bottom of CCP. The first half of this is easy because in the system image, CCP is always at 980H, no matter what size system you have. CBASE for high memory isn't quite so easy to find. However, if you examine locations 6H and 7H in memory while CP/M (not DDT) is running, you'll find an address that's close to the start of BDOS. CCP is usually about 800H bytes long; so if you subtract 800H from this address, you obtain CBASE, in our case, C406 − 800 = BC06. Knowing that CCP starts on a page boundary, we figure it's probably at BC00H.

Another way to find CBASE is to examine the BIOS.PRN (not ASM) listing. CBASE and several other fascinating addresses are often part of the address location arithmetic in the beginning of the file. Checking this file, we find that BC00H is, in fact, the start of CCP.

DDT has a handy function that performs arithmetic on hexidecimal numbers. While in DDT, you can use this function by typing "hx,y" after the - prompt, where *x* and *y* are four-digit hex numbers. For any two hex numbers, DDT will print out the sum (x + y) and difference (x − y). In this case, we want to know the difference between, say, 980H and BC00H. It would also be nice if we obtained a negative number so we could later simply add it to other numbers to perform the conversions.

If you type "h980,bc00" after the DDT prompt, DDT would respond with "C580,4D80". It's the latter difference number, 4D80, we want, which is our so-called "magic" number. We must know this number for two reasons. First, we want to be able to look at certain sections of code in the MOVCPM image in low memory and know what we're looking at. We know where things are in BIOS in high memory, from BIOS.ASM, and we must be able to translate this into equivalent locations in low memory. The magic number does this, as we shall see.

The second reason we must know this number is that we're going to use DDT's ability to load a HEX file with a "bias" (offset) instead of at the ORG address of the file. Thus, if we have a HEX file ORGed at, say, D200 and we want to load it into memory somewhere else—say, at 1F80—we simply find the difference between these two numbers and type it into DDT following the *r* (read) command. As you can see, this is the same old magic number, 4D80. For example, if we want to load with bias a HEX file called NEWBIOS.HEX that is ORGed at D200, we'd do the following:

```
-inewbios.hex
-r4d80
```

and the file will be placed in memory at location 1F80.

Inserting the New Driver. At this point, you should have a working driver routine that you're ready to insert into your CP/M operating system. The first thing you want to do is create a new version of the BIOS.ASM file, one that incorporates the new driver. (Remember that this file might have a different name, depending on your system, such as BIOS.ASM, GBBIOS.ASM, etc.)

Start by making a copy of the old BIOS.ASM file and call it newbios.asm by typing "pip newbios.asm= biosio.asm" after the A> prompt. Bring NEWBIOS.ASM into your word-processing or text-editing program. Delete the program lines for the existing driver. Then either type in the assembly code for the new driver or, if your word processor will permit it, copy the file containing the new driver directly into the correct location in NEWBIOS.ASM. Also, if you have to add anything to the initialization part of BIOS, to get the UART off on the right foot, now is the time to do it.

Reassemble the new BIOS by typing "asm newbios" after the A> prompt. You now have NEWBIOS.HEX and NEWBIOS.PRN files. You can now use MOVCPM to create the CP/M image, as described above. If you already have the system image (CPM56.COM or whatever) stored as a file, you can skip this step.

You're now going to use DDT to do the actual merging of the new driver into the system. Load the system image as you call DDT by typing "ddt cpm56.com" after the A> prompt. (Don't forget that the number after cpm in the file name will be different for different-size memory systems.) To make certain that everything is where you think it is, use DDT to explore this image by looking at the beginning of CCP, as shown in Fig. 24. It should be the same as the running CCP in high memory. You can check this out by typing

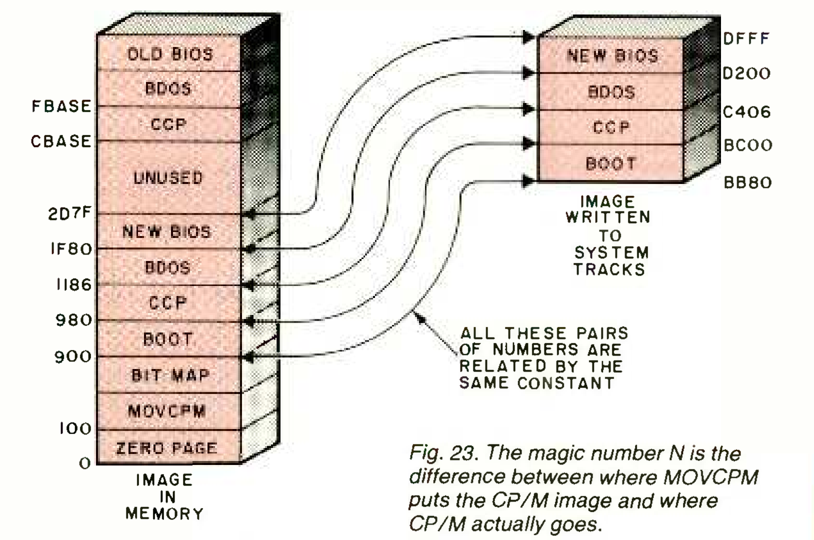


Fig. 23. The magic number N is the difference between where MOVCPM puts the CP/M image and where CP/M actually goes.

a"dbc00" after the DDT prompt; it should be as in Fig. 25. Note that the address column, should now read "**BC00, BC10, BC20**, etc." instead of the low-memory addresses.

Using the *d* command lets us see that the sign-on message is really there. Check the beginning of BIOS to see if this is where the jump table is:

```
-l1f80
1F80 JMP D3D3
1F83 JMP D334
1F86 JMP DE79
1F89 JMP DE7C
(etc.).
```

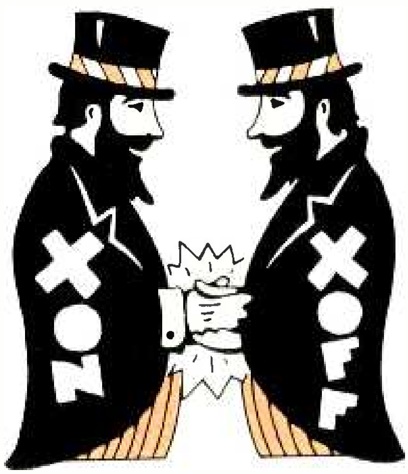
A look at the running BIOS in high memory should be the same, again with exception of the addresses. Now find the older driver routine, if there was one, in the system image and in the running BIOS. They may not be the same.

Merge In New BIOS File. We're now going to use DDT to merge the NEWBIOS.HEX file into the CP/M image in low memory. This is where we use offset number N. Although NEWBIOS.HEX is ORGed in high memory (at DE70 in our case), we want to lay it down on top of the BIOS part of the system image in low memory (at 2BF0 in our system).

Type "inewbios.hex" after the DDT prompt to put the file name in FCB. Then type "r4d80" to read in the file with an offset of 4d80. Now look at the image with the *l* command to ascertain that the new driver is where you want it to be. If it is, you're ready to save the image as a file back onto the disk:

```
-g0
A > save 45 cpm56n.com
```

The 45 is the same number of 256-byte pages that MOVCPM told you to save; this number will remain the same unless your modification has expanded BIOS past a page boundary. The *n* simply means "new."



XON/XOFF protocol.

We're now ready to create a new system disk. Start by placing in drive B a formatted disk. SYSGEN is often used to simply copy the current CP/M system from the system tracks of the working disk to those of a formatted disk. In that case, no file name is specified when SYSGEN is called. However, we want to use the CPM56n.COM file when we generate our new system; so we type "sysgen cpm56n.com" after the A > prompt (don't forget the *n*). SYSGEN will reply as shown in Fig. 26. Note that you must type a *b* to specify the destination drive and a RETURN once the destination disk is on B:. SYSGEN will write the new version of the operating system onto the system tracks of the new disk.

You're done! You now have a new custom-configured operating system that you've made yourself. Test it using DIR, and use TYPE to see if it will really print out when you toggle your printer with a ctrl-p. If you're testing an xon/xoff or etx/ack printer, you'll have to send enough characters at one time to fill up the print buffer.

Driver Installation Summary. Once you become very familiar with this installation process, this is what you'll be typing on-screen. (We're assuming you aren't going to check memory at all with DDT.) Of course, memory size and the number of pages to SAVE will depend on your specific system.

```
A > pip newbios.asm=biosio.asm
```

You add your driver to NEWBIOS.ASM with a word processor and then store the revision as NEWBIOS.ASM:

```
A > asm newbios

A > movcpm 56 *
A > save 45 cpm56.com
```

These last two steps won't be needed every time.

```
A > ddt cpm56.com

-inewbios.hex
-r4d80
-g0

A > save 45 cpm56n.com

A > sysgen.
```

That's all there is to it. By going through this procedure a few times, you'll be gaining valuable understanding of the BIOS in general and experience in manipulating it according to specific needs.

Comes the End. This concludes our series, which was excerpted and condensed from the forthcoming book *The Soul Of CP/M*. We've covered here only highlights of portions of what the book covers in greater detail. We hope you've enjoyed your journey through the fascinating realm of CP/M and have added considerably to your knowledge of this powerful popular operating system for small computers. ◇

```
-d980
0980  C3 5C BF C3 58  BF 7F 00 20 20 20 20 20 20 20 20 .\..X...
0990  20 20 20 20 20  20 20 20 43 4F 50 59 52 49 47 48     COPYRIGH
09A0  54 20 28 43 29  20 31 39 37 39 2C 20 44 49 47 49 T (C) 1979, DIGI
(etc.)
```

Fig. 24. The image at the beginning of CCP.

```
-dbc00
BC00 C3 5C BF C3 58  BF 7F 00 20 20 20 20 20 20 20 20 .\..X...
BC10 20 20 20 20 20  20 20 20 43 4F 50 59 52 49 47 48     COPYRIGH
BC20 54 20 28 43 29  20 31 39 37 39 2C 20 44 49 47 49 T (C) 1979, DIGI
(etc.)
```

Fig. 25. The running CCP in high memory.

```
SYSGEN VER 2.0
DESTINATION DRIVE NAME (OR RETURN TO REBOOT)b
DESTINATION ON B, THEN TYPE RETURNRETURN
FUNCTION COMPLETE
DESTINATION DRIVE NAME (OR RETURN TO REBOOT)RETURN
```

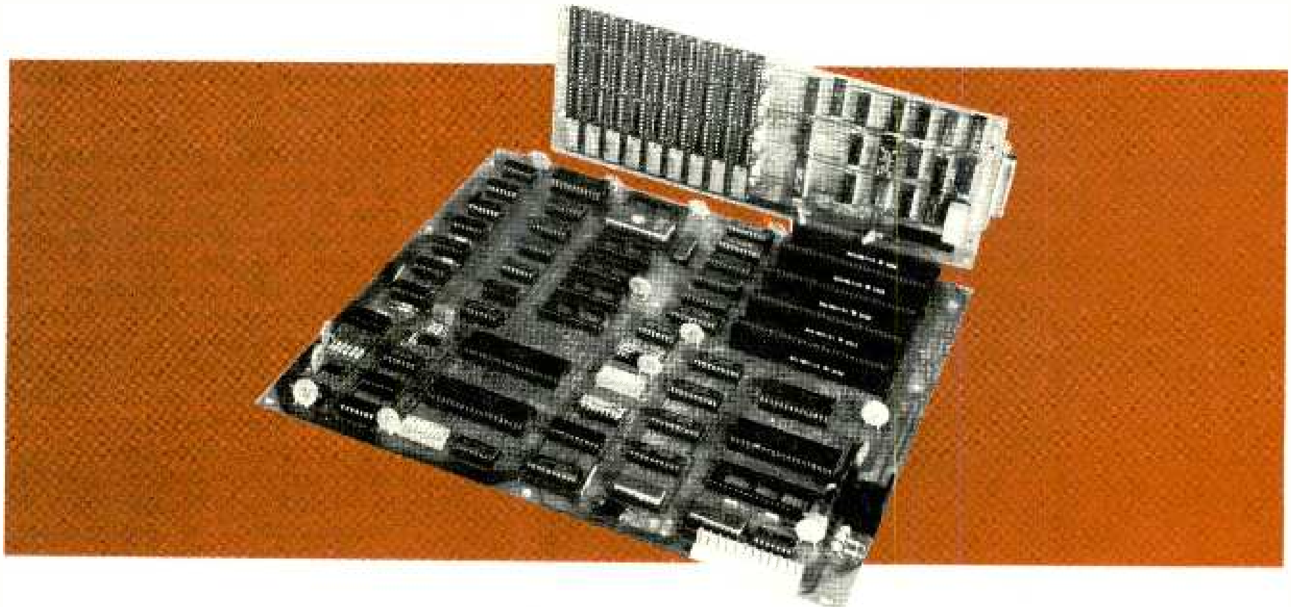
Fig. 26. SYSGEN replies to the prompt for the new file.

Learning

16-BIT MICROCOMPUTER TECHNOLOGY

Part 6: How to Use Machine Language Programming

By George Meyerle



PREVIOUS articles in this series should have convinced you that, before you can understand, repair, or design microcomputers that use the latest generation of hardware, you must have had at least an introduction to machine/assembly language programming. By using machine language subroutines in conjunction with BASIC or other high-level languages, it is possible to increase execution speed and, in some cases, allow operations that are not possible using the high-level interpreter alone. This month we will discuss how to learn machine-language programming painlessly and we will gain some practice using it with the monitor program resident in the IBM-compatible, 16-bit Explorer 88/PC microcomputer.

