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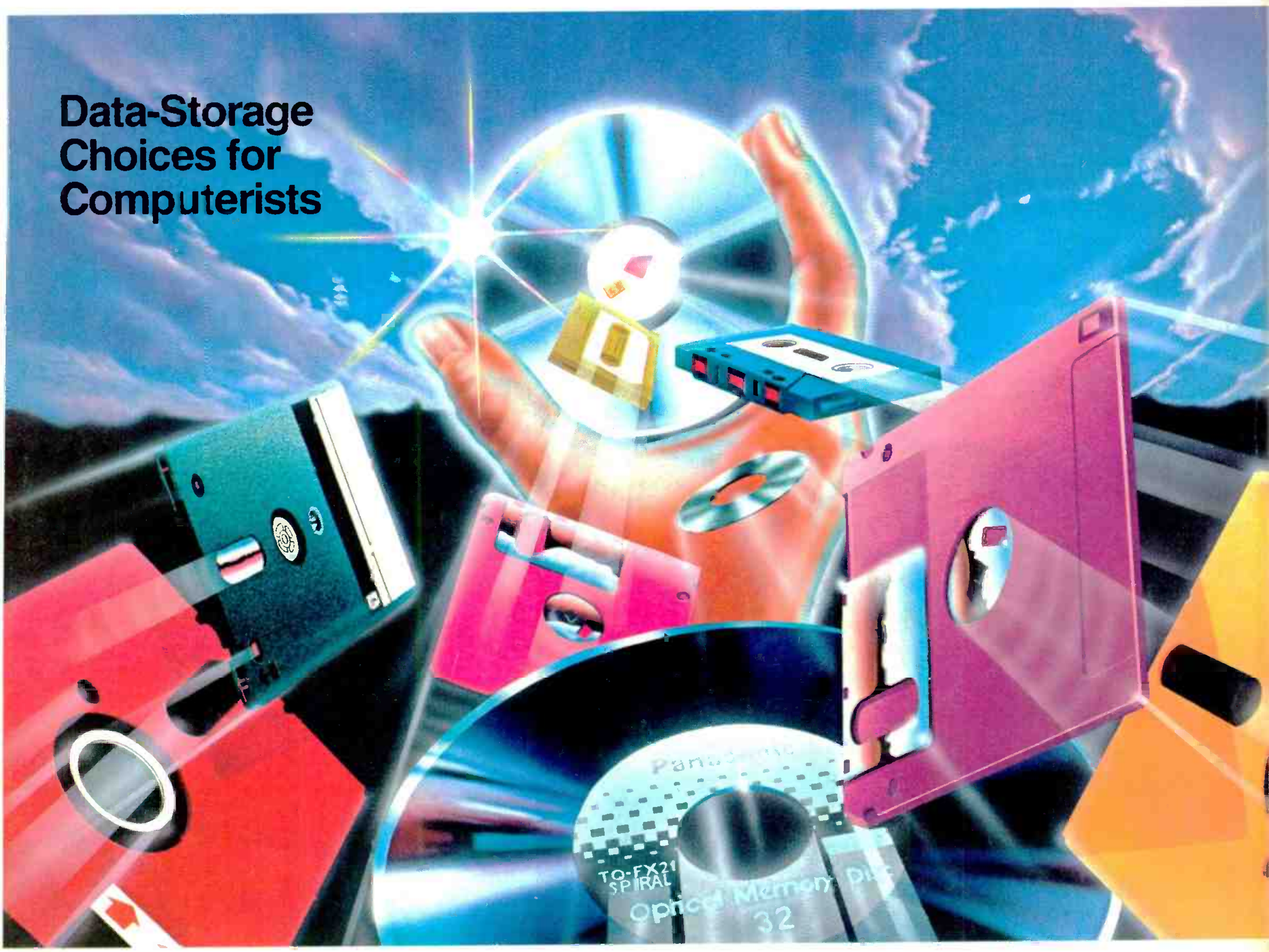

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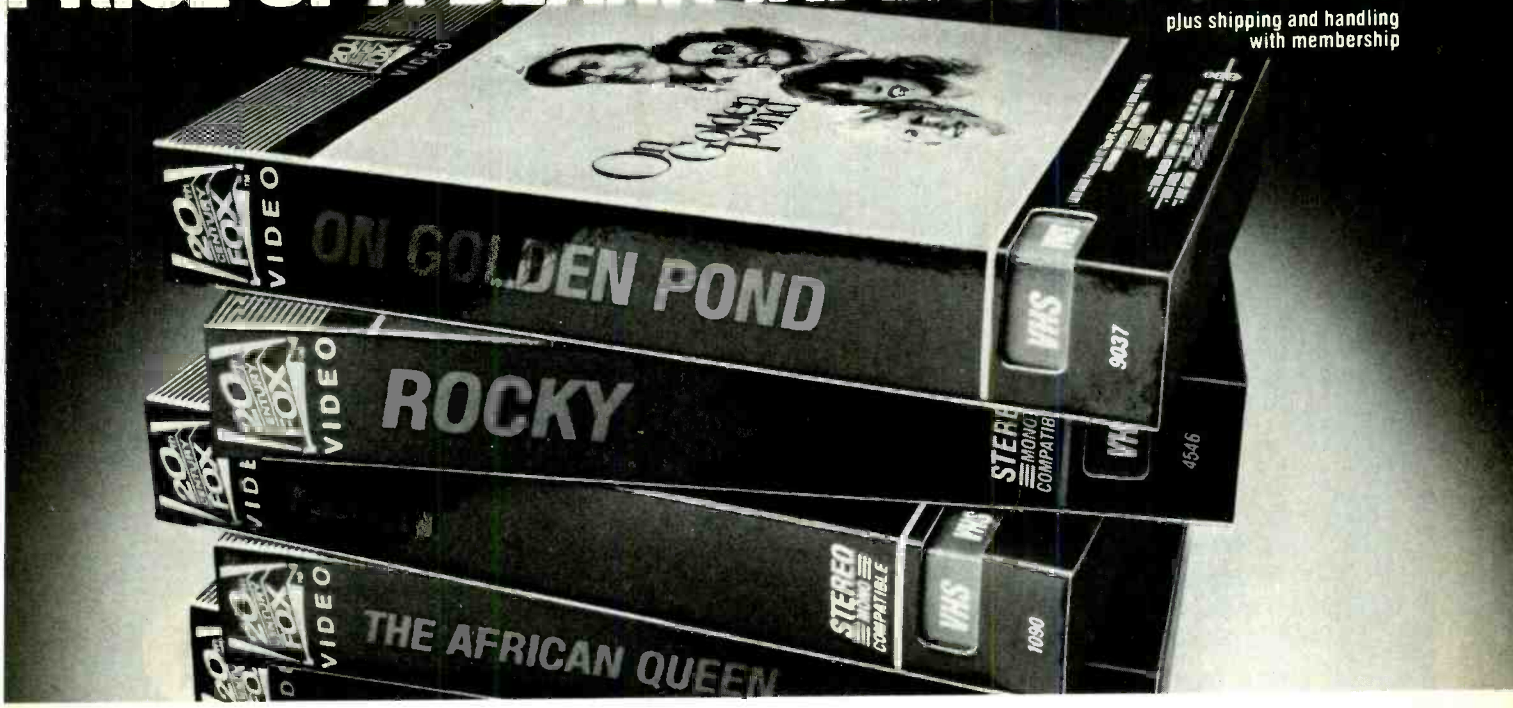

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Now...Diskettes you can swear by, not swear at.

Lucky for you, the diskette buyer, there are many diskette brands to choose from. Some brands are good, some not as good, and some you wouldn't think of trusting with even one byte of your valuable data. Sadly, some manufacturers have put their profit motive ahead of creating quality products. This has resulted in an abundance of low-quality but rather expensive diskettes in the marketplace.