Quickly reviewing the design of the Explorer 88, recall that it can be set up to operate in 3 different modes. The first, and least expensive mode ($400), allows accessing the monitor program using a standard terminal connected to the RS232 port. The second choice (about $600 more) is to add an IBM-compatible keyboard, color board, and either a color or black/white monitor. This gets you that much closer to being truly IBM-compatible. The next step involves the addition of a floppy-disk card and up to four floppy drives. At this point, you can run IBM-PC DOS or any of the many IBM-compatible disk operating systems, including Digital Research CP/M-86, all of which include fine monitor or debugging programs. The following applies to any configuration selected.

Monitor Programs. In its simplest form, a monitor program is a collection of routines that allow programs to be generated, tested, modified, and saved for future use. The original microcomputer monitors consisted of a front panel array of switches and LEDs that allowed access to the CPU and memory. However, the flashing LED approach was hard to use and scared away many casual observers. On the other hand, ROM-based monitors, including that used in the Explorer 88, are easy to use and understand; and, with a litle practice, you should be able to write short programs in 16-bit 8088 machine language. Since it is not practical to write long programs or subroutines without the help of an assembler, once the basics are learned, it is suggested that you invest in one of the many available assembler programs.

Monitor Overview. All 8088 microprocessors auto-boot on power-up or reset to location FFFF0H. This location, in the Explorer monitor, contains a jump to location FE000H which is the beginning address of the upper-most 8K of ROM and of the monitor program

TABLE VI—I/O PARAMETER SETTINGS

Baud rate	S1-3	S1-2	S1-1
110	On	On	On
150	On	On	Off
300	On	Off	On
600	On	Off	Off
1200	Off	On	On
2400	Off	On	Off
4800	Off	Off	On
9600	Off	Off	Off

Parity disabled: S1-4 on
Parity enabled: S1-4 off
Parity odd: S1-5 on
Parity even: S1-5 off

TABLE VII—MEMORY MAP

00000-0FFFF	RAM
FE000-FFFFF	ROM
00000-00003	Divide-by-zero interrupt
00004-00007	Single-step interrup
00010-00013	Overflow interrupt
0000C-0000F	Monitor-trap
00010-0002F	System
00030-00033	UART interrupt
00034-0FEFF	System

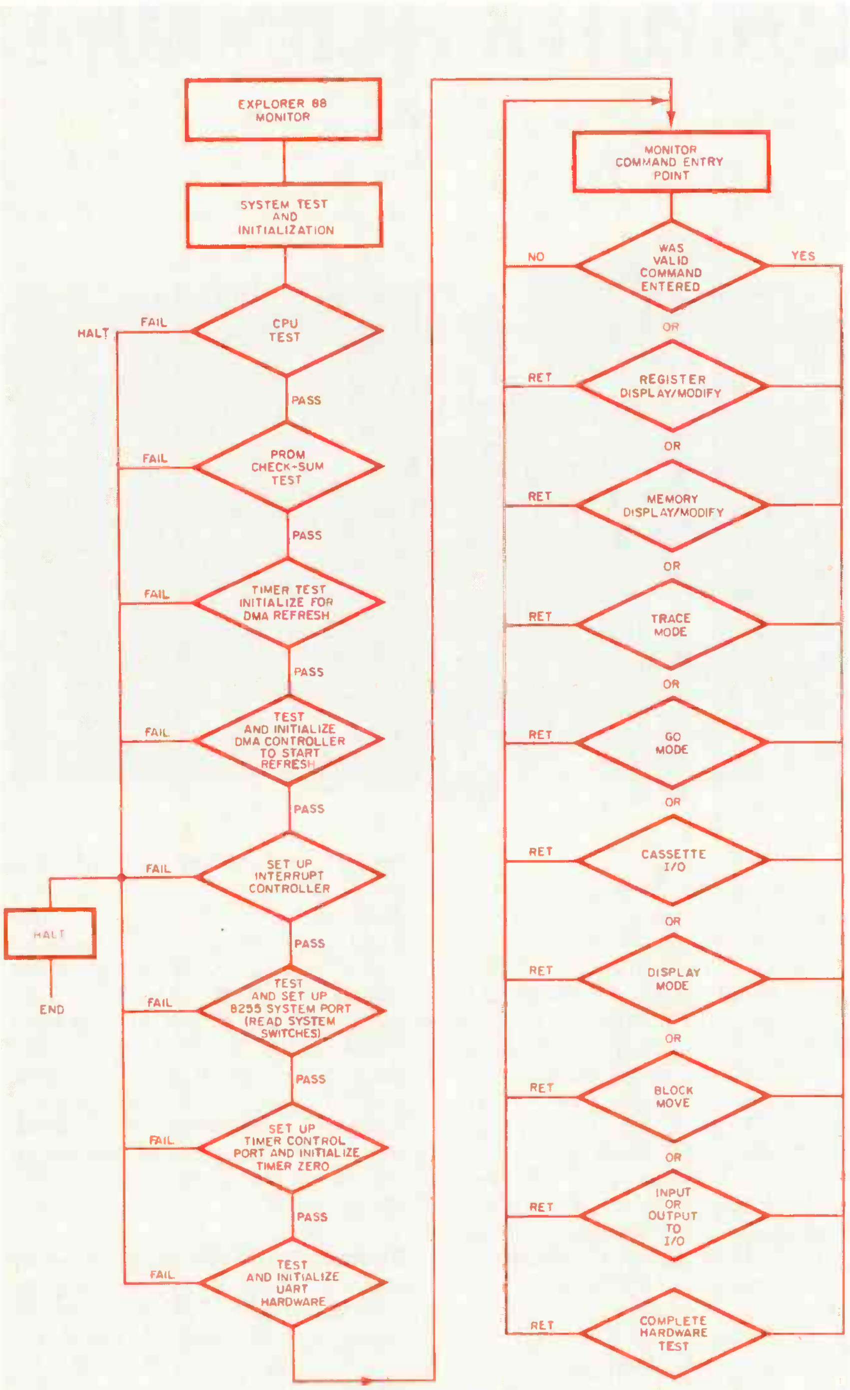


Fig. 18. Flowchart of the monitor program.

whose flowchart is shown in Fig.18. Note in this flowchart that, before the program is ready to accept commands from the keyboard, a preliminary hardware check is made. If any hardware test fails, the CPU is automatically halted. The program begins by checking the CPU. All registers, including the flags, are tested. If they are OK, the program continues with a PROM check-sum test. This adds the contents of all 8K of ROM and compares the results with the correct answer.

The next component tested is channel 1 of the timer. If the timer test is OK, channel 1 is programmed to provide the refresh clock signal to the DMA controller. Next the DMA controller is tested. The count and command registers are tested by writing various patterns and then checking the results by reading the registers. If all tests are passed, the count register is set for a 64K system and channel 0 is enabled so that the RAM refresh process can begin.

The program then sets up the interrupt controller mode registers and masks off all interrupts. This is followed by the initialization of the 8255 system and timer control ports. The monitor then sets up the data and stack segment registers and the stack pointer. It also clears the console input and output buffers. The 8250 UART is then initialized. This process involves reading the switch #1 at port B of the 8255. These switch settings determine the baud rate and parity selections (Table VI) to which the UART will be initialized. The monitor also downloads the interrupt jump vectors to the lowest locations in RAM as shown in the memory map in Table VII. Note that the top 256 bytes in the first 64K bank are reserved for the stack and other monitor operations.

After testing the hardware and setting the UART, the monitor idles at the Command Entry Point awaiting entries from the keyboard. The program is set up so that it will only accept valid commands. All invalid entries will result in the display of "??" and the abortion of the process attempted. Valid commands are:

D	Display memory contents
R	Register display/modification
B	Block move of memory
M	Memory modification/display
I	Input one byte from an I/O device
O	Output one byte to an I/O device
CO	Cassette output from memory to cassette
CI	Cassette input from cassette to memory
T	Trace instructions
TR	Trace instructions with register report
G	Go run from memory with optional breakpoint
GR	Go run from memory with optional breakpoint and register report
HT	Hardware tests of ROM, RAM, cassette, interrupt controller, timer, DMA controller and UART.

In future issues, we will show how to use the ROM-based monitor in practical programming.

(To be continued)

TELETEXT EXPERIMENTS BY NETWORK

Computers may cover the world on this latest communication network, now being tested in the U.S.

By Leslie Solomon

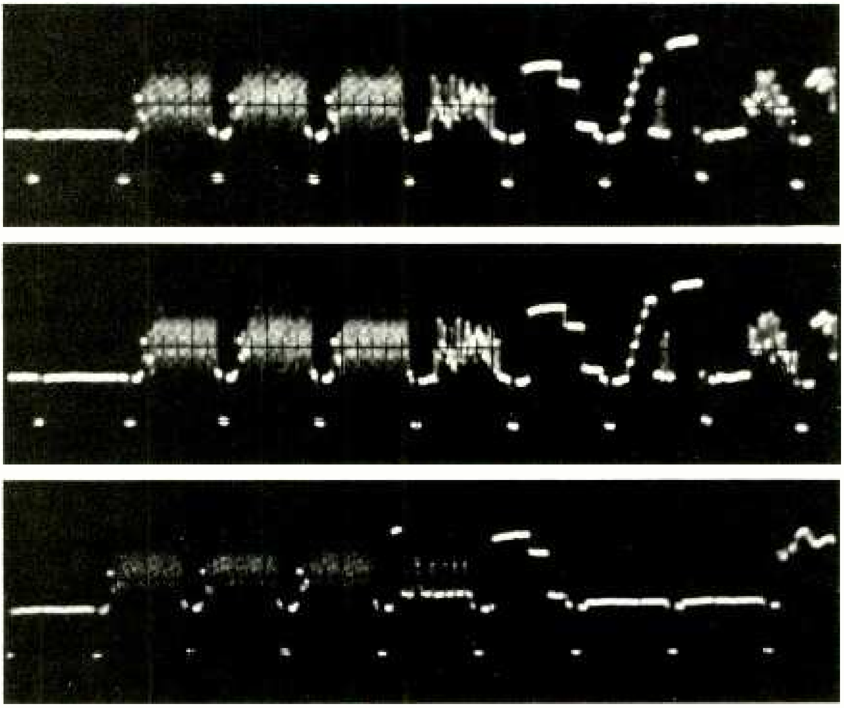
While we computer types have been busy designing new computers and putting new software together, others have also been very busy (and very quiet) doing something that might affect the future of computing as we know it.

A couple of times during the past few years, I have written about signal activity during the vertical interval of the NTSC TV signal. To see this interval and the activity, all one has to do is adjust the vertical speed of any TV receiver until the wide, dark horizontal bar appears in the display area. This dark bar is the vertical interval and it occupies some 20 horizontal lines. If you look at the lines immediately above the picture, you will see several strange-looking sets of dots and bars, some in color and some appearing to be in motion. If you have a good scope and access to the receiver video signal, you can take an even closer look at the interval between the vertical sync and the beginning of the next field's video information.

Until recently, the vertical interval contained engineering test signals such as multiburst, color bar test, a composite test signal, VIR (for auto color setting), and various forms of digital test signals used by the networks—nothing very exciting except for those people interested in such doings.

Most of us have heard of "Teletext," and usually associated it with happenings in European TV—the BBC has been using it for years, and the French have been involved with their Antiope approach. Some might have even been aware that there is some Teletext activity next door in Canada, and that Japanese stations were testing a form of this new digital signal.

Now, Teletext is here in the USA, and being tested by NBC and CBS. If you take a look at lines 15 through 18 of the current vertical interval being transmitted by these networks, you will see some full lines of very busy signals. An example of each is shown in the accompanying photos. The Teletext signals occupy the four horizontal line intervals leading up to the conventional test signals. (If you are looking at the interval on a TV receiver, the Teletext signals are those "grassy" lines slightly above the top of the picture.) These signals are not to be confused with the closed captioning currently used by ABC and PBS as an aid to the deaf.



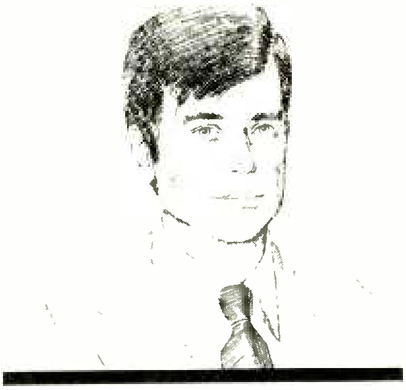
Top and center are Teletext signals on NBC and CBS respectively. At bottom are closed-caption signals on PBS.

According to the North American Broadcast Teletext Specification, this activity may be extended to encompass lines 10 through 14, and may even reach the full field. Hardware people should keep in mind that this data is being transmitted through a 4-MHz channel (begins to look like a disk to you?).

What is being transmitted? At the present, only test data. But even this can consist of a very large number of pages, selectable via a hand control attached to the TV decoder. The user can page through the system in the same way as paging through the menus on The Source, Compuserve, or any other data base, and thus pick and choose his/her subjects. Unlike the data base, the received data can be in color, and even reasonably high-resolution color graphics can be displayed (using the color-TV receiver as the monitor). And there is almost no end to the number of pages that can be sent. Page updating can occur in real time as fast as someone can type.

It is not beyond the range of probability that a computer can be used to download data from this TV source, with all types of software being made available. Furthermore, with a telephone attachment, interacting (or even data storage) can be attained. One other thought: now that we have battery-powered TV receivers, battery-powered computers, and direct satellite-to-home TV in the offing, we are in a position to have worldwide software distribution. Computers will really cover the world in the very near future, even if you are in a canoe paddling up the Amazon.

We shall have to keep an eye on further Teletext operations. ◇



Flat-Panel Displays
A Tunable 60-Hz Hum Filter

By Forrest M. Mims, III

Flat-Panel Displays Will Revolutionize Information Processing

MORE and more new products are exploiting the rapidly advancing state of liquid-crystal and other flat-screen display technologies. These products will revolutionize the way many of us process information both at home and at work.