A NEW COMPANY WAS NEEDED AND STARTED
Fortunately, other people in the diskette industry recognized that making ultra-high quality diskettes required the *best* and newest manufacturing equipment as well as the best people to operate this equipment. Since most manufacturers seemed satisfied to give you only the everyday quality now available, an assemblage of quality conscious individuals decided to start a new company to give you a new and better diskette. They called this product the *Ultra* diskette, and you're going to love them. Now you have a product you can swear by, not swear at.

HOW THEY MADE THE BEST DISKETTES EVEN BETTER
The management of *Ultra* Magnetics then hired all the top brains in the diskette industry to make the *Ultra* product. Then these top bananas (sometimes called floppy freaks) created a new standard of diskette quality and reliability. To learn the "manufacturing secrets" of the top diskette makers, they've also hired the remaining "magnetic media moguls" from competitors such as Verbatim, Memorex, Dysan and many more. Then all these top-dollar engineers, physicists, research scientists and production experts (if they've missed you, send in your resume to *Ultra*) were given one directive...to pool all their manufacturing know-how and create a new, better diskette.

HOW ULTRA DISKETTES ARE MANUFACTURED
The *Ultra* Magnetics crew then assembled the newest, totally quality monitored, automated production line in the industry. We know that some of Ultra's competitors are still making magnetic media on equipment that is old enough to vote. Since all manufacturing equipment at *Ultra* is new, it's easy for *Ultra* to consistently make better diskettes. You can always be assured of ultra-tight tolerances and superb dependability when you use *Ultra*. If all this manufacturing mumbo-jumbo doesn't impress you, we're sure that at least one of these other benefits from using *Ultra* diskettes will:

1. **TOTAL SURFACE TESTING** - For maximum reliability, and to lessen the likelihood of disk errors, all diskettes must be totally surface tested. At *Ultra*, each diskette is 100% surface tested. *Ultra* is so picky in their testing, they even test the tracks that are in between the regular tracks.
2. **COMPLETE LINE OF PRODUCTS** - For a diskette to be useful to you and your computer, it must be compatable physically. *Ultra* Magnetics has an entire line of 5¼-inch and 8-inch diskettes.
3. **SPECIALLY LUBRICATED DISK** - *Ultra* uses a special oxide lubricant which is added to the base media in the production of their diskettes. This gives you a better disk drive head to media contact and longer head and disk life.
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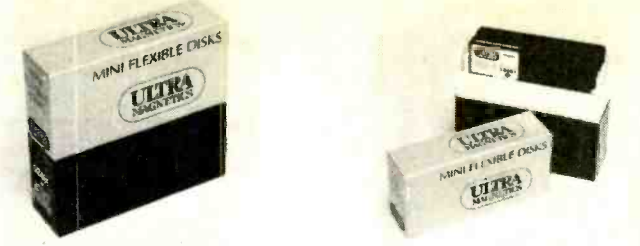
6. **DISK DURABILITY** - *Ultra* disks will beat all industry standards for reliability at well over millions and millions of revolutions. They are compatible with all industry specifications as established by ANSI, ECMA, ISO and JIS.
7. **CUSTOMER ORIENTED PACKAGING** - All *Ultra* disks are packaged 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.
8. **LIFETIME WARRANTY** - If all else fails, remember, all disks made by *Ultra* Magnetics, (except bulk pack) have a lifetime warranty. If your *Ultra* disks fail to meet factory specifications, *Ultra* Magnetics will replace them under the terms of their warranty.
9. **SUPERB VALUE** - With Ultra's automated production line, high-quality, error-free disks are yours without high cost.



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8" DSDD Soft Sector (Unformatted)	82701	3.19
8" DSDD Soft Sector (1024 B/S, 8 Sectors)	82708	3.19
5¼" SSSD Soft Sector w/Hub Ring	50001	1.79
5¼" Same as above, but bulk pack w/o envelope	00153	1.39
5¼" SSSD 10 Hard Sector w/Hub Ring	50010	1.79
5¼" SSSD 16 Hard Sector w/Hub Ring	50016	1.79
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JULY 1983

VOLUME 21, NUMBER 7

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CIRCLE NO. 19 ON FREE INFORMATION CARD

EDITORIAL

Shades of de Gaulle

IT rankled the French Government when a survey revealed that some 75 percent of French scientists wrote research papers in English for conferences in France. Authors were urged to use their native tongue. The scientists naturally balked at this because their language ranks only 11th among the number of people who use the tongue in the world, whereas English is Number One! Obviously, no one wants to limit his audience. In defense, the scientists observed that many technical words have no equivalent in French. To counter this, the French Industry Minister Office blithely created a list of new French computer words.

Now le hardware is replaced by *le materiel,* while le software uses the worlds *le logiciel.* Logical? A listing is now *un listage,* and data bank is called *la banque de donnees.* So far French scientists view the effort to purify computer terms as being inoperative.

It's difficult to persuade people to adopt industry standards. Witness the U.S. efforts to go metric. Thus far it's been a total failure. More to the point, our editors continually bemoan the dearth of standards in the computer field. Most of us, though, don't appreciate the enormous challenge faced in developing standards that will be accepted by everyone. They don't come easy.

There are many ways to get a standard, of course. Legislation is one, such as with weights and measures. Government agencies mandate others. That is, if you want to do business with this huge buyer. Can one ignore the bar code 39 system, for example? Or the Ada computer language? Most standards, however, are voluntary.

A formal method of going about establishing voluntary standards is in place, you should know. This is coordinated by the American National Standards Institute. The process is an open one, with standards adopted reflecting a consensus. A host of organizations is accredited by ANSI to develop standards that fall within its area of expertise. The IEEE is one, for instance. When a standard is developed and approved by, say, this association, it carries a designation such as IEEE Std. xxx and is submitted to ANSI for its adoption. When this is done, the standard's designation is changed to ANSI/IEEE Std. xxx.

You don't have to sit back and wait for some standards to be developed, of course. Unlike the weather, you can do something about it besides griping. For example, if you're a member of an organization that works with ANSI on standards, all you generally need to do is gain sponsorship from one of its technical committees to get the ball rolling. You might be appointed as head of a working group on it. The newly adopted IEEE-696 standard for the S-100 bus was sponsored by the IEEE Computer Society's Technical Committee on Mini/Microcomputers, for example, with Mark Garetz, San Carlos, CA as Chairperson.

The marketplace establishes *de facto* standards, too, such as the IBM 3270 terminal "standard." This method of generating standards will probably come about for others, such as Teletext, the 5¼" Winchester interface, etc.

There's a new standards effort churning out there since 1973 that will affect all of us. It concerns new logic symbols that show input relative to output without indicating internal logic. The final draft on this is expected to be released sometime this year, though Texas Instruments is already using them in its handbooks on digital logic devices. You'll be reading about it in COMPUTER & ELECTRONICS.

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LETTERS

FUNCTION GENERATOR

The Programmable Function Generator (February 1983) should be useful in many types of design work, but its utility might be increased even more by the addition of a 25-pin "D" connector to allow external access to the BCD data lines and a switch to disable the thumbwheel switches. Then the generator could be interfaced with a computer.—*D. W. West, Norwood, MA.*

PUBLIC DOMAIN SOFTWARE

In a recent column, you mentioned Tony Gold and the CP/M Users Group. May I please have an address for the group?—*David Hinrichs, Wilkes-Barre, PA.*

Tony Gold is no longer connected with the CP/M Users Group. However, the address is:

CPMUG
1651 Third Ave.
New York, NY 10028

A lot of public-domain software is collected by SIG/M. Its address is:

SIG/M User's Group
Amateur Computer Club of New Jersey, Inc.,
PO Box 97
Islen, NJ 08830

A complete catalog of public-domain software is published by The S-100 User's Group of The N.Y. Amateur Computing Club, PO Box 106, Church St. Station, New York, NY 10018. There are 7 volumes in the complete catalog at this time and they sell for $10 each.—Ed.

LIKES CP/M

I have been trying to teach myself assembly language for some time, with no success. Your articles on CP/M provide the first approach I have found that is understandable. I am reading the articles and running the programs. They really work and I am finally understanding assembly.—*A.L. Tripamer, Olympia Fields, IL.*

OUT OF TUNE

In "Learning 16-Bit Microcomputer Technology Part 3" (May 1983), in Figs. 16 and 17, *J2* numbers refer to the DB-25 connector on the 64K RAM/RS232C port board rather than the S-62 expansion slot as shown.

In "Super Hold: A Telephone Peripheral" (May 1983), the polarity of *RECT1* should be reversed on both the schematic and the component layout; on the schematic, *C13* should be 0.47 μF and *R21* should be 1 kilohm; and on the component layout, *IC7* should be installed with its OUT terminal facing up.

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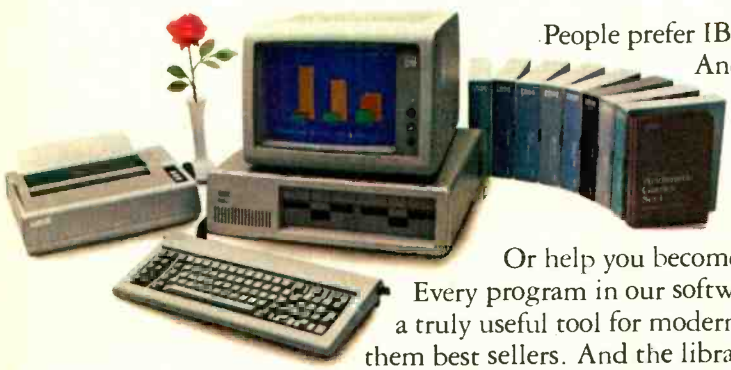

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LINEAR-TRACKING TURNTABLE

JVC's Model QL-L2 linear-tracking turntable has quartz lock and a microcomputer-supervised fully automatic mechanism. An optical tracking system maintains arm tangency to the groove at all times. The tonearm accepts P-mount cartridges. The microcomputer operates in conjunction with an optical sensing system that detects record size and automatically sets correct platter speed ($33^1/_3$ or 45 rpm). A pulse-count system cues the tonearm onto the record and returns it to rest and shuts off power after play. Wow and flutter are rated at 0.025% wrms. $240, including dust cover.

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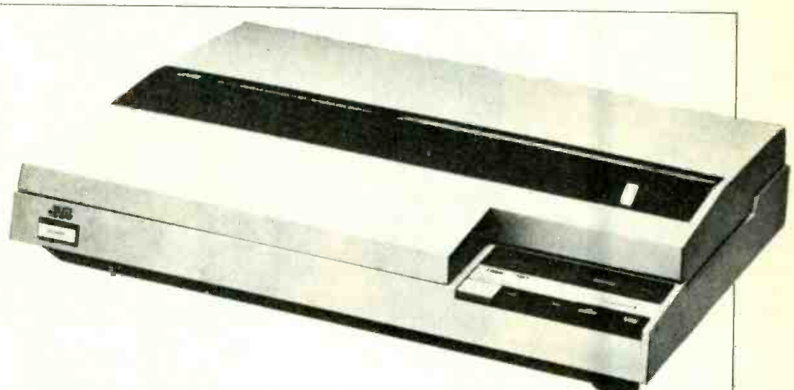

TELEPHONE INTERFACE WITH SPEECH

CompuFone, from Computalker, is a telephone interface and speech storage/output device for IEEE-696 (S-100) bus computers. FCC-approved direct connection is via a standard modular phone jack and it can originate and answer calls. On-board Touch-Tone™ decoder permits entering commands from a remote phone. Voice digitizer subsystem permits speech recording from telephone or MIKE IN or LINE IN connections on the board. Previously recorded speech can be sent over the phone line or reproduced locally. $995.

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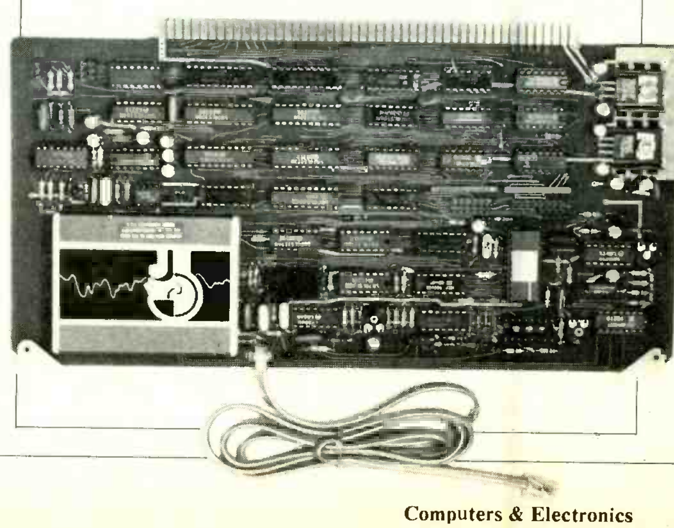

CAR STEREO POWER AMPLIFIER

Model Alphasonik A265, from Visonik of America, is a class-A stereo power amplifier with a rated output of 65 W/channel into 4 ohms. It is bridgeable for mono, delivering 130 W into either 4 or 8 ohms. THD is said to be under 0.01%, 20 to 20,000 Hz. A Perma-Tect™ circuit monitors output current and voltage and limits power without interfering with the signal. Thermal breakers are also used.

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Chalange Sales & Mfg. has introduced the Model 1000 video editor designed for home and small business use. It contains a "color monitor function" and is compatible with most camera-capable VCRs, including mono and stereo units. Professional results are claimed to be obtainable with only three easy editing steps. A dub function is done automatically, *after* the complete edit has been performed and reviewed. $299.95.

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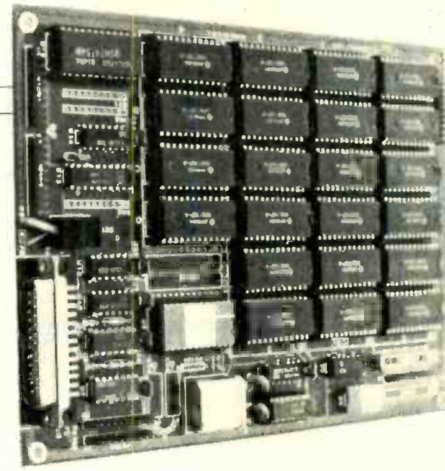

ADD-ONS FOR HERO 1 ROBOT

Perbotics is offering three add-ons for the Heath Hero 1 robot: 8K RAM/communications board (20 sockets for extending memory); 44K RAM/communications board (gives Hero a total of 48K RAM plus RS232C-compatible port); and software on a Hero-readable cassette to use the memory/communications products. $795 for 44K board; $395 for 8K board; $49 for cassette program tape.

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IBM-PC INTERFACE CARD

The Wico Corp. has introduced an interface card that it claims should prove useful to computer video games players who want to be able to use arcade-quality controls with their IBM-PC computer. The Model 40-2070 card is designed to interface the company's Command Control line of Trackball and Joystick controllers to the IBM-PC computer. $64.95.