They will, for instance, make "personal" computers truly personal. After all, have you actually considered as "personal" a computer system that fills a tabletop with its television monitor, keyboard, disk drives, and other paraphernalia, all connected by a bird's nest of cables and wires?

Portable computers with all the features of today's desktop units will be made possible in part by large-capacity liquid-crystal and other flat-panel displays. Applications for these portables will go beyond the standard word-processing, spreadsheet, and communications packages. For example, a portable computer with a flat-panel display could be used as an oscilloscope.

The display on the new Radio Shack Model 100, for example, has 64 by 240 or 15,360 elements or pixels (Fig. 1). This is more than adequate for a low-resolution solid-state oscilloscope. Indeed, many of you may recall the series of "Experimenter's Corner" columns several years ago in this magazine in which I described various kinds of do-it-yourself flat-screen LED oscilloscopes. The maximum resolution of those simple scopes was only 10 by 16 elements.

Considering the peripherals already available for existing personal computers, one can envision a new family of highly sophisticated peripherals for the new generation of portable computers represented by machines like the Model 100.

For example, consider the Model 85 aScope™ module that transforms the Apple II into a powerful, programmable dual-trace oscilloscope with memory capability and a 50-MHz bandwidth. This computer accessory, which is made by Northwest Instrument Systems, Inc. (PO Box 1309, Beaverton, OR 97075), and others like it have greatly expanded the potential role of personal computers and, at the same time, alarmed makers of conventional test equipment. And if the conventional test equipment companies are worried now, just wait until instrumentation peripherals become available for the portables (rest assured they will).

Hopefully by now you can understand my enthusiasm for the new flat-panel display technology. But you'll have to actually see and use a product with a large-capacity flat-panel display to fully appreciate the convenience and portability it offers. You'll probably have that opportunity soon, considering the rate at which new products are being announced. Meanwhile, let's examine some of the technical aspects of flat-panel displays.

Liquid-Crystal Displays. Thus far liquid crystals are dominating the commercial flat-panel display market. A few years ago makers of the comparatively simple liquid-crystal readouts used in digital watches took a beating due to severe competition. Many companies either abandoned or were forced out of the liquid-crystal readout business.

The market for high-resolution, flat-panel, liquid-crystal displays, however, was unaffected by this development. The market for non-watch liquid-crystal displays, for example, more than doubled between 1980 and 1982.

Among the first commercial "high-resolution" liquid-crystal displays was the 16 by 16 element unit used in Milton-Bradley's "Blockbuster" handheld game. I was so impressed when this toy was introduced several years ago that I immediately bought one for my son. Today, of course, the resolution of the "Blockbuster" screen is downright primitive when compared to the 220 by 240 display elements (pixels) of Toshiba's handheld television receiver. This receiver's two-inch screen is made by applying a thin film of nematic liquid crystal to a 51.4 by 41.4-mm silicon chip containing an array of 220 by 240 PMOS switching transistors.

A single pixel consists of a PMOS transistor and a capacitor. When the gate of the transistor is strobed by the video scan signal, the capacitor is charged to the appropriate video signal level. The capacitor holds its charge until refreshed by the next strobe signal.

Toshiba's researchers found that the electrodes that interconnect the picture element transistors must be highly reflective and as smooth as a mirror. Otherwise, undesirable scattering of light within the display would greatly reduce its apparent contrast. They eventually selected platinum for the reflective electrode since it appears very white and is therefore well suited for a black and white television display.

Figure 2 is a simplified block diagram of Toshiba's display chip. Note the presence of two gate bus drivers (to address the rows) and connections to both ends of the drain buses (to address the columns). This redundancy is part of a clever design ploy to salvage chips that may have defective bus driver elements or bus lines. Such built-in redundancy has become a standard design technique for very large scale integrated circuits

Fig. 1. Radio Shack's Model 100 has an LCD with 15,360 pixels.

(VLSI), especially memory chips.

Figure 3 is a cross section of the edge of the Toshiba display. The silicon chip, which is very thin and fragile, is mounted on a very flat and sturdy glass substrate. A 10-micron layer of mixed nematic liquid crystals is applied to the chip. The assembly is topped by a protective window that includes a transparent conductive film on its inner surface. This provides the display's counter electrode.

Since the chip includes its own gate bus drivers, actually multiplexers, only twelve bonding pads are necessary to access all 220 gate buses. Only one of the two gate bus drivers is used in practice, so only six of the bonding pads are required!

Toshiba's display is typical of what can now be done with high-resolution liquid-crystal flat-panel displays. Its display achieves a contrast ratio of 20:1 and has a response of only 30 ms. While I've not been able to determine the power consumption of the display alone, the complete miniature television receiver in which it is used consumes only 1.3 W. This is certainly higher than a portable radio of similar size, but it is less than the 1.8 W consumed by Sony's miniature television, which uses a flat cathode-ray tube.

After miniature computers and television receivers, a third major market for flat-panel liquid-crystal displays is compact oscilloscopes. The pioneer in this field is England's Royal Signals and Radar Research Establishment. Display technology developed there has been used by Scopex, Ltd. to produce the Voyager flat-screen scope.

The Voyager has a screen resolution of 128 by 256 elements for a total of 32,768 pixels. Easily viewed in bright sunlight, an advantage shared by most liquid-crystal displays, the Voyager has a frequency response of 150 kHz and weighs 2.5 kilograms. It operates for up to 12 hours from self-contained rechargeable batteries.

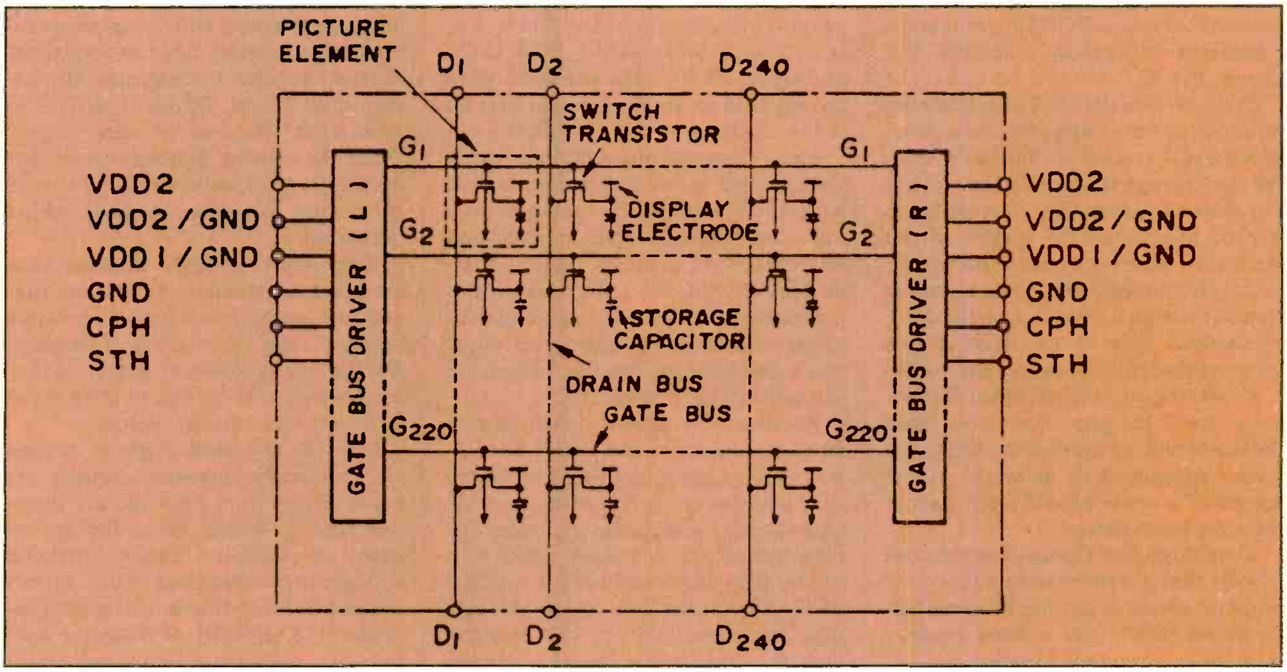
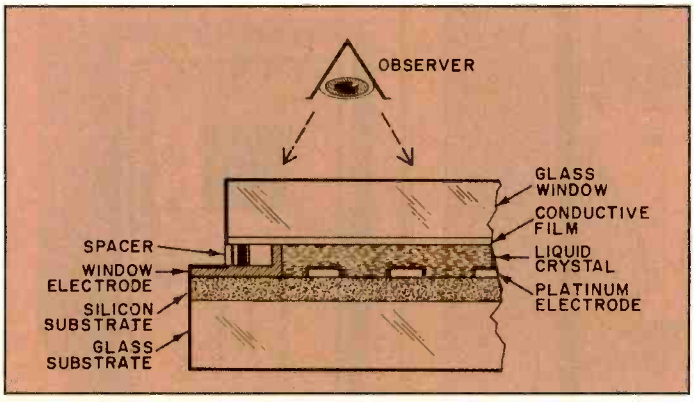
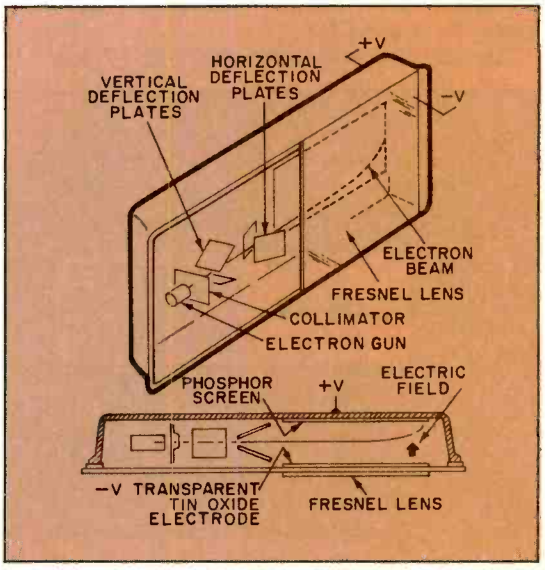


Fig. 2 (above). Toshiba's liquid crystal display.

Fig. 3 (below). Cross section of Toshiba's LCD.

Fig. 4 (right). Construction of Sinclair flat CRT.





At $6000 the Voyager is not intended for the general market. Instead, it's targeted for use in explosive atmospheres and for applications requiring the ultimate in portability. Considering the rapid advances in flat-panel display technology, I'm sure it's only a matter of time before compact battery-powered scopes with liquid-crystal displays become available for a few hundred dollars.

Other Flat-Panel Displays. Considerable work has been undertaken over the years to develop various kinds of flat-panel displays. Most effort has centered around the ubiquitous cathode-ray tube (CRT). Among the first firms to develop a viable flat-panel CRT for miniature equipment is England's Sinclair Research (Fig. 4).

In a conventional CRT, electrons are propelled at right angles toward a phosphor-coated screen. In Sinclair's tube, the electron gun is located to one side of the phosphor screen. The electron beam is propelled across the surface of the screen and then bent toward the screen by an electrostatic field. The screen is viewed through a window coated with a transparent film of tin oxide which serves as one of the focusing electrodes.

According to Sinclair, since the observer views the phosphor screen from the side struck by the electron beam, the screen appears twice as bright as the screen of a conventional CRT having the same beam energy.

Though Sinclair Research announced in 1981 that it was entering a four-year program aimed at putting its miniature flat-screen CRT into volume production, Japan's Sony Corporation was the first company to introduce a miniature television receiver using a remarkably similar flat-screen CRT.

The operating principle of the Sony tube is virtually identical to that of the Sinclair tube. The only significant difference between them is their physical appearance. The Sinclair tube is shaped like a flat rectangle. The electron gun of the Sony tube is enclosed in a neck-like extension projecting from one side of the square display portion of the tube. Figure 5 illustrates the physical difference between the two tubes.

Figure 6 shows a demonstration version of still another kind of flat-panel display, a plasma dot-matrix readout panel made by Sigmatron Nova (1901 Oak Terrace Lane, Thousand Oaks, CA 91320). The Sigmatron displays are available with from 1.3 to 150 cm^2 of active display area. At least two versions are now in production. Model TE 1 × 32 is a 32 by 32 array having 1024 pixels, and Model TE 1 × 56 is a 56 by 56 array having 3156 pixels. Both arrays have an active display area of 2.6 by 2.6 cm.

These demonstration plasma panels are installed in an enclosure complete with 12-V rechargeable batteries, analog and digital input ports, and microprocessor routines derived from an 8K EPROM and a 4K RAM. Demonstration routines include alphanumeric characters, graphics, scrolling, and a real-time oscilloscope. These are just some of the possibilities.

Because of the nature of their written language, Japanese companies have always been highly motivated to design very high-resoluion flat-panel displays. One of their latest entries in plasma display technology is a Sony panel with 512 by 1024 addressable dots for a total of 524,288 pixels! This remarkable display has a resolution of 127 lines per inch. It easily displays complex Chinese and Japanese characters and provides excellent graphics capabilities.

Other flat-panel display technologies are also being developed. Although considerable work has been expended on light-emitting diode arrays, they require much more operating current than most other displays. More promising are electroluminescent and cathodoluminescent devices. We will probably hear more of this in the future.

Comparing Flat-Panel Displays. Each of the various flat-panel technologies has relative advantages and disadvantages. Liquid-crystal panels use very little power and are ideal for battery-powered equipment. Furthermore, they are easily viewed in direct sunlight, something that surely cannot be said of some light-emitting displays.

On the other hand, liquid-crystal displays are relatively fragile and temperature sensitive. And they can sometimes be tricky to view. For example, the display of the Model 100 can be difficult to view when observed at some angles. When the external lighting is just right for the operator, others wishing to read the display may have to stand behind the operator.