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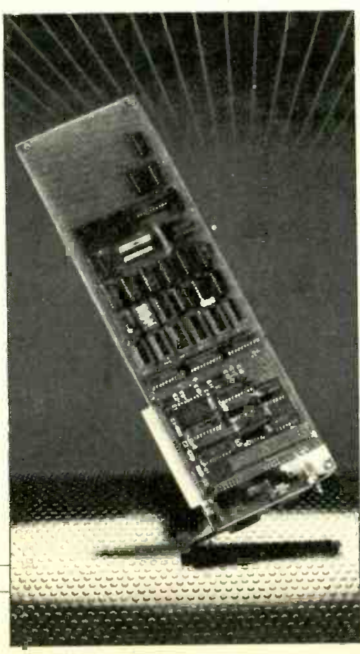

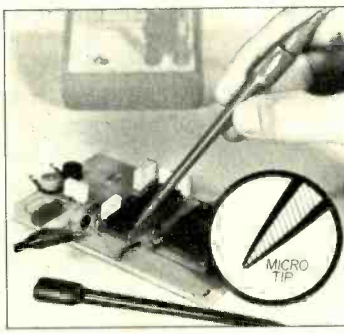

NONSHORTING TEST PROBES

Versi-Probe, from Versi-Corp., is said to be totally insulated except at the very tip to prevent short circuits during tests in crowded electronic circuits. The point itself is sharpened to permit piercing insulation on pc boards and hookup wires for making checks without removing insulation. Connection to the Versi-Probe is made with standard insulated alligator clips. $3.95 per pair. **Address:** Versi-Corp., 15802 Springdale St., #72, Huntington Beach, CA 92649.

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The battery-powered "Gavilan" portable, CMOS-based, 16-bit (8088) computer has an 8-line by 66-character LCD panel, integral solid-state "mouse," full-size typewriter-style keyboard with separate numeric pad, and built-in 3″ (320K) microfloppy disk drive. Programmed into ROM are the operating system (MS-DOS) kernel, interpreter BASIC, and human-interface and data-structuring software. 11″ × 11″ × 2″; 9 lb. Under $4000.

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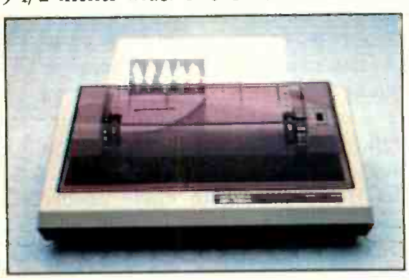

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64K RAM	149.95		
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Keyboard with Interface	99.95		
High Resolution Graphics	99.95		
Centronics Parallel Interface	74.95		
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GP 100A Printer Package**	399.00		
Shipping and Handling	4.95		$ 4.95
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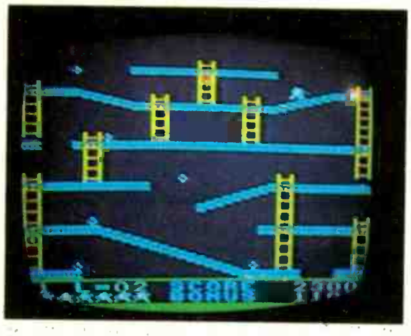
COMPUTER VIDEO GAMES

Hands-On Reviews of Recently Released Game Software

JUMPMAN



Diskette for Atari 400/800
EPYX (Automated Simulations, Inc.), 1043 Kies Ct., Sunnyvale, CA 94086, 408-745-0700. $39.95.
Graphics ★★★
Gameplay ★★★★
Sustained Interest ★★★★+
Type: *Joystick action game*
Memory Required: *32K*

Of all the new action games we've seen, this one has to rate near the top of the list for its originality and sustained interest. The game scrolls through no less than 30 different screens in the course of gameplay, and each one presents your hero with new hazards.

The scenario supposedly takes place in Jupiter headquarters, infiltrated by the enemy—who has planted bombs all over the place. As Jumpman, you are to single-handedly grab and defuze the bombs. To do this, you have to scale ladders, jump gaps, climb ropes, and avoid falling off the platform you're on, because to fall is to die.

There are also various missiles (bullets) fired at you, but because you are Jumpman, you are usually quick to jump out of their way—unless you happen to be too engrossed in trying to negotiate a particularly difficult bomb retrieval.

You start out with seven lives, which you lose rapidly during the learning phases of this intriguing game. As you get better, you can clear a level of all the bombs. At this point the screen scrolls to the next level where there are different enemies to contend with as you chase down the twinkling bombs. The gameplay speed can be changed. You can also select one of four options, including "Randomization" so you can see many levels that you might not otherwise reach.

High scores? Who cares? This game is about as totally absorbing and addictive as the best we've seen in the past couple of years—and that covers an awful lot of games. The overall graphics may not be all that great, but they *are* precise, and work well on a monochrome monitor which is an important plus.

HANGMAN-HANGMATH

Tape Cassette for VIC-20
Creative Software, 201 San Antonio Circle, Mountain View, CA 94040; 408-745-1655. $11.95.
Graphics ★
Gameplay ★★★★+
Sustained Interest ★★★★+
Type: *Keyboard educational game*
Memory Required: *Resident 3.5K RAM*

Okay, so the graphics are awful and use simplistic stick figures. But the interest level and guessing-game nature of the word and math quizzes and the execution (no pun intended) are excellent.

This game is an educational experience for both children and adults, using the typical "Hangman" scenario: you're given the blank spaces for a word and have only so many moves to guess the word correctly. For each wrong guess of a letter, your man takes a step up onto the scaffold. With the ultimate wrong guess, the trap springs and he bobs and jumps at the end of the hangman's rope.

The math portion is a bit more complex. You are presented with a multiplication problem and have to specify column numbers (1 through 5) and guess a number for each column. Sometimes

you hit it lucky, and once you get one number in place, some fancy in-the-head figuring should help you come up with the right numbers until you fill the other spaces correctly.

The two games are on flip sides of the cassette, and the program packs a surprisingly large amount of data into that minuscule 3.5K of user RAM that is resident in the VIC. As educational games go, this is one of the better ones we've seen. The number combinations are randomly generated. Accordingly, problems seldom repeat themselves.

WALL WAR

Diskette for Atari 400/800
Sierra On-Line, Inc., Sierra On-Line Building, Coarsegold, CA 93614, 209-683-6858. $29.95.
Graphics ★★★★
Gameplay ★
Sustained Interest ★★
Type: *Joystick action game*
Memory required: *40K*

Do superb graphics make a game great or just "interesting"? That's what this game has, but they carry the entire weight of this particular disk. The gameplay itself ranks very low.

The packaging suggests a fugitive spin-off from the movie "Tron," but then Tron was all about games of just this type. Two opposing microrobots (one is yours) face off and fire at each other through a moving barrier wall of light plates. These must be shot out of the way before any of your missiles can land on your opponent, or in his plasma bin. Get enough hits on his plasma bin, and he runs out of the precious stuff and you win the game as his robot disintegrates.

You may elect to shoot it out with another human, or play against the computer. You can also set up the game so the computer fights itself. When you square off against the computer, though, you don't stand much of a chance!

The microrobots can elude enemy missiles by firing side-lasers that give them thrust to move horizontally. When hit by a bomb, the laser can become erratic for a time until it "heals."

Overall, this game is well thought-out and contains a lot of design sophistry, but that doesn't make the action any better. It's repetitive and can get boring very quickly, and therein lies its main weakness. But, oh those graphics! They are something. ◇

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Hardware Tricks To Improve Computer Usage

THERE are many areas of computer hardware that, for some reason or other, are seldom discussed. For example, did you know that it is possible to tell just how good a video monitor is without having to make extensive electrical tests? In fact, using the simple test I'll describe here, you can pick the best monitor out of a bunch or find out just how good the monitor you are using really is.

The test requires no hardware or software, takes only a couple of minutes, and is so unobtrusive that it can be performed without attracting attention.

All you have to do is turn on the video monitor and, using the keyboard of the computer, fill each line on the screen with lower-case *m*'s. Note that in a lower-case *m*, there is a dark gap (unpixel?) between the bright pixels making up the three short vertical arms (ignore the top of the letter). This letter produces an almost maximum bandwith display.

Adjust the monitor's brightness, contrast, and focus for the best viewing conditions, then carefully examine the *m*'s at the center of the screen. Since the screen center provides the best video quality, each vertical arm of the *m*'s should be clean and distinct, with a clear dark gap between. If the arms or spaces are blurry, then either the bandwidth or the focus of the monitor is poor. The lower the bandwidth, or the poorer the focus, the more blurry the vertical arms and the harder the letters will be to read. If you are performing this test using a color-TV set as a video monitor, blurriness may also be produced by poor convergence of the CRT/yoke combination.

Note that the complete set of letters should be formed within the usable screen area of the CRT, and the display should not extend to the bezel that surrounds the CRT (which may be the case in a TV receiver used as a monitor).

Check the legibility of the display right out to the four edges (top, bottom, right, left). The closer to the edges that the display remains clear and legible, the better the monitor. This is a direct effect of bandwidth and focus capability (and in the case of color, convergence).

Also check that the top and bottom groups of horizontal lines are straight and not bowed up or down, and that the right and left sides of the display are truly vertical and not bowed in or out. Any bowing, in either direction, is a symptom of poor linearity in the monitor sweep sections that should be corrected.

Using this simple test, several monitors can be checked in a few minutes and the best of a group can be found. Obviously, this same test can be used to check the quality of your present video monitor to see just how good or bad it is.

Direct Video Output. The second hardware area is a followup of the direct video output item I covered in my March column. In that case, a Sinclair/Timex was used as the example. I received considerable mail asking me how this conversion can be done with other computers/video games.

The conversion requires the ability to read a schematic, knowing how to solder, having a little mechanical aptitude with some simple tools, and the willingness to lose the warranty on your computer/video game.

All computers or video games that use a TV receiver as a video display must use an r-f modulator—usually giving a choice between vhf channels 3 or 4. In most of these machines, the r-f modulator is a small, square metal enclosure that contains the r-f oscillator and modulator. There is invariably a slender coaxial cable between the enclosure and the r-f connector that is coupled to the externally mounted TV/game switch.

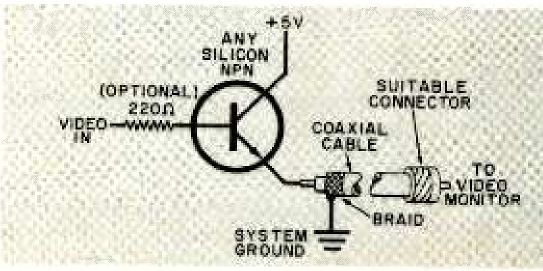
In most cases, there will be three leads interconnecting the system "motherboard" to the r-f modulator. These usually carry the +5 volts, video, and ground. The schematic will identify these. In the case of the Atari 400, for example, pin 4 is the baseband video to the modulator, while pins 3 and 1 are the +5 volts and ground, respectively. If you do not have a schematic, then an oscilloscope can be used to locate the video, while a dc voltmeter can locate the +5 volts and ground.

To make the direct video conversion, which will not affect the r-f output, carefully remove the screws (usually on the bottom of the case) that secure the plastic enclosure halves together.

Gently lift or move aside the now-loose cover and locate the r-f modulator. Then identify the three required signals (video, +5, and ground).

The accompanying drawing shows an emitter follower that can be used to interface almost any r-f modulator to almost any video monitor. With the computer/game power off, solder one end of an optional 220-ohm resistor to the base of any silicon npn transistor, and the other end to the video lead that supplies the r-f modulator. To determine whether you need the resistor or not, first try it with, then without. If the video contrast drops too much, leave the resistor out. Connect the collector to the +5 volts and the emitter to the center lead of a slender coaxial cable. Connect the braid of the coaxial cable to the system ground. To avoid short circuits, insulate the transistor, resistor, etc., with a turn or two of electrical tape. Route the other end of the slender coaxial cable out of the cabinet and terminate it with a connector that will mate with the video monitor to be used. Carefully close the computer enclosure. (In some instances, the video monitor may have a capacitor input, so the emitter follower will not work. If this is the case, terminate the follower by connecting a resistance of 50 to 300 ohms between the emitter of the transistor and ground. Then connect the center lead of the coaxial cable to the emitter.)

You should now be able to use either the direct or r-f output of the computer. If you try both, there is no doubt as to which you will stay with. ◇



Use an emitter-follower circuit to interface an r-f modulator to almost any video monitor.

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The Comstar is an excellent addition to any micro-computer system. (Interfaces are available for Apple, VIC-20, Commodore-64, Pet, Atari 400 and 800, and Hewlett Packard) At only $279. the Comstar gives you print quality and features found only on printers costing twice as much. Compare these features.

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CIRCLE NO. 68 ON FREE INFORMATION CARD

What Makes a DBMS Tick and What Kind Do You Need?

DATA-BASE and data-file systems constitute one of the most widely used groups of application software on the market. Actually, we can put them both under the umbrella name of Data-Base Management Systems (DBMS); and believe me, that's a big umbrella!

What is a DBMS? Well, it is a collection of information organized so that it can be stored and later recalled by using logical inquiries. This is a broad explanation, but it is accurate and simple. A file cabinet with folders containing papers full of information is a physical data base. That is the structure we are duplicating with computer data bases.

It is only our filing, cross-reference, and retrieval methods that make the subject so complicated. We also include elaborate sorting routines and reports within our systems. These really have nothing to do with DBMS, but we keep including them because they do jobs that are needed.

Because we have no file cabinet in our computer, we use some kind of magnetic storage, either tape or disks. Tape is slow because what you are looking for may be in the middle of a half-mile of the stuff and you have to move the whole reel to get to it. Disks are much more practical, so we use floppies and hard disks for our file cabinets. A group of information stored together on a disk is called a file. The first data-base systems were just programs for finding the correct file in a hurry. They were file management systems. The user supplied the name of the item and the system associated it with the name of the file and where it was located, retrieved the file, and displayed the information.

Such associative data-base systems were the first put on microcomputers. An outstanding one was called Whatsit, and it helped sell a lot of computers. It prompted you with "Whatsit" and you supplied the information in a simple format. If it was new information, it stored it. If it was on file, it was retrieved.

Large mainframe computers used a data-base system organized into a tree structure. The data was stored by subject in a record of a file. Each record was divided into a number of subdivisions called fields. An example of this is the record about a person. It would have fields representing Name, Address, City, State, Telephone No., and any other information about a person. These fields would be the same for each person listed and they were all stored on the disk. The system could find the records when asked by "selection criteria" such as "people named Smith" or all people who live in the 10034 Zip code area.

There were so many systems and each one used different names for the same thing that the entire field became a Tower of Babel. Therefore, a meeting was called and a set of definitions was established. This is known as the Council on Data Description Languages (CODASYL). You will notice that they couldn't even agree on the name "Data Base." Very few personal computer DBMS systems conform to the CODASYL specification. It's very complicated and needs lots of memory. The good part of it is the ability to "leap" from one branch to another without going back to the main "trunk" of the tree and traversing the next higher level of branches until you come to the desired branch. Such systems as Micro Seed and MDBS from Micro Data Base Systems (Lafayette, IN) conform, more or less, to this concept. They are hierarchical (like an inverted tree).

Another method of locating information stored in data files uses an indexed file system (ISAM). In this system there is a directory file where the location of each information file is stored. When you are looking for a record, the system searches the index files for you, locates the information, and displays it for you. Most of the personal computer DBMS systems used this system until recently. Typical of them are Selector, DBMaster, Profile, PFS, and many others.

A few years ago, after such spreadsheets as Visicalc became popular, it was recognized that the tabular form was really a type of information storage called a "flat file." This has led to the development of what we call Relational Data Bases, which is simply a table of rows (horizontal) and columns (vertical) information. The row contains the name of the record subject in the first (or second) column and a unique record number that make it easy to find. The other columns are for specific information that are characteristics of the record subject. You have seen this type of table many times, no doubt. It describes computers, modems, or whatever, and compares them in tabular form. A Relational Data Base is just a collection of such tables and a simple way to store and locate information stored in them. The entire idea is simple, but it has been complicated by giving it names that are hard to remember and define. The flat file is called a Relationship and the row containing all the information a Tuple. The column listing all the same kinds of information for all rows is called a Domain.