Light-emitting diode displays have the potential of being much more rugged and having much longer operating lifetimes than other kinds of displays. But they are expensive to make and they use considerable current so their popularity depends on these factors.

Like liquid-crystal displays, plasma and cathodoluminescent displays are made largely from glass and are therefore fragile. Worse, these displays require considerably higher operating voltages than those using liquid crystals or light-emitting diodes. This greatly increases the difficulty of designing suitable drive circuitry. Electroluminescent displays are sturdier than those that require glass packaging, but they, too, require relatively high drive voltages.

(Continued on page 100.)

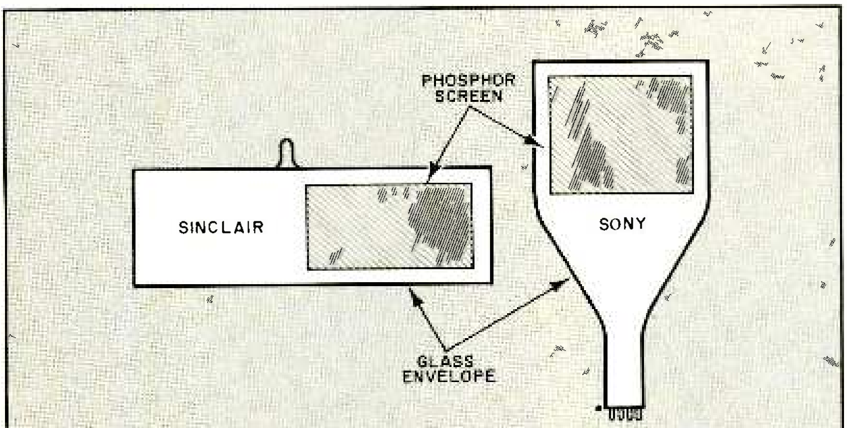


Fig. 5. Comparison of Sinclair and Sony miniature, flat CRTs.

Fig. 6. Sigmatron Nova hi-res plasma display demonstrator.

An Easily Adjusted Switched-Capacitor 60-Hz Hum Filter

In the "Project of the Month," in September 1982, I described two active notch filters designed to block 60-Hz hum. Both these filters used a single operational amplifier and six or seven outboard resistors and capacitors.

Newly developed switched-capacitor filters such as National Semiconductor's MF-10 can provide improved 60-Hz hum rejection. A basic 60-Hz notch filter requires only three external resistors and *no* capacitors. A 300- or 600-Hz clock signal is required, however, so there are no component savings over conventional op-amp 60-Hz notch filters.

Though they are more expensive than conventional op-amp active filters, the center frequency (f_o), gain, and Q of a switched-capacitor notch filter are all easily adjusted. This means virtually any degree of 60-Hz rejection can be achieved. Furthermore, a switched-capacitor notch filter designed for 60-Hz rejection can be easily retuned to reject any frequency up to 30 kHz.

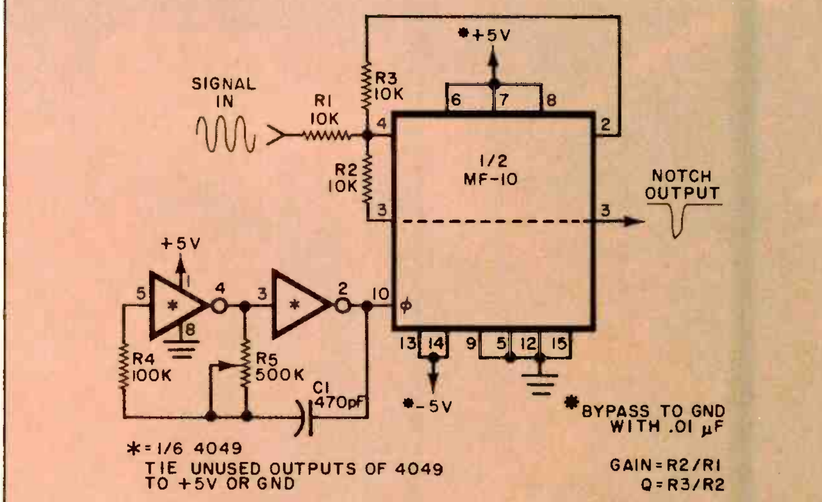


Fig. 7. Switched capacitor 60-Hz hum filter.

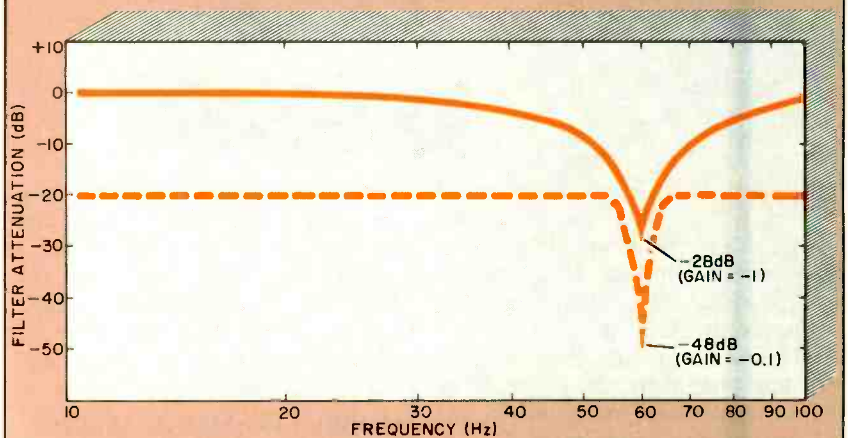


Fig. 8. Frequency response of filter in Fig. 7.

How it Works. Figure 7 is the circuit for a straightforward 60-Hz notch filter designed around the MF-10. The filter, which is operated in the inverting mode, provides a voltage gain of $-R2/R1$. The Q is f_o/BW (bandwidth at the -3 dB points).

The solid line in Fig. 8 is a logarithmic plot of the frequency response I measured for the circuit in Fig. 15. The dashed line in Fig. 8 is a logarithmic plot of the filter's response when *R2* is reduced to 1K. This simultaneously reduces the gain to -0.1 and increases the Q to 10.

Notice the excellent sharpness of the second notch. Note also that both notches are precisely centered at 60 Hz and that their stopband and notch maximums are separated by 20 dB. (A voltage gain of 1 is 0 dB, and a voltage gain of ± 0.1 is -20 dB.)

The filter is calibrated by setting the clock adjust potentiometer (*R5*) to 100 times the desired notch, f_o, or about 6000 Hz. For best results, the filter should be fine-tuned with the help of a 60-Hz signal coupled into pin 4 of the MF-10 via *R1*. Adjust *R5* while observing the 60-Hz output waveform at pin 3 of the MF-10. The filter is precisely tuned when the amplitude of the wave is at a minimum.

The clock frequency of the test circuit I built was 5964 Hz when the filter was fine-tuned for a maximum notch at 60 Hz. This corresponds to a clock frequency-to-f_o ratio of 99.4:1. The MF-10BN chip I used is specified for a clock frequency-to-f_o ratio of 99.35:1, $\pm 0.6\%$ (pin 12 low). The particular chip I tried in building my circuit was within 0.1% of the specified ratio. ◇

ENGLISH BROADCASTS Audible in No. AMERICA

(Continued from last month)

By Glenn Hauser

TIME[1] EST	TIME UTC/GMT	STATION	QUAL.[2]	FREQUENCIES, kHz[3]
7:00 p.m.-4:00 a.m.	0000-0900	UN Radio	A	6055 (when in session)
7:05-8:55 p.m.	0005-0155	Spanish Foreign R.	B	11880, 9630
7:30-8:00 p.m.	0030-0100	R. Prague	C	6055
7:30-8:00 p.m. (+)	0030-0100	R. Budapest	B	17710, 15220, 11910, 9835, 9585, 6025 (Wed. & Sat.)
7:30-8:00 p.m.	0030-0100	La Cruz del Sur, Bolivia	D	4875 (Mon. only)
7:30-8:15 p.m.	0030-0115	BRT Belgium	C	11625, 9880
7:30-8:30 p.m.	0030-0130	HCJB, Ecuador	A	15175
7:30-9:00 p.m.	0030-0200	R. Mexico	C	17765, 15430, 11770, 9705, 5985 (Sat.)
7:30-9:30 p.m.	0030-0230	SLBC, Sri Lanka	C	15425
7:30-9:30 p.m.	0030-0230	BBC	A	15260, 15070, 11835, 11750, 9915, 9515, 9410, 7325, 6175, 6120, 5975
7:30-12:00 p.m.	0030-0500	HCJB, Ecuador	B	15155, 9745
7:50-8:15 p.m.	0050-0115	Vatican Radio	B	11845, 9605, 6015
8:00-8:20 p.m.	0100-0120	RAI, Italy	B	11800, 9575
8:00-8:25 p.m.	0100-0125	Kol Israel	A	11655, 9815, 7410
8:00-8:30 p.m.	0100-0130	R. Argentina	C	15345, 11710 (not Mon.)
8:00-8:30 p.m.	0100-0130	R. Japan	C	17755
8:00-8:30 p.m. (+)	0100-0130	R. Budapest	B	17710, 15220, 11910, 9835, 9585, 6025 (not Mon.)
8:00-8:30 p.m.	0100-0130	La Voz de la Mosquitia, Honduras	C	4910
8:00-9:00 p.m.	0100-0200	R. Canada International	A	9755, 5960 (Tue.-Sat.)
8:00-8:50 p.m.	0100-0150	V. of Germany	A	15105, 11865, 9590, 9565, 9545, 6145, 6085, 6040
8:00-8:55 p.m.	0100-0155	R. Prague	B	11990, 11970, 9740, 9630, 9540 7345, 6015, 5930
8:00-8:55 p.m.	0100-0155	R. Beijing	B	17855, 15120
8:00-9:00 p.m.	0100-0200	V. of Free China	C	17890, 15345, 11825
8:00-9:00 p.m.	0100-0200	V. of Nicaragua	B	5950
8:00-9:00 p.m.	0100-0200	R. Zinica, Nicaragua	C	6120 (variable; Tue.-Sat.) (time varies)
8:00-9:00 p.m.	0100-0200	VOA	A	21460, 17735, 7205, 6873-USB
8:00-9:00 p.m.	0100-0200	AFRTS, Los Angeles	A	25615, 21570, 15430, 15330, 11790, 6030
8:00-10:00 p.m.	0100-0300	WRNO, New Orleans	A	9705 (not all Eng.)
8:00-10:30 p.m	0100-0330	R. Australia	B	21740
8:00-11:50 p.m	0100-0450	R. Habana Cuba	B	17735, 9525
8:20 p.m.-12:10 a.m.	0120-0510	R. Belize	C	3285, 834
8:30-8:40 p.m.	0130-0140	V. of Greece	B	11645, 9865, 9420 (not Sunday)
8:30-8:57 p.m.	0130-0157	Austrian Radio	B	9770, 5945
8:30-8:55 p.m.	0130-0155	R. Tirana	B	9750, 7120
8:30-9:00 p.m.	0130-0200	R. Moscow	A	17700, 15425, 12010, 11780, 11770, 9710, 9700, 9610
8:30:-9:15 p.m. (+)	0130-0215	R. Berlin International	C	11975, 9730
8:30-9:30 p.m.	0130-0230	R. Japan	C	21640, 21610, 17825, 15195
8:30-10:30 p.m.	0130-0330	AWR, Guatemala	C	6090, 12180, 18270, 24360, 30450
8:45-9:15 p.m.	0145-0215	Swiss R. International	A	15305, 11715, 9725, 6135
9:00-9:25 p.m.	0200-0225	Kol Israel	A	12025, 11655, 9815
9:00-9:30 p.m.	0200-0230	R. Canada International	A	9755, 5960 (Sun. & Mon. also 15190, 11845, 9535)
9:00-9:30 p.m. (+)	0200-0230	R. Budapest	B	17710, 15220, 11910, 9835, 9585, 6025
9:00-9:30 p.m. (+)	0200-0230	R. Kiev	B	17900, 17860, 15180, 11770, 11720
9:00-9:40 p.m.	0200-0240	R. Polonia	C	15120, 11815, 9525, 7270, 7145, 6135, 6095 (length varies)
9:00-9:55 p.m.	0200-0255	R. Bucharest	C	11940, 11810, 9690, 9570, 9550 6155, 5990
9:00-9:55 p.m.	0200-0255	R. Beijing	B	15120
9:00-9:57 p.m.	0200-0257	R. RSA	B	9615, 6020, 5980
9:00-10:00 p.m.	0200-0300	VOA	A	21460, 17735, 7205, 6873-USB
9:00-10:00 p.m.	0200-0300	R. Moscow	A	17700, 15425, 12010, 11780, 11770 9700, 9610
9:00-10:00 p.m.	0200-0300	R. Nacional, Brazil	A	17830, 15290
9:00-10:00 p.m.	0200-0300	R. Korea	C	11575, 11810
9:00-10:00 p.m.	0200-0300	V. of Free China	B	11740 (via WYFR)
9:00-10:30 p.m.	0200-0330	R. Cairo	B	12000, 9475
9:00-11:00 p.m.	0200-0400	VOA to Latin America	A	17640, 15205, 9650, 6130, 5995, 1580
9:00-11:30 p.m.	0200-0430	AFRTS, Los Angeles	A	21570, 17765, 11790, 6030
9:00-12:00 p.m.	0200-0500	R. Australia	B	17795
9:15-9:30 p.m.	0215-0230	UN Radio	A	15435, 10869-SSB, 10454-SSB, 6190 (Sat.)
9:30-9:45 p.m.	0230-0245	R. Pakistan	C	21470, 21595, 17840
9:30-9:55 p.m.	0230-0255	R. Tirana	B	9750, 7120
9:30-10:00 p.m.	0230-0300	RAE, Argentina	C	15345, 11710, 6060 (not Mon.)
9:30-10:00 p.m.	0230-0300	R. Sweden	B	11705, 15420, 17840-SSB
9:30-10:00 p.m.	0230-0300	R. Lebanon	D	11955†
9:30-10:15 p.m. (+)	0230-0315	R. Berlin International	C	11975, 11890, 11840, 9560
9:30-10:25 p.m.	0230-0325	R. Nederland	A	9590, 6165 (Mon. 0230-0320)