Naturally, to make it even more complicated, all such systems don't use these names. For example, dBase II, the most popular of them, calls the row a Record and the column a Field.

If you take all the flat files and stack them like a deck of cards, you have the concept of a Relational Data Base. All the same kinds of fields (domains) fall in the same column on all the flat files. Now you can extract information in three dimensions. You can find a particular record, including all the information about it, and you can find all the information on the fields in one relationship or in all relationships.

This sounds simple, but the complexity comes about by the programming necessary to store, retrieve, sort, and print the data. In fact, some of these systems have become Date Description Languages. Again, dBase II is the most popular example of this. People program in dBase II in the same way they program in COBOL or BASIC! Don't let this keep you from trying it. You do not have to use all the features. However, you should carefully consider how much system you need.

Perhaps all you want to do is to store a reasonable amount of information—say, 3000 records with 60 different "keys"—to locate them, and you don't need to do math operations with the information. Therefore you only need a data-base file system like PFS (Personal Filing System) or Data Fax from Link Systems. These will do a good job for you at a much smaller price. If you need a full-blown system to do complicated searches, sorts, and calculations then dBase II, or Condor, or Selector, or MDBS is for you. So don't buy more than you need, and try not to buy less! ◇

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HARDWARE

Winchester for Z-100. The Zenith Z-100 computer is now available in either low-profile (ZW-110) or all-in-one (ZW-120), and features a built-in 5", 11 M-byte (formatted) Winchester hard-disk drive. Using the Winchester increases the Z-100 storage capacity some 17 times to 11M bytes. A built-in 5¼" floppy is used to enter programs or pro-

vide backup. The RAM has been increased to 192K. Using only one of the five S-100 expansion slots, the Winchester controller has error-correction circuits for user reliability. A back-up and restore utility is provided to enable selecting files created on or after a particular date, and back up only those files. All Zenith software that runs on the Z-100 is usable on the Winchester version. ZW-110 (low profile) is $5499, with ZW-120 (all in one) is $5599. **Address:** Zenith Data Systems, 1000 Milwaukee Ave., Glenview, IL 60025 (312-391-8744).

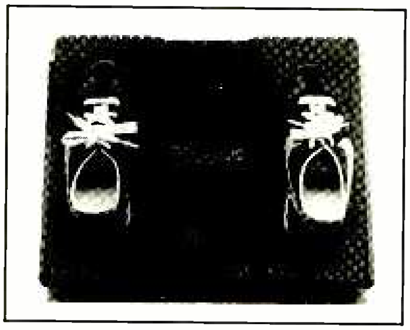
IBM Memory Expansion. The PC 4-PACK contains 64K (expandable in 64K increments to 256K bytes) of memory, an asynchronous RS232C port, a real-time clock/calendar, and a parallel printer port. Automatic parity insertion and verification are included and switches allow selective addressing on any 64K boundary. The RS232 port includes cable and is jumper selectable in baud rate, word length, and stop bits. It can also be addressed as COM1 or COM2. Clock battery life expectancy is one year. The parallel port comes with cable, Centronics connector, and protocol. Jumper selection configures LPT1 or LPT2 without interfering with operation of the parallel printer portion on the monochrome board. $395 (64K). **Address:** Data Impact Products, Inc., 745 Atlantic Ave., Boston, MA 02111 (617-482-4214).

BASIC Controller. The Z8 BASIC Computer Controller uses a Zilog Z8671 that has Tiny BASIC, up to 6K of RAM and EPROM, an RS232 port with selectable baud rates, and two parallel ports, all on a 4" by 4½" board. Expansion is to 124K and connecting a CRT terminal allows immediate programming in BASIC or machine language. The software can be transferred to 2732 EPROMs with an optional EPROM programmer. Other peripherals include a real-time clock, serial and parallel I/O, A/D converter, and an EPROM programmer. $199. **Address:** The Micromint, Inc., 561 Willow Ave., Cedarhurst, NY 11516 (516-374-6793).

H-89 Hard Disk. The WIN-5 is a 5-megabyte Winchester disk system that is compatible with the Heath 89 or Heath 90 systems operating under CP/M. The sealed Shugart drive requires only one I/O slot. Assembled unit is $1695; kit, $1000. **Address:** Computer Dynamics, Inc., 105 S. Main St., Greer, SC 29651 (803-877-7471).

Commodore 64 RS-232. The ADA-6410 is an interface cable that plugs into the Commodore 64 serial port connector and provides the voltage conversions to make this port true RS232. The cable is 6' long and the electronics are fully enclosed. Power is received from the computer and no special software is needed. Address #2 is used. $79. **Address:** Connecticut Microcomputer, 36 Del Mar Drive, Brookfield, CT 06804 (203-775-4595).

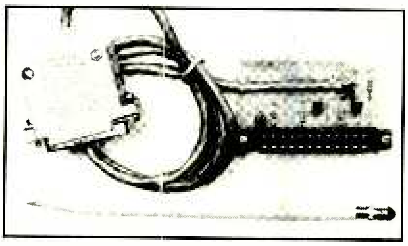
Atari Platform Stick. The Joyboard designed for the Atari 2600 is a different form of joystick in that it can be stood on to simulate skiing, sat on for bobsledding, or even layed on for body surfing programs. It can also be used with any



other type of game. In some cases, the joystick pushbutton is used for "firing" while the Joyboard controls movement of shooter. The device comes with Mogul Maniac a skiing/slalom game. Additional "body" games are under development. The Joyboard is available in two versions; one for use with this company's Power Module ($39.95), with the other using a ROM cartridge that plugs into the Atari VCS ($49.95). **Address:** Amiga Corp., 3350 Scott Blvd., Santa Clara, CA 95051 (408-748-0222).

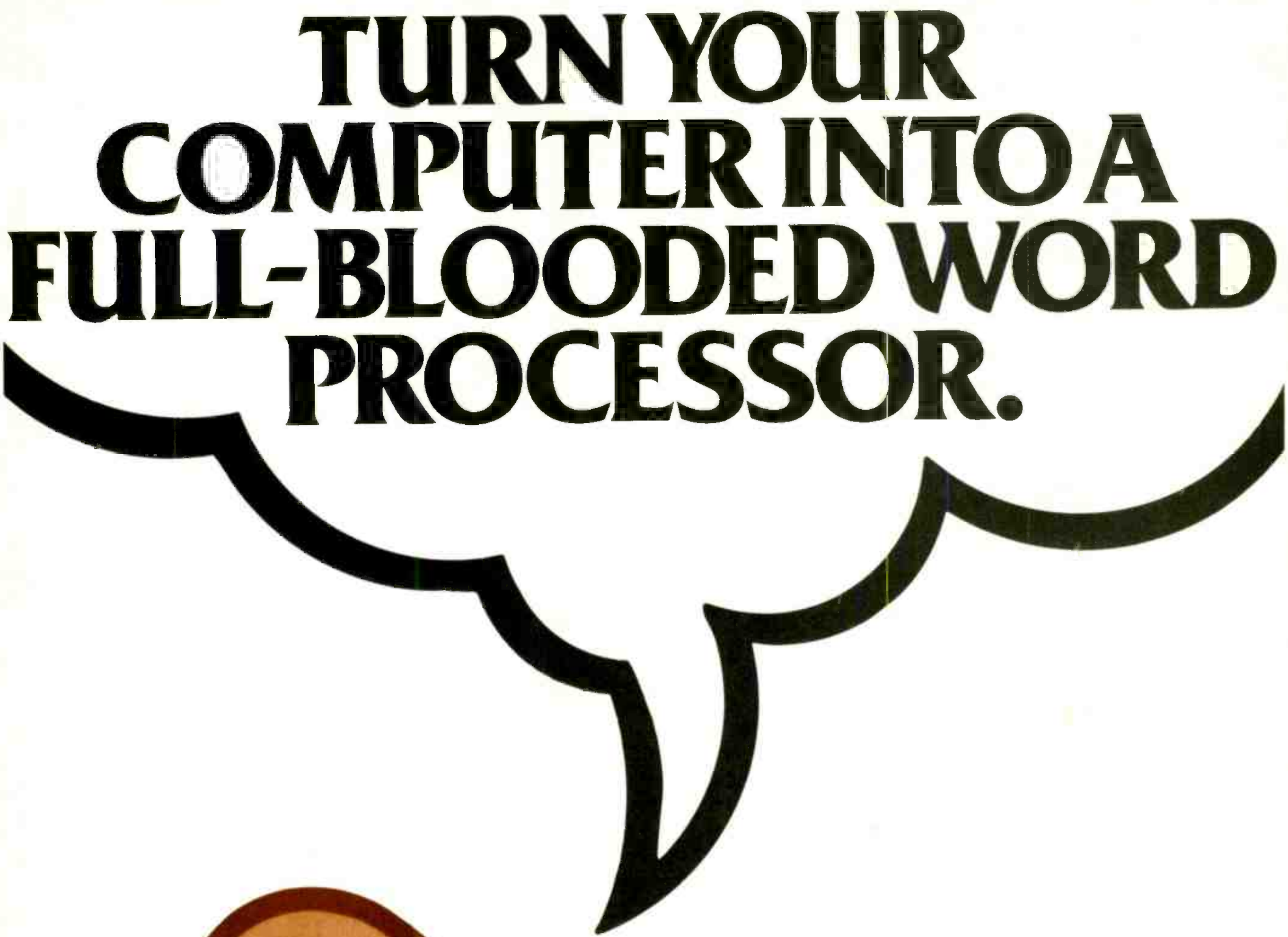
Ergonomic Desk Kit. The Ergonomic Furniture Conversion Kit consists of a CRT platform that can tilt, move back and forth, and rotate; a keyboard support that is designed to fit on the desk, move up or down, tilt, and is provided with wrist support; and a footrest that is designed with both heel and toe height adjustments. The system will fit any standard office desk. **Address:** Diversified Business Communications Ltd., 7475 Kimbel St., Unit #8, Mississauga, Ontario, Canada L5S 1E7 (416-677-4000).

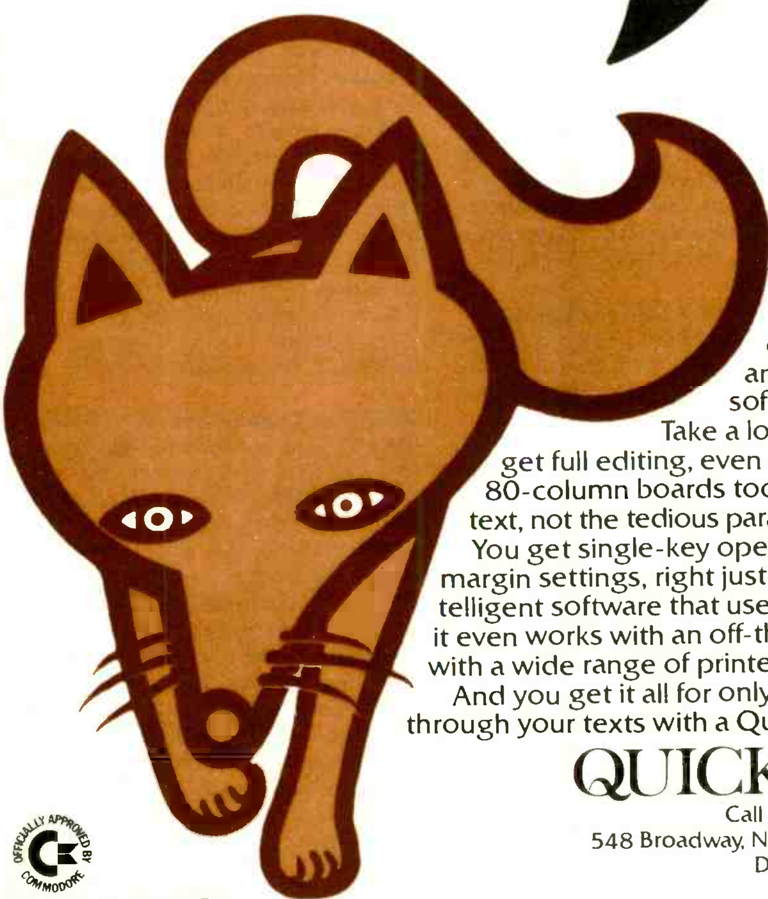
VIC Modem Interface. The Modem Interface allows VIC-20/64 users to interface to a Microconnection, Smartmodem, CAT, etc. It is provided with a



3-foot cable terminated in a DB25 connector, and allows use of the modem autodial/autoanswer features. It comes with an autodial terminal program. $21.95. **Address:** Bytesize Micro Technology, PO Box 21123, Dept. CJ, Seattle, WA 98111 (206-236-2983).

PC Memory Expansion. The Ramplus memory expansion board for the IBM-PC has a memory mapping feature that provides the user with over a megabyte of memory on a single board using 256K RAM chips. Because the IBM-PC reserves blocks of memory for system programs, the BASIC language, and CRT display, two circuit boards are usually required. The board accepts up to four banks of RAM, designed to accept either 64K or 256K RAM chips. Parity error-detection logic is provided on-





VIC 20™ and Commodore 64™ users, something very clever is lying in wait for you. It's called Quick Brown Fox.™

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board. Other functions include a serial and parallel port, and clock/calendar with battery backup. $499. **Address:** Vitek, 930-G Boardwalk Ave., San Marcos, CA 92069 (619-744-8305).

SOFTWARE

SAT Tutoring. A series of programs introduced by Krell Software "guarantee" that the user (student) will increase his/her proficiency in the SAT by 70% as a result of using the instructional programs in the series. The programs are based on the latest artificial intelligence techniques to customize instruction for each student. The purchase price, less sales tax, will be refunded if the goal is not achieved. **Address:** Krell Software Corp., 1320 Stony Brook Rd., Stony Brook, NY 11790 (Tel. 516-751-5139).

E-COM Mail via Personal Computer. Digisoft Computer's E-Com software allows you to write letters on your personal computer. Instead of writing, stuffing and sealing envelopes, the computer can transmit a large volume of personalized letters. E-Com service prints each letter, places it in an envelope, and delivers it within two business days, and in some cases overnight. The package runs an the IBM-PC and costs $195. **Address:** Digisoft Computers, 1501 Third Ave., New York, NY 10028 (212-734-3875).

Editor For Z-100 CP/M. The well-known PIE full-screen editor has been tailored for the Heath/Zenith Z-100 in version 1.5. It will be included with the package designed for use with CP/M-80 on the Heath/Zenith H89/Z90 Computers. The new release incorporates a HELP key to provide a brief summary of the PIE function keys. The Z-100 version of PIE takes advantage of the computer's many function keys, while leaving the numeric keypad available for numeric data entry. The screen scrolling feature has been enhanced for efficient operation of the Z-100, which older Z89/Z90. $29.95. **Address:** The Software Toolworks, 14478 Glorietta Dr., Sherman Oaks, CA 91432 (213-986-4885).

Timex/Sinclair TS1000 Software. New programs for the TS1000 released by Timex include:

IRA Planner—a 16K finance program that enables the user to determine the net effect of IRA planning. Periodic contributions, inflation adjustment, interest earned, and other variables can be set up and the retirement amount calculated in value of both future and current dollars.

Home Improvement Planner—a 16K program that enables the home owner to store up to 20 room measurements, estimate the cost of painting, wallpapering, and carpeting. Blueprints of the house can also be drawn and printed out.