...ENGLISH BROADCASTS

9:30-10:30 p.m.	0230-0330	BBC	A	(15070 from 0300) 11750, 9915, 9515, 9410, 7325, 6175, 6120, 5975
9:51-9:58 p.m. (+)	0251-0258	V. of Yerevan	B	17900. 17870, 15180
10:00-10:25 p.m.	0300-0325	R. Polonia	C	15120, 11815, 9525, 7270, 7145, 6135, 6095 (length varies)
10:00-10:25 p.m.	0300-0325	R. Mexico	C	17765, 15430, 11770, 9705, 5980 (Sun.)
10:00-10:30 p.m. (+)	0300-0330	R. Budapest	B	17710, 15220, 11910, 9835, 9585, 6025 (Mon; 0300-0312 Wed. & Sat.)
10:00-10:30 p.m.	0300-0330	R. Japan	C	17755
10:00-10:30 p.m. (+)	0300-0330	R. Canada International	A	9755, 5960
10:00-10:30 p.m.	0300-0330	R. Portugal	B	11925, 9765
10:00-10:30 p.m.	0300-0330	R. Australia to Antarctica	C	17750 (Fri.)
10:00-10:50 p.m.	0300-0350	V. of Free China	C	17800, 15345, 11825
10:00-10:55 p.m.	0300-0355	R. Prague	B	11990, 11970, 9740, 9630, 9540, 7345, 6015, 5930
10:00-10:55 p.m.	0300-0355	R. Beijing	B	17855, 17680, 15520
10:00-11:00 p.m.	0300-0400	VOA	A	21460, 17740, 9670, 7200, 6040
10:00-11:00 p.m.	0300-0400	TIFC Costa Rica	C	5055, (Mon. 0235-0435)
10:00-11:00 p.m.	0300-0400	V. of Free China	A	5985 (via WYFR)
10:00-11:00 p.m.	0300-0400	R. Baghdad	D	Some of: 21585, 15400, 11935, 9745
10:00-11:00 p.m.	0300-0400	HRVC, Honduras	B	4820 (Mon.)
10:00-11:00 p.m.	0300-0400	R. Uganda	B	15325 (irregular)
10:00-11:00 p.m.	0300-0400	V. of Turkey	B	17760, 11740
10:00-11:26 p.m.	0300-0426	R. RSA	C	9585, 7270, 5980, 4990, 3230
10:00-11:30 p.m.	0300-0430	VOA to Africa	A	15752-USB, 15240, 15185, 15175, 10877.5-USB, 10869-USB, 7280, 6035
10:00-12:00 p.m.	0300-0500	WRNO, New Orleans	A	6185 (not all Eng.)
10:00 p.m.-2:00 a.(+)	0300-0700	R. Moscow	A	17900, 15425, 15180, 15100, (12050 from 0330; 11750 and 11710 from 0530)
10:25 p.m.-fade	0325-	R. One, Zimbabwe	C	3396 (exc. Sun.)
10:30-10:55 p.m.	0330-0355	R. Tirana	B	7300, 6200
10:30-10:57 p.m.	0330-0357	Austrian Radio	C	9770, 5945
10:30-11:00 p.m.	0330-0400	U.A.E. Radio, Dubai	B	17775, 15300 (length varies)
10:30-11:30 p.m.	0330-0430	R. Cultural, Guatemala	B	3300 (Mon. 0030-)
10:30-11:30 p.m.	0330-0430	BBC	C	15070, 12095, 9410, 6175, 5975
10:30 p.m.-1:00 a.m.	0330-0600	R. Habana Cuba	A	11760, 17735
10:40-10:47 p.m.	0340-0347	V. of Greece	B	11645, 9865, 9420 (not Sun.)
10:50-11:10 p.m.	0350-0410	RAI, Italy	B	17795, 15330, 11905
11:00-11:30 p.m.	0400-0430	R. Bucharest	C	11940, 11810, 9690, 9570, 9550, 6155, 5990
11:00-11:30 p.m.	0400-0430	R. Norway	C	15175, 11870, 9610 (Mon.)
11:00-11:55 p.m.	0400-0455	R. Beijing	B	17680, 15120
11:00-12:00 p.m.	0400-0500	R. Sofia	B	11860†
11:00-12:00 p.m.	0400-0500	V. of Nicaragua	B	5950
11:00-12:00 p.m.	0400-0500	R. Australia	B	21680, 21650, 17795, 15320, 15160
11:00-12:00 p.m.	0400-0500	FEBA, Seychelles	C	11800, 15200 (Sat. & Sun.)
11:00 p.m.-1:00 a.m.	0400-0600	VOA	A	15205, 9670, 7200, 6040, 5995
11:00 p.m.-1:00 a.m.	0400-0600	TWR, Bonaire	A	9535, 800 (length varies)
11:15 p.m.-11:30 p.m.	0415-0430	R. France Int.	B	7135, 11735, 11875
11:30-11:57 p.m.	0430-0457	Austrian R.	B	15165, 11665
11:30-12:00 p.m.	0430-0500	VOA to Africa	A	15752-USB, 15240, 15185, 15175, 10869-USB, 7280, 6035
11:30-12:00 p.m.	0430-0500	Swiss R. International	B	11715, 9725
11:30-12:00 p.m.	0430-0500	RAE Argentina	C	15345, 11710, 6060 (not Mon.)
11:30 p.m.-12:45 a.m.	0430-0545	BBC	A	15070, 12095, 9510, 9410, 7160, 6175, 5975
11:30 p.m.-1:00 a.m.	0430-0600	AFRTS, Los Angeles	A	11790, 15330, 6030
11:30 p.m.-1:30 a.m.	0430-0630	TWR, Swaziland	C	7925, 3200
11:45-12:00 p.m. (+)	0445-0500	R. France International	B	9795. 11735, 11875
11:55 p.m.-3:00 a.m.	0455-0800	V. of Nigeria	B	15185, 15120
12:00-12:15 a.m.	0500-0515	Kol Israel	B	21710, 15585, 12025, 15105, 9815,
12:00-12:20 a.m. (+)	0500-0520	Vatican Radio	C	6185, 9645, 11725. 15190
12:00-12:30 a.m.	0500-0530	R. Japan	C	15300
12:00-12:30 a.m.	0500-0530	R. Norway	C	17840, 15175, 11870 (Mon.)
12:00-12:45 a.m.	0500-0545	R. Nationale, Cameroons	C	9745
12:00-12:50 a.m.	0500-0550	V. of Germany	A	11905, 11705, 9690, 9545, 5960
12:00-1:00 a.m.	0500-0600	R. Korea	C	15575, 11820, 11810
12:00-1:00 a.m.	0500-0600	R. Australia	C	21680, 17870, 17725, 15240, 15160
12:00-1:00 a.m.	0500-0600	VOA	A	15752-USB, 15345, 15185, 10869-USB, 7280, 6035
12:00-2:00 a.m.	0500-0700	HCJB Ecuador	B	11910, 9745, 6095
12:00-3:00 a.m.	0500-0800	R. Kuwait	C	15345
12:00-3:00 a.m.	0500-0800	R. Nigeria, Kaduna	B	4770 (not all Eng.)
12:30-12:40 p.m.	0530-0540	R. Garoua, Cameroon	C	5010
12:00-5:00 a.m.	0500-1000	WRNO, New Orleans	A	6185 (Sun) (not all Eng.)
12:30-1:00 a.m.	0530-0600	R. Portugal	A	9575, 6075†
12:30-fade	0530-	R. Ghana	C	3366 (4915 from 0600)
12:30-1:15 a.m. (+)	0530-0615	R. Berlin International	B	11890, 9560
12:30-1:25 a.m.	0530-0625	R. Nederland	A	9715, 6165 (Mon. 0530-0620)
12:30-1:30 a.m.	0530-0630	Spanish Foreign R.	B	11880, 9630
12:45-1:00 a.m.	0545-0600	UN Radio	B	15105, 11740 (Sat.)
12:45-2:30 a.m.	0545-0730	BBC	B	15070, 11955, 9640, 9510, 9410, 7150, 6175
12:55-3:25 a.m.	0555-0825	V. of Malaysia	C	15295, 12350, 9750
1:00-1:30 a.m.	0600-0630	V. of Germany	C	17875, 15275, 11905, 11765, 9700
1:00-1:30 a.m.	0600-0630	R. Australia	C	21680, 17795, 17755, 15160, 9570
1:00-2:00 a.m.	0600-0700	AFRTS, Los Angeles	B	17765, 15330, 11790, 6030
1:00-2:00 a.m.	0600-0700	VOA	A	15205, 9670, 7325, 7200, 6060, 6040, 5995
1:00-2:30 a.m.	0600-0730	R. Kiribati	C	16433-SSB (not all English)
1:00-2:30 a.m.	0600-0730	Solomon Isl. Broadcasting	C	9545 (time varies) (not all English)
1:00-2:30 a.m.	0600-0730	VOA to Africa	A	15752-USB, 15345, 15330, 11915, 10869-USB, 9530, 7280, 6125, 6080, 6035
1:00-3:00 a.m.	0600-0800	WYFR	A	15130, 11805, 9680
1:00-4:00 a.m.	0600-0900	R. Cook Islands	D	11760, or 9695 or 5045 (not all Eng.)
1:10-2:10 a.m.	0610-0710	V. of Free China	A	5985, via WYFR
1:15-1:30 a.m.	0615-0630	R. Canada International	B	11960, 11825, 11775, 9760, 6140 (Mon-Fri)
1:25-3:40 a.m. (+)	0625-0840	TWR, Monte Carlo	B	9492.5 (Sun. 0625-1000)
1:30-1:45 a.m.	0630-0645	RTVC, Congo	C	9715 (Mon.-Fri.) (irr.)

1:30-2:00 a.m.	0630-0700	R. Australia	B	21680, 17870, 17725, 15240, 15160, 15115, 9570
1:30-2:00 a.m.	0630-0700	Radio Polonia	B	9675, 7270
1:30-2:30 a.m.	0630-0730	R. RSA	C	17780, 15220, 11900
1:30-2:00 a.m.	0630-0800	R. Habana Cuba	A	11725
1:45-2:00 a.m.	0645-0700	R. Canada International	B	11960, 11825, 11775, 9760, 6140 (Mon.-Fri.)
1:57-4:55 a.m.	0657-0955	V. of Philippines	C	9578 (not all English)
2:00-2:15 a.m.	0700-0715	R. Japan	C	15300, (15235 via Portugal)
2:00-2:20 a.m.	0700-0720	R. Nederland	C	21480, 15560, 11930, 9895
2:00-2:30 a.m.	0700-0730	Swiss Radio International	C	21520, 15305, 9560, 9535,
2:00-3:00 a.m.	0700-0800	ELWA, Liberia	C	11830
2:00-3:00 a.m.	0700-0800	V. of Vietnam	C	9840
2:00-3:30 a.m.	0700-0830	HCJB, Ecuador	C	11835†, 9720†
2:00-4:00 a.m.	0700-0900	R. Australia	B	15115, 12290-SSB (9570 to 0800)
2:00-6:00 a.m.	0700-1100	HCJB, Ecuador	C	11925, 6130, (9745, 0700-1030)
2:10-2:15 a.m.	0710-0715	UN Radio	A	17815, 15195, 11875, 9555 (Sat.)
2:30-3:25 a.m.	0730-0825	R. Nederland	B	9770, 9715
2:30-4:00 a.m.	0730-0900	BBC	B	15070, 11955, 9640, 9510
2:30-6:30 a.m.	0730-1130	Solomon Isl. Broadcasting	C	5020 (not all Eng.)
2:30-9:00 a.m. (-)	0730-1402	ABC Melbourne	C	9680
2:30 a.m.-fade	0730-	Action Radio, Guyana	C	5950
2:45-4:30 a.m.	0745-0930	KTWR, Guam	B	11840
3:00-3:15 a.m. (+)	0800-0815	AWR, Portugal	C	9760 (Sun.)
3:00-3:15 a.m.	0800-0815	UN Radio	A	17860. 15235, 15120,11740 (Sat.)
3:15-3:30 a.m.	0815-0830	R. Vanuatu	D	7260, 3945
3:30-4:25 a.m.	0830-0925	R. Nederland	B	9715
3:30-5:00 a.m.	0830-1000	FEBC, Philippines	C	11890
3:30-7:15 a.m. (-)	0830-1215	R. New Zealand	C	15485, 9620
3:45-4:45 a.m.	0845-0945	R. Japan	C	15235, 11875
24 Hours	24 Hours	CFRX, Toronto	C	6070
24 Hours	24 Hours	WWV, Colorado	A-B	20000, 15000, 10000, 5000, 2500

Explanatory Notes.

1. Times in first column are CDT. For EDT add 1 hour; MDT subtract 1 hour; PDT subtract 2 hours. Days of week are in GMT.
2. Quality. A—Strong signal and very reliable reception. B—regular reception. C—occasional reception under favorable conditions. D—rarely audible. These ratings are for locations in the central USA. European and African stations are in general, more reliably received in eastern North America. Asian and Pacific stations are more reliably received in western North America. North American stations are received well except in areas too close to the transmitter site.
3. The information in the listing is correct to press time. However, frequencies and schedules are constantly changing. Listen to "SWL Digest" on R. Canada International for late changes, Friday at 2240 Saturday at 2135; Sunday at 1930; GMT Mondays at 0206; and to "World of Radio" on WRNO, GMT Sundays at 0230 and 2330.
4. R.—Radio; V.—Voice

† = frequent changes

(+) = time one hour later after DST period (Europe, last Sunday in Sept.; Soviet Union, Oct. 1; Canada and USA, last Sunday in Oct.)

(-) = time one hour earlier during southern hemisphere DST (starting last Sunday in Oct.)

Circle No. 36 on Free Information Card

COMPUTER-PERIPHERAL SWITCHERS

Connect any number of peripherals to a single I/O port — use a single printer to support several microcomputers — use two or more printers to support a single microcomputer — access a modem from any of several microcomputers — Ideal for demonstrating or comparing equipment. The Selecto-Switches are designed to eliminate the unnecessary plugging & unplugging of cables which connect printers, terminals, or modems to various computers. By using a Selecto-Switch, you achieve more efficient system operation, better utilization of peripherals & computer ports, eliminate redundant hardware & reduce service calls. 5 yr. limited warranty on all Selecto-Switches. No power required. Size (inches): 10L x 7W x 3H 2½ lbs.

RS232 SERIAL SELECTO-SWITCH

• Switches all lines of asynchronous data • Easy expansion of serial ports • Connectors are female DB25 type

PART NO.	DESCRIPTION	PRICE
GRS232-AB	2-Way Switch	$139.95
GRS232-ABC	3-Way Switch	$179.95

DB25 PARALLEL SELECTO-SWITCH

• TRS-80, Apple, and IBM compatible • Switches 24 lines (line 1 is ground) • Connectors are female DB25 type

PART NO.	DESCRIPTION	PRICE
GP24-AB	2-Way Switch	$139.95
GP24-ABC	3-Way Switch	$179.95

CENTRONICS-STYLE SELECTO-SWITCH

• Switches all 36 lines • Connectors are female Centronics

PART NO.	DESCRIPTION	PRICE
GCENT-AB	2-Way Switch	$199.95
GCENT-ABC	3-Way Switch	$229.95

Micro-Logic Corp. MICRO-CHARTS

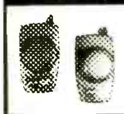
• Fully decoded data • Instant access • 2-sided, totally comprehensive • Compact 8½ x 11 in. durable credit card plastic • Perfect for programmers & engineers • Clear & concise tables for: full instruction set, disassembly, ASCII, base conversion, effect of flags, compare vs. jump, interrupt structure, pinout, cycle times, diagrams, bug notes, & much more...

PART NO.	REFERENCE	PRICE
ML-Z80	Z80 CPU	$5.95
ML-8080A	8080A/8085A	$5.95
ML-6502	6502 (65XX)	$5.95
ML-8048	8048, Relatives, Algorithms	$5.95
ML-7400	5400/7400 TTL	$5.95

BOOKS

30001	National CMOS Data Book (1981) (640 pages) 74C, CD4000, and A/D Converters	$6.95
30003	National Linear Data Book (1982) (1376 pages) LM, LF, ADC, DAC, LH Series	$11.95
30008	National Memory Data Book (1980) (464 pages) RAMs, ROMs, PROMs, EPROMs Series	$6.95
30009	Intersil Data Book (1983) (1356 pages) Complete line.	$9.95
30010	National Audio/Radio Handbook (1980) (240 pages) Pre-Amps, AM, FM & FM Stereo, Power Amps	$5.95
30011	National Linear Application Handbook (1980) (736 pages) Application Notes, Linear Briefs, etc.	$15.95
30012	National PAL Data Book (1982) (176 pages) Application Notes, Linear Briefs, etc.	$5.95
30013	Zilog Data Book (1983) (641 pages) Microprocessors and Support Chips	$7.95
210830	Intel Memory Components Handbook (1983) (798 pages) Contains all Application Notes, Article Reprints, Data Sheets, and other design information on Intel's RAMs, EPROMs, E²PROMs & Bubble Memories.	$14.95
210844	Intel Microprocessor & Peripheral Handbook (1983) (1027 pages) Contains Data Sheets on all of Intel's Microprocessors and Peripherals	$14.95

ATARI

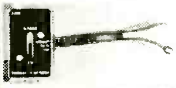


ATARI PADDLES

JSP (2) .... $4.95 pair

ATARI DRIVER

JSD (1) .... $2.95 ea.



TV GAME SWITCH

Used on Atari. Cosmetically blemished. 100% functional.

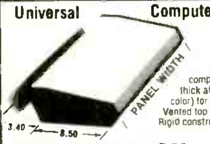
TGS-1 . . . $2.95 ea.

Jameco ELECTRONICS Digital Thermometer Kit

Dual sensors — switch controls for indoor/outdoor or dual monitoring — can be extended to 500 feet. Continuous LED .8" ht. display. Range: 40°F to 199°F, -40°C to 100°C. Accuracy ±1° nominal. Calibrate for Fahrenheit/Celsius. Simulated walnut case. AC wall adapter included. Size: 6⅝"L x 3¼"H x 1⅞"D.

JE300 ...... $39.95

Universal Computer Keyboard Enclosures



"DTE" Blank Desk-Top Enclosures are designed for easy modification. High strength epoxy molded end pieces in mocha brown finish. Sliding rear/bottom panel for service/component access. Top/bott. panels .080" thick alum. alodine type 1200 finish (gold tint color) for best paint adhesion after modification. Vented top & bottom panels for cooling efficiency. Rigid construction provides unlimited applications. Assembly instructions included.

DTE-8	Panel Width 7.5"	$24.95
DTE-11	Panel Width 10.13"	$27.95
DTE-14	Panel Width 13.5"	$29.95
DTE-20	Panel Width 19.25"	$34.95

TIMEX sinclair 1000

• Powerful - fully programmable 2K memory • Portable - 6⅞" x 6⅝" x 1⅞" - 12 oz. • Expandable - Optional 16K RAM module • Single-key entry commands • Educational • Unique syntax-check report codes for error identity • Accurate to 9½ decimal places for full range math and scientific functions • Graph drawing and animated display • Advanced 4-chip design combining power, portability and affordable price.

TS1000 .... $54.95

ACCESSORIES FOR TIMEX sinclair 1000 and ZX81

TIMEX sinclair 1016	Expansion from 2K to 16K, size: 3" x 3" x 1.5" (5 oz)	TS1016	$49.95
	32 column thermal printer (4 lbs)	TS2040	$99.95
TIMEX sinclair 2040	Printer paper - 3 rolls (4.3 in. x 82 ft.)	TPP-3	$5.95

Keyboard Mask for Your ZX81/1000* Computer

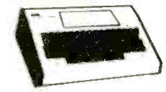
BRAND NEW!!

FEATURES:
• Install in seconds. Remove adhesive backing from mask and place over keyboard.
• All characters and symbols reproduced on mask.
• Durable — formed with polycarbonite sheet-satin finish

The JE681 Keyboard Mask provides users of the ZX81/1000 series computer the individual feel of each keypad on the keyboard. The mask has a raised outline around each keypad allowing the user to feel and correctly position their fingers onto the keyboard.

JE681 KEYBOARD MASK ...... $9.95 each

Jameco ELECTRONICS ZX81/1000* Keyboard Conversion Kit



JE682-AK KEYBOARD KIT MOUNTED IN DTE-AK ENCLOSURE LIGHT TAN PANELS WITH MOLDED DARK BROWN END PIECES. SIZE: 14¼"W x 3¼"D x 3½"H

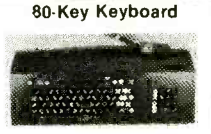
The JE682 Kit provides users of the ZX81/1000 series computers a full size industrial keyboard hook up to their computer. The JE682 Kit allows the use of either the full size keyboard or the Sinclair/Timex Keyboard. The kit also permits the simple disconnection of the Sinclair/Timex Keyboard for portable use. The JE682 Kit consists of a full size industrial grade keyboard with 62 keys, 2 p.c. boards, 24" ribbon cable, DIP socket and 4 rubber feet. The keyboard conversion kit can easily be mounted into the DTE-AK enclosure. This enclosure is large enough to contain the ZX81/1000 computer and the full size keyboard together. A handy label representing the ZX81/1000 keyboard layout is placed on the enclosure.

JE682-AK Keyboard Conversion Kit ...... $99.95 ea.
(WITH DTE-AK CASE - AS PICTURED)

JE682 Keyboard Conversion Kit ...... $59.95 ea.
(WITHOUT DTE-AK CASE)

*ZX81/1000 is a trademark of Sinclair/Timex

80-Key Keyboard



CA150C $69.95

95-Key Keyboard

CA154A $79.95

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★ SPST Switching
★ FTZ Shielded Base
★ N-Key Rollover
★ 128 Character ASCII
★ Non-Slip, Non-Glare Keycaps
★ CDC752 Terminal Keyboards
★ Attractive Case

These Control Data Keyboards consist of a base, cover, the keyboard assembly, and an interface cable. Color (case): Harvest gold and black. Color (keycaps): Black, blue, and red. Electrical requirements: +5V @ 600mA, -12V @ 50mA. Size: 21½"W x 9"D x 3½"H. Weight: 6 lbs. All units brand new in original boxes, specifications included.

Keytronics 90-Key Soft-Programmable Keyboard

WITH SECURITY KEYLOCK SWITCH

350 Available!

BRAND NEW!!

• RFI shielded
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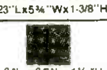
• Numeric keyboard
• 8-bit Parallel
• Capacitance keys
• 10 user-programmable keys
• Positive TTL Logic
• Size: 17"L x 8¼"W x 2¾"H

Made for Visual Technology, this keyboard features: a security keylock (includes two keys) to guard against unauthorized use; an 11-key numeric keypad; cursor controls, and 10 user-programmable keys. Electrical requirements: +5VDC. Color (case): White. Color (keycaps): Black. Complete with case, keyboard assembly, 40-inch interface cable, and schematics. Weight: 7 lbs.

Part No. KB270 .... $79.95 each

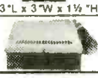
23"L x 5¾"W x 1-3/8"H

MICRO SWITCH 85-KEY KEYBOARD
Word Processing Keyboard, 26 Pin Edge Card Connection. Supply Voltage +5VDC. Main Keyboard is QWERTY. Additional Key Pads for Cursor and word processing functions.
Part No. 85SD18-1 .... $29.95 each



3"L x 3"W x 1½"H

HI-TEK 14-KEY NUMERIC KEYPAD
SPST switching. Charcoal grey keycaps. Mounted on printed circuit board.
Part No. K-14 .... $9.95 each



POWER SUPPLY +5VDC @ 1 AMP REGULATED *Transaction Tech*
Output +5VDC @ 1A (also +30VDC) reg. Input 115VAC 60Hz. 2-tone (black/beige) self-enclosed case. 6 ft. 3 cond. black power cord. 6⅛"W x 7"D x 2¼"H. Wt. 3 lbs. Data sheet incl.
Part No. PS51194S .... $14.95 each

POWER SUPPLY +5VDC @ 3 AMP REGULATED *Deltron*
Input: 115VAC, 47-440Hz. Output: 5VDC Adjustable @ 3 amp, 6VDC @ 2.5 amp. Adjustable current limit, Ripple & Noise: 1MV rms, 5MV p-p — 2 mounting surfaces. UL recognized. Size: 4"W x 4½"L x 2-7/16"H - wt. 2 lbs. Data sheet included.
Part No. QPS-1 .... $29.95 each

POWER SUPPLY +5VDC @ 7.5 AMP, 12VDC @ 1.5 AMP SWITCHING
Input: 115VAC, 50-60Hz @ 3 amp/230VAC, 50Hz @ 1.6 amp. Fan volt / power supply select switches (115/230VAC). Output: 5VDC @ 7.6 amp. 12VDC @ 1.6 amp. 8 ft. blk. pow. cord. 11⅞"W x 13¼"D x 3¾"H. Wt. 6 lbs.
Part No. PS94VOS .... $39.95 each

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Part No. FCS-604A .... $69.95 each

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— PROGRAMS 2764's IN 64 SECONDS —

• Programs, validates, and checks for properly erased EPROMs • Emulates PROMs or EPROMs • RS232C Computer Interface for editing/program loading • Loads data into RAM by keyboard • Changes data in RAM by keyboard • Loads RAM from an EPROM • Compares EPROMs for content differences • Copies EPROMs • Power Input: 115VAC, 60Hz, ◄ 10W power consumption • Enclosure: Color-coordinated, light tan panels w/molded mocha brown end pieces • Size: 15-5/8"L x 8¾"D x 3½"H • Wt.: 5¾ lbs.

JE664-A EPROM Programmer **$995.00**
Assembled & Tested (Includes JM16A Module)

JE665 — RS232C INTERFACE OPTION — The JE665 RS232C Interface Option implements computer access to the JE664's RAM. Sample software written in BASIC provided for TRS-80® Model I, Level II Computer. Baud rate: 9600. Word Lgth: 8 bits. 2: odd parity. Stop bits: 2. Option may be adapted to other computers.

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EPROM JUMPER MODULES — The JE664's JUMPER MODULE (Personality Module) is a plug in Module that pre-sets JE664 for proper programming pulses to the EPROM & configures EPROM socket connections for that particular EPROM.

Part No.	EPROM	EPROM MANUFACTURER	PRICE
JM08A	2708	AMD, Motorola, National, Intel, TI	$14.95
JM16A	2716, TMS2516	Intel, Motorola, National, NEC, TI	$14.95
JM16B	TMS2716	Motorola, TI (+5, -12, +12)	$14.95
JM32A	TMS2532	Motorola, TI	$14.95
JM32B	2732	AMD, Fujitsu, NEC, Hitachi, Intel	$14.95
JM32C	2732A (21V)	Fujitsu, Intel	$14.95
JM64A	MCM68764, MCM68L764	Motorola	$14.95
JM64B	2764	Intel	$14.95
JM64C	TMS2564	TI	$14.95
JM640	HN482764G-4	Hitachi (21V)	$14.95

iii's Black Hole EPROM Eraser

9 Chips — 8 Minutes

The Black Hole EPROM Eraser will completely and safely erase 9 EPROMs in less than 8 minutes. The Black Hole is a fully automatic cassette loading eraser featuring U-shaped 4000 hr. UV lamps mounted in a special ALZAK (UV reflectivity of .9) parabolic light tunnel. In operation, the user slips in an anti-static Bug Box (3 ea. incl.) containing the EPROMs to be erased into the loading slot on the front panel of Black Hole. The rest is fully automatic. The Black Hole latches the Bug Box into place, turns on the UV lamps and starts its fully solid state (CMOS) UV integration dose timer. The percentage erasure time is monitored and displayed on a front panel LED readout. At the end of the erase cycle, the Black Hole ejects the Bug Box containing the 9 erased EPROMs and turns off power.

PART NO.		PRICE
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**Model 1 = From 4K to 16K Requires (1) One Kit
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Color = From 4K to 16K Requires (1) One Kit

**Model 1 equipped with Expansion Board up to 48K Two Kits Required
— One Kit Required for each 16K of Expansion —

TRS-16K3 *200ns	for Color & Model III	$12.95
TRS-16K4 *250ns	for Model I	$10.95

TRS-80 Color 32K or 64K Conversion Kit

Easy to install kit comes complete with 8 ea. 4164-2 (200ns) 64K dynamic RAMs & conversion documentation. Converts TRS-80 color computers with E circuit boards, & all new color computers to 32K. Minor modifications of 32K memory will allow the use of all the 64K of the dynamic RAM providing you have a FLEX DOS operating system.

TRS-64K2 .... $54.95

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Pertec Computer Corp.

FOR TRS-80 MODEL I · COLOR COMPUTER

Features single or double density. Recording mode: FM single, MFM double density. Seek time: 25msec. track to track. Power: +12VDC (±0.6V) 1.6A max., +5VDC (±0.25V) 0.8A max. Unit as pic. at right does not incl. case, power supply, cables). 30-pg. data book incl. Wt. 3½ lbs. Size: 5¾"W x 8"D x 3¼"H.

Part No.	*Limited Quantity!*	Price
FD200	Single-sided, 40 tracks, 250K bytes capacity	$179.95
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Siemens

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• Single-Sided
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• 400/800K Bytes Capacity
• Industry Standard

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Part No. Price

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LED HOLDERS
TWO PIECE HOLDER FOR JUMBO LED
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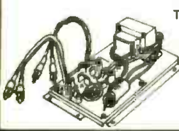

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The EXPLORER 88-PC STARTER KIT includes a mother board, memory/I/O board, all components needed, sockets for IC's used, one 62-pin bus connector and complete assembly/test instructions. All you need is a soldering iron, solder, a power supply, and a standard RS232 terminal (Netronics has 2 low-cost ones to choose from).
Explorer 88-PC Starter Kit...$399.95 + 10.00 p&i
☐ (wired & tested, add $100.00)
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Use your own terminal with the EXPLORER 88-PC or, if you plan to expand it to be fully IBM compatible, we offer our IBM compatible keyboard and an IBM compatible color graphics board (only available wired and tested).

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☐ IBM compatible color board...$299.95 + 10.00 p&i.
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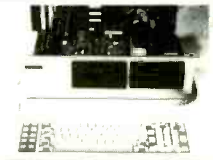
☐ INTEL 8086/8088 user manual...$15.00 + 1.50 p&i.
☐ THE 8086 BOOK by RECTOR & ALEX... $16.00 + 1.50 p&i.



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TMM2016 2KX8 STATIC 200 NS $4.15

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5101	256 x 4 (450ns) (cmos)	3.95
2102-1	1024 x 1 (450ns)	.89
2102L-4	1024 x 1 (450ns) (LP)	.99
2102L-2	1024 x 1 (250ns) (LP)	1.49
2111	256 x 4 (450ns)	2.49
2112	256 x 4 (450ns)	2.99
2114	1024 x 4 (450ns)	8/9.95
2114L-4	1024 x 4 (450ns) (LP)	8/12.95
2114L-3	1024 x 4 (300ns) (LP)	8/13.45
2114L-2	1024 x 4 (200ns) (LP)	8/13.95
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TMS4044-3	4096 x 1 (300ns)	3.99
TMS4044-2	4096 x 1 (200ns)	4.49
MK4118	1024 x 8 (250ns)	9.95
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TMM2016-150	2048 x 8 (150ns)	4.95
TMM2016-100	2048 x 8 (100ns)	6.15
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HM6116-3	2048 x 8 (150ns) (cmos)	4.95
HM6116-2	2048 x 8 (120ns) (cmos)	8.95
HM6116LP-4	2048 x 8 (200ns) (cmos)(LP)	5.95
HM6116LP-3	2048 x 8 (150ns) (cmos)(LP)	6.95
HM6116LP-2	2048 x 8 (120ns) (cmos)(LP)	10.95
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LP = Low Power Qstat = Quasi-Static

DYNAMIC RAMS

TMS4027	4096 x 1 (250ns)	1.99
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MM5280	4096 x 1 (300ns)	3.00
MK4108	8192 x 1 (200ns)	1.95
MM5298	8192 x 1 (250ns)	1.85
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4116-120	16384 x 1 (120ns)	8/29.95
2118	16384 x 1 (150ns) (5v)	4.95
4164-200	65536 x 1 (200ns) (5v)	5.95
4164-150	65536 x 1 (150ns) (5v)	6.95

5V = single 5 volt supply

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2758	1024 x 8 (450ns) (5v)	5.95
2716	2048 x 8 (450ns) (5v)	3.95
2716-1	2048 x 8 (350ns) (5v)	5.95
TMS2516	2048 x 8 (450ns) (5v)	5.50
TMS2716	2048 x 8 (450ns)	7.95
TMS2532	4096 x 8 (450ns) (5v)	5.95
2732	4096 x 8 (450ns) (5v)	4.95
2732-250	4096 x 8 (250ns) (5v)	8.95
2732-200	4096 x 8 (200ns) (5v)	11.95
2764	8192 x 8 (450ns) (5v)	9.95
2764-250	8192 x 8 (250ns) (5v)	14.95
2764-200	8192 x 8 (200ns) (5v)	24.95
TMS2564	8192 x 8 (450ns) (5v)	17.95
MC68764	8192 x 8 (450ns) (5v)(24 pin)	39.95

5v = Single 5 Volt Supply

EPROM ERASERS

	Timer	Capacity Chip	Intensity (uW/Cm²)	
PE-14		6	5,200	83.00
PE-14T	X	6	5,200	119.00
PE-24T	X	9	6,700	175.00
PL-265T	X	20	6,700	255.00
PR-125T	X	16	15,000	349.00
PR-320	X	32	15,000	595.00

Z-80

2.5 Mhz

Z80-CPU	3.95
Z80-CTC	4.49
Z80-DART	10.95
Z80-DMA	14.95
Z80-PIO	4.49
Z80-SIO/0	16.95
Z80-SIO/1	16.95
Z80-SIO/2	16.95
Z80-SIO/9	16.95

4.0 Mhz

Z80A-CPU	4.95
Z80A-CTC	4.95
Z80A-DART	11.95
Z80A-DMA	16.95
Z80A-PIO	4.95
Z80A-SIO/0	16.95
Z80A-SIO/1	16.95
Z80A-SIO/2	16.95
Z80A-SIO/9	16.95

6.0 Mhz

Z80B-CPU	11.95
Z80B-CTC	13.95
Z80B-PIO	13.95
Z80B-DART	19.95

ZILOG

Z6132	34.95
Z8671	39.95

CRYSTALS

32.768 khz	1.95
1.0 mhz	4.95
1.8432	4.95
2.0	3.95
2.097152	3.95
2.4576	3.95
3.2768	3.95
3.579535	3.95
4.0	3.95
5.0	3.95
5.0688	3.95
5.185	3.95
5.7143	3.95
6.0	3.95
6.144	3.95
6.5536	3.95
8.0	3.95
10.0	3.95
10.738635	3.95
14.31818	3.95
15.0	3.95
16.0	3.95
17.430	3.95
18.0	3.95
18.432	3.95
20.0	3.95
22.1184	3.95
32.0	3.95

CRT CONTROLLERS

6845	14.95
68B45	19.95
HD46505SP	15.95
6847	11.95
MC1372	6.95
68047	24.95
8275	29.95
7220	99.95
CRT5027	39.95
CRT5037	49.95
TMS9918A	39.95
DP8350	49.95

KEYBOARD CHIPS

AY5-2376	11.95
AY5-3600	11.95

8000

8035	5.95
8039	6.95
INS-8060	17.95
INS-8073	24.95
8080	3.95
8085	5.95
8085A-2	11.95
8086	29.95
8087	CALL
8088	39.95
8089	89.95
8155	6.95
8155-2	7.95
8156	6.95
8185	29.95
8185-2	39.95
8741	39.95
8748	24.95
8755	24.95

8200

8202	24.95
8203	39.95
8205	3.50
8212	1.80
8214	3.85
8216	1.75
8224	2.25
8226	1.80
8228	3.49
8231	call
8237	19.95
8237-5	21.95
8238	4.49
8243	4.45
8250	10.95
8251	4.49
8253	6.95
8253-5	7.95
8255	4.49
8255-5	5.25
8257	7.95
8257-5	8.95
8259	6.90
8259-5	7.50
8271	39.95
8272	39.95
8275	29.95
8279	8.95
8279-5	10.00
8282	6.50
8283	6.50
8284	5.50
8286	6.50
8287	6.50
8288	25.00
8289	49.95

DISC CONTROLLERS

1771	16.95
1791	24.95
1793	26.95
1795	49.95
1797	49.95
2791	54.95
2793	54.95
2795	59.95
2797	59.95
6843	34.95
8272	39.95
UPD765	39.95
1691	17.95
2143	18.95

CONNECTORS

RS232 MALE	2.50
RS232 FEMALE	3.25
RS232 HOOD	1.25
S-100 ST	3.95

6800

68000	59.95
6800	3.95
6802	7.95
6808	13.90
6809E	19.95
6809	11.95
6810	2.95
6820	4.35
6821	3.25
6828	14.95
6840	12.95
6843	34.95
6844	25.95
6845	14.95
6847	11.95
6850	3.25
6852	5.75
6860	9.95
6862	11.95
6875	6.95
6880	2.25
6883	22.95
68047	24.95
68488	19.95

6800 = 1MHZ

68B00	10.95
68B02	22.25
68B09E	29.95
68B09	29.95
68B10	6.95
68B21	6.95
68B45	19.95
68B50	5.95

68B00 = 2 MHZ

6500

1 MHZ

6502	4.95
6504	6.95
6505	8.95
6507	9.95
6520	4.35
6522	7.95
6532	9.95
6545	22.50
6551	11.85

2 MHZ

6502A	6.95
6522A	9.95
6532A	11.95
6545A	27.95
6551A	11.95

3 MHZ

6502B	14.95

UARTS

AY3-1014	6.95
AY5-1013	3.95
AY3-1015	6.95
PT1472	9.95
TR1602	3.95
2350	9.95
2651	8.95
TMS6011	5.95
IM6402	7.95
IM6403	8.95
INS8250	10.95

GENERATORS

BIT-RATE

MC14411	11.95
BR1941	11.95
4702	12.95
COM5016	16.95
COM8116	10.95
MM5307	10.95

FUNCTION

MC4024	3.95
LM566	1.49
XR2206	3.75
8038	3.95

74LS00

74LS00	.24	74LS173	.69
74LS01	.25	74LS174	.55
74LS02	.25	74LS175	.55
74LS03	.25	74LS181	2.15
74LS04	.24	74LS189	8.95
74LS05	.25	74LS190	.89
74LS08	.28	74LS191	.89
74LS09	.29	74LS192	.79
74LS10	.25	74LS193	.79
74LS11	.35	74LS194	.69
74LS12	.35	74LS195	.69
74LS13	.45	74LS196	.79
74LS14	.59	74LS197	.79
74LS15	.35	74LS221	.89
74LS20	.25	74LS240	.95
74LS21	.29	74LS241	.99
74LS22	.25	74LS242	.99
74LS26	.29	74LS243	.99
74LS27	.29	74LS244	.99
74LS28	.35	74LS245	1.49
74LS30	.25	74LS247	.75
74LS32	.29	74LS248	.99
74LS33	.55	74LS249	.99
74LS37	.35	74LS251	.59
74LS38	.35	74LS253	.59
74LS40	.25	74LS257	.59
74LS42	.49	74LS258	.59
74LS47	.75	74LS259	2.75
74LS48	.75	74LS260	.59
74LS49	.75	74LS266	.55
74LS51	.25	74LS273	1.49
74LS54	.29	74LS275	3.35
74LS55	.29	74LS279	.49
74LS63	1.25	74LS280	1.98
74LS73	.39	74LS283	.69
74LS74	.35	74LS290	.89
74LS75	.39	74LS293	.89
74LS76	.39	74LS295	.99
74LS78	.49	74LS298	.89
74LS83	.60	74LS299	1.75
74LS85	.69	74LS323	3.50
74LS86	.39	74LS324	1.75
74LS90	.55	74LS352	1.29
74LS91	.89	74LS353	1.29
74LS92	.55	74LS363	1.35
74LS93	.55	74LS364	1.95
74LS95	.75	74LS365	.49
74LS96	.89	74LS366	.49
74LS107	.39	74LS367	.45
74LS109	.39	74LS368	.45
74LS112	.39	74LS373	.99
74LS113	.39	74LS374	.99
74LS114	.39	74LS377	1.39
74LS122	.45	74LS378	1.18
74LS123	.79	74LS379	1.35
74LS124	2.90	74LS385	1.90
74LS125	.49	74LS386	.45
74LS126	.49	74LS390	1.19
74LS132	.59	74LS393	1.19
74LS133	.59	74LS395	1.19
74LS136	.39	74LS399	1.49
74LS137	.99	74LS424	2.95
74LS138	.55	74LS447	.37
74LS139	.55	74LS490	1.95
74LS145	1.20	74LS624	3.99
74LS147	2.49	74LS640	2.20
74LS148	1.35	74LS645	2.20
74LS151	.55	74LS668	1.69
74LS153	.55	74LS669	1.89
74LS154	1.90	74LS670	1.49
74LS155	.69	74LS674	9.65
74LS156	.69	74LS682	3.20
74LS157	.65	74LS683	3.20
74LS158	.59	74LS684	3.20
74LS160	.69	74LS685	3.20
74LS161	.65	74LS688	2.40
74LS162	.69	74LS689	3.20
74LS163	.65	74LS783	24.95
74LS164	.69	81LS95	1.49
74LS165	.95	81LS96	1.49
74LS166	1.95	81LS97	1.49
74LS168	1.75	81LS98	1.49
74LS169	1.75	25LS2521	2.80
74LS170	1.49	25LS2569	4.25

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7400

7400	.19	74132	.45
7401	.19	74136	.50
7402	.19	74141	.65
7403	.19	74142	2.95
7404	.19	74143	2.95
7405	.25	74145	.60
7406	.29	74147	1.75
7407	.29	74148	1.20
7408	.24	74150	1.35
7409	.19	74151	.55
7410	.19	74152	.65
7411	.25	74153	.55
7412	.30	74154	1.25
7413	.35	74155	.75
7414	.49	74156	.65
7416	.25	74157	.55
7417	.25	74159	1.65
7420	.19	74160	.85
7421	.35	74161	.69
7422	.35	74162	.85
7423	.29	74163	.69
7425	.29	74164	.85
7426	.29	74165	.85
7427	.29	74166	1.00
7428	.45	74167	2.95
7430	.19	74170	1.65
7432	.29	74172	5.95
7433	.45	74173	.75
7437	.29	74174	.89
7438	.29	74175	.89
7440	.19	74176	.89
7442	.49	74177	.75
7443	.65	74178	1.15
7444	.69	74179	1.75
7445	.69	74180	.75
7446	.69	74181	2.25
7447	.69	74182	.75
7448	.69	74184	2.00
7450	.19	74185	2.00
7451	.23	74190	1.15
7453	.23	74191	1.15
7454	.23	74192	.79
7460	.23	74193	.79
7470	.35	74194	.85
7472	.29	74195	.85
7473	.34	74196	.79
7474	.33	74197	.75
7475	.45	74198	1.35
7476	.35	74199	1.35
7480	.59	74221	1.35
7481	1.10	74246	1.35
7482	.95	74247	1.25
7483	.50	74248	1.85
7485	.59	74249	1.95
7486	.35	74251	.75
7489	2.15	74259	2.25
7490	.35	74265	1.35
7491	.40	74273	1.95
7492	.50	74276	1.25
7493	.35	74279	.75
7494	.65	74283	2.00
7495	.55	74284	3.75
7496	.70	74285	3.75
7497	2.75	74290	.95
74100	1.75	74293	.75
74107	.30	74298	.85
74109	.45	74351	2.25
74110	.45	74365	.65
74111	.55	74366	.65
74116	1.55	74367	.65
74120	1.20	74368	.65
74121	.29	74376	2.20
74122	.45	74390	1.75
74123	.49	74393	1.35
74125	.45	74425	3.15
74126	.45	74426	.85
74128	.55	74490	2.55

LINEAR

LM301	.34	LM340 (see 7800)		LM566	1.49	LM1800	2.37
LM301H	.79	LM348	.99	LM567	.89	LM1812	8.25
LM307	.45	LM350K	4.95	NE570	3.95	LM1830	3.50
LM308	.69	LM350T	4.60	NE571	2.95	LM1871	5.49
LM308H	1.15	LM358	.69	NE592	2.75	LM1872	5.49
LM309H	1.95	LM359	1.79	LM709	.59	LM1877	3.25
LM309K	1.25	LM376	3.75	LM710	.75	LM1889	1.95
LM310	1.75	LM377	1.95	LM711	.79	LM1896	1.75
LM311	.64	LM378	2.50	LM723	.49	ULN2003	2.49
LM311H	.89	LM379	4.50	LM723H	.55	LM2877	2.05
LM312H	1.75	LM380	.89	LM733	.98	LM2878	2.25
LM317K	3.95	LM380N-8	1.10	LM741	.35	LM2900	.85
LM317T	1.19	LM381	1.60	LM741N-14	.35	LM2901	1.00
LM318	1.49	LM382	1.60	LM741H	.40	LM3900	.59
LM318H	1.59	LM383	1.95	LM747	.69	LM3905	1.25
LM319H	1.90	LM384	1.95	LM748	.59	LM3909	.98
LM319	1.25	LM386	.89	LM1014	1.19	LM3911	2.25
LM320 (see 7900)		LM387	1.40	LM1303	1.95	LM3914	3.95
LM322	1.65	LM389	1.35	LM1310	1.49	LM3915	3.95
LM323K	4.95	LM390	1.95	MC1330	1.69	LM3916	3.95
LM324	.59	LM392	.69	MC1349	1.89	MC4024	3.95
LM329	.65	LM394H	4.60	MC1350	1.19	MC4044	4.50
LM331	3.95	LM399H	5.00	MC1358	1.69	RC4136	1.25
LM334	1.19	NE531	2.95	MC1372	6.95	RC4151	3.95
LM335	1.40	NE555	.34	LM1414	1.59	LM4250	1.75
LM336	1.75	NE556	.65	LM1458	.59	LM4500	3.25
LM337K	3.95	NE558	1.50	LM1488	.69	RC4558	.69
LM337T	1.95	NE561	24.95	LM1489	.69	LM13080	1.29
LM338K	6.95	NE564	2.95	LM1496	.85	LM13600	1.49
LM339	.99	LM565	.99	LM1558H	3.10	LM13700	1.49

H = TO-5 CAN T = TO-220 K = TO-3

RCA

CA 3023	2.75	CA 3082	1.65
CA 3039	1.29	CA 3083	1.55
CA 3046	1.25	CA 3086	.80
CA 3059	2.90	CA 3089	2.99
CA 3060	2.90	CA 3096	3.49
CA 3065	1.75	CA 3130	1.30
CA 3080	1.10	CA 3140	1.15
CA 3081	1.65	CA 3146	1.85
CA 3160	1.19		

TI

TL494	4.20	75365	1.95
TL496	1.65	75450	.59
TL497	3.25	75451	.39
75107	1.49	75452	.39
75110	1.95	75453	.39
75150	1.95	75454	.39
75154	1.95	75491	.79
75188	1.25	75492	.79
75189	1.25	75493	.89
75494	.89		

BI FET

TL071	.79	TL084	2.19
TL072	1.19	LF347	2.19
TL074	2.19	LF351	.60
TL081	.79	LF353	1.00
TL082	1.19	LF355	1.10
TL083	1.19	LF356	1.10
LF357	1.40		

CMOS

4000	.29	4527	1.95
4001	.25	4528	1.19
4002	.25	4531	.95
4006	.89	4532	1.95
4007	.29	4538	1.95
4008	.95	4539	1.95
4009	.39	4541	2.64
4010	.45	4543	1.19
4011	.25	4553	5.79
4012	.25	4555	.95
4013	.38	4556	.95
4014	.79	4581	1.95
4015	.39	4582	1.95
4016	.39	4584	.75
4017	.69	4585	.75
4018	.79	4702	12.95
4019	.39	74C00	.35
4020	.75	74C02	.35
4021	.79	74C04	.35
4022	.79	74C08	.35
4023	.29	74C10	.35
4024	.65	74C14	.59
4025	.29	74C20	.35
4026	1.65	74C30	.35
4027	.45	74C32	.39
4028	.69	74C42	1.29
4029	.79	74C48	1.99
4030	.39	74C73	.65
4034	1.95	74C74	.65
4035	.85	74C76	.80
4040	.75	74C83	1.95
4041	.75	74C85	1.95
4042	.69	74C86	.39
4043	.85	74C89	4.50
4044	.79	74C90	1.19
4046	.85	74C93	1.75
4047	.95	74C95	.99
4049	.35	74C107	.89
4050	.35	74C150	5.75
4051	.79	74C151	2.25
4053	.79	74C154	3.25
4060	.89	74C157	1.75
4066	.39	74C160	1.19
4068	.39	74C161	1.19
4069	.29	74C162	1.19
4070	.35	74C163	1.19
4071	.29	74C164	1.39
4072	.29	74C165	2.00
4073	.29	74C173	.79
4075	.29	74C174	1.19
4076	.79	74C175	1.19
4078	.29	74C192	1.49
4081	.29	74C193	1.49
4082	.29	74C195	1.39
4085	.95	74C200	5.75
4086	.95	74C221	1.75
4093	.49	74C373	2.45
4098	2.49	74C374	2.45
4099	1.95	74C901	.39
14409	12.95	74C902	.85
14410	12.95	74C903	.85
14411	11.95	74C905	10.95
14412	12.95	74C906	.95
14419	7.95	74C907	1.00
14433	4.18	74C908	2.00
4502	.95	74C909	2.75
4503	.65	74C910	9.95
4508	1.95	74C911	8.95
4510	.85	74C912	8.95
4511	.85	74C914	1.95
4512	.85	74C915	1.19
4514	1.25	74C918	2.75
4515	1.79	74C920	17.95
4516	1.55	74C921	15.95
4518	.89	74C922	4.49
4519	.39	74C923	4.95
4520	.79	74C925	5.95
4522	1.25	74C926	7.95
4526	1.25	74C928	7.95
		74C929	19.95

74S00

74S00	.32	74S163	1.95
74S02	.35	74S168	3.95
74S03	.35	74S169	3.95
74S04	.35	74S174	.95
74S05	.35	74S175	.95
74S08	.35	74S181	3.95
74S09	.40	74S182	2.95
74S10	.35	74S188	1.95
74S11	.35	74S189	6.95
74S15	.35	74S194	1.49
74S20	.35	74S195	1.49
74S22	.35	74S196	1.49
74S30	.35	74S197	1.49
74S32	.40	74S201	6.95
74S37	.88	74S225	7.95
74S38	.85	74S240	2.20
74S40	.35	74S241	2.20
74S51	.35	74S244	2.20
74S64	.40	74S251	.95
74S65	.40	74S253	.95
74S74	.50	74S257	.95
74S85	1.99	74S258	.95
74S86	.50	74S260	.79
74S112	.50	74S274	19.95
74S113	.50	74S275	19.95
74S114	.55	74S280	1.95
74S124	2.75	74S287	1.90
74S132	1.24	74S288	1.90
74S133	.45	74S289	6.89
74S134	.50	74S301	6.95
74S135	.89	74S373	2.45
74S138	.85	74S374	2.45
74S139	.85	74S381	7.95
74S140	.55	74S387	1.95
74S151	.95	74S412	2.98
74S153	.95	74S471	4.95
74S157	.95	74S472	4.95
74S158	.95	74S474	4.95
74S161	1.95	74S482	15.25
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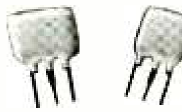

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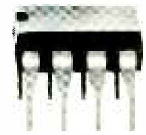

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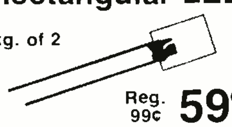

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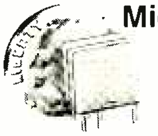

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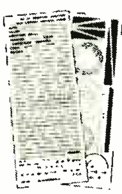

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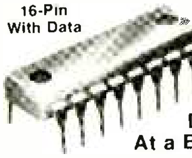

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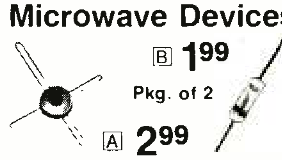

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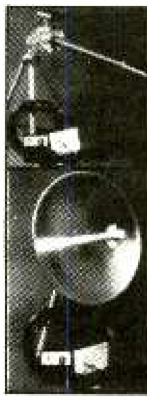

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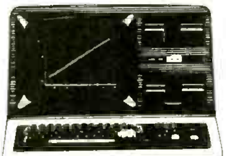

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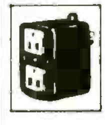

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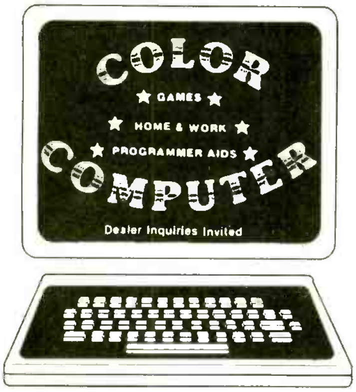

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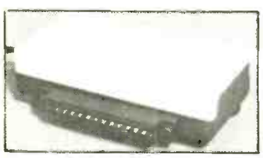

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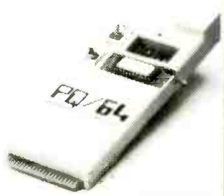

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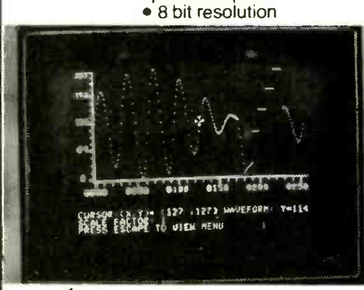

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