Punctuation Master—an educational program (16K) that increases skill in using periods, question marks and commas.

"Ator the ABC Gator"—teaches recognition and sequency of the alphabet to the very young (16K).

Geometry I, Algebra I, and Algebra II—individual 2K programs for school drills in basic math and algebra.

All programs are on cassette and priced from $9.95 to $19.95 at Timex dealers.

CP/M for 12M-Byte Hard Disk. The popular operating system CP/M 2.2 is now available to run on Radio Shack's new 12M-byte hard disk for the TRS-80 Model II, and Models 4,12, and 16. It is memory-space efficient, using only 16K of controller RAM and 2K bytes of CPU memory. This leaves 62K of RAM for user processing. The disk can be partitioned with this system into several user-specified logic drives that simulate multiple drives. This also lets the user back-up data on unused portions of the same hard disk. A utility allows files as large as 8M bytes to be backed up onto multiple floppy disks. $279. **Address:** Aton International, 260 Brooklyn Ave., San Jose, CA 95128 (408-554-9922).

VIC-20 Amateur Radio Logging. Using the VIC-20 Micro Log system, ham radio operators can keep a log of QSO's for any purpose—especially contests (including duplicate checking). The amount of records the system can keep depends on the size of the computer memory. Minimum requirements are: VIC-20 with 8K memory expansion, cassette recorder, and printer (such as VIC-1525). A disk drive and additional memory are also supported. The basic 8K memory will allow up to 250 to 300 calls. $9.95 on cassette, $12.95 on diskette, both plus $2 for shipping. **Address:** RAK Electronics, PO Box 1585, Orange Park, FL 32073.

Program for School Records. The PFS: School Recordkeeper for Apple II and IIe works with the PFS: File program to produce over 30 reports for student record management, budget and requisition control, property management, and room and event scheduling. Consists of four ready-to-use forms, each designed to include five to eight predefined report formats. Information can be entered on the form and then retrieved, updated, and sorted by any category. Form designs and reports can be changed to meet special needs by individual schools. $150; $400 with PFS: File and PFS:Report. **Address:** Software Publishing Corp., 1901 Landings Dr., Mountain View, CA 94043 (415-962-8910).

Forth-79 Ver. 2 for CP/M and Apple. Complete software system that meets the Forth-79 Standard provides interactive environment that allows rapid program development. Suited for real-time applications, it has a high-speed compiled code and programs are said to run faster that BASIC. Base system includes a screen editor, macro-assembler, string-package, 3-bit integer arithmetic and 200-page tutorial/reference manual. Floating point is available for all versions. HiRes graphics for Apple and North Star versions. $99.95 to $139.95. **Address:** MicroMotion, 12077 Wilshire Blvd., #506, Los Angeles, CA 90025 (213-821-4340).

Almost-Free Software for Timex/Sinclair. Listings for some interesting Timex/Sinclair programs for $3 per package include a Home Financial Package, an Arcade Games package, and a program similar to the famous "Eliza." Listings must be keyed in, but the programs are really worthwhile. The company gives permission to copy the listings for friends, but requests that it be sent a royalty payment of 25¢ per copy. **Address:** Florida Creations, PO Box 16422, Jacksonville, FL 32245

Graphing Capabilities for TS1000 (ZX81). Data Storage and Display System is the first system for the Timex/Sinclair to offer garphic capabilities in a data-storage program. This program allows the user to monitor stock market prices, experimental data, or any numerical values. The values are stored in the computer in up to 25 files. They can be recalled as either a tabular list or in graph form. Either form of display is accompanied by a data summary including lowest and highest points, closing point, file number and title, file sum, and average score. Available on cassette with complete instructions for $14.75 (plus $1.25 postage). **Address:** ZX-Panding Ltd. PO Box 25, Newton, NC 28658 (704-464-2742).

Forget the old-fashioned cordless phones of the early 1980s.

The Muraphone MP-800/801 is a complete phone system, with as many as five cordless remote independent "satellite" phones!

The Muraphone MP-800/801 is a superior cordless phone with super-range — not just 700 feet but **1,000 feet.**

Voice quality is indistinguishable from a conventional phone. It's perfect.

The old cordless phones wouldn't activate a Touchtone™ signal. You could make local calls but you couldn't use your cordless phone to dial a computer or Sprint or MCI or any of the tone-activated systems. The Muraphone switches from rotary pulse to Touchtone in a flash.

Both the base unit **and** the remote unit are complete telephones. You can make or answer calls on either or both, and they're full duplex, so you don't have to wait until the other party isn't talking before you can interject a comment.

It's an Intercom System

The base unit and the remote unit also have full duplex intercom capability. Either can call the other.

They even can have a private intercom conversation while an outside call is put on hold. Try that with your old-fashioned cordless phone.

Only you can have your channel. You're assured of complete privacy because you yourself pre-set the channel security code from more than 20,000 possible combinations. Change the code any time.

Up to 5 Remote Phones

The base unit can handle up to five remote phones. Each of the five is on a different channel code, which means you can have separate private intercom conversations with each — or you can put them all on the same channel. Up to you, and if you change your mind you can switch any or all of them back and forth.

Each remote unit can dial out or accept incoming calls. (You see why we call this a complete phone system?)

A Memory Better Than Your Own

The Muraphone remembers up to 32 phone numbers, up to 16 digits each. Dial any of those numbers at a touch. (Few people remember 32 different numbers.)

The remote handset has the same built-in 32-number memory. You can order additional handsets with or without the memory, so if most of your fast-dialed outgoing calls are from the base unit or just one of the remotes, you can save some money.

Oh, yes — the phone talks to you, in a pleasant synthesized voice. It'll recite for you any of the 32 stored numbers. Or, if you're programming the memory and do it wrong, it'll tell you what mistake you've made. You can err, but your smart Muraphone can't.

That isn't all the voice will do for you. Push the button marked "List" and the voice will recite, in sequence, each of the numbers in the memory. The files can be locked and the lights off — you'll always be able to recall **all** the numbers in the memory.

The Muraphone, with its 32-memory brain, its privacy codes, and its full duplex intercom system, is $249.95. That includes a base station which can be used as a complete, separate phone; and one remote unit which also has the 32 memories in its trim innards.

Additional handsets are $129.95 with memory, $109.95 without. As we told you, one base station can handle up to five remote phones, and you can mix and match memory and non-memory phones as you like.

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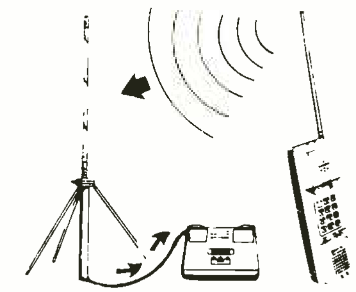

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CIRCLE NO. 27 ON FREE INFORMATION CARD

Are those Digital Discs All They're Cracked up to Be?

By Len Feldman

As of this writing, it's possible to buy several different brands of CD (compact disc) players. The general press and audio-oriented journals have been, in recent months, extolling the virtues of the laser-read grooveless discs as though they were about to make obsolete everything from Edison's first recorded cylinders to the most recently issued audiophile "digitally mastered" records. (The latter, incidentally, have helped to thoroughly confuse the public who will now have a difficult time differentiating between older "digitally mastered" LPs and the true digital discs becoming available.)

So far, I have had an opportunity to audition some two dozen or more of the first available CD discs on nearly a dozen different players. I have also checked out these disc players, using a test record supplied by Sony Corporation and, more recently, three test records supplied by Philips, the people who invented the basic system that has now become the world standard for digital discs.

Player Differences. Some discerning ears have detected a subtle difference in quality of sound reproduction between various brands of compact disc players due to technical differences in the way these players reproduce sound. The main difference is in the signal-conversion process from digital to analog. The conventional method, used by most manufacturers, involves straight 16-bit digital-to-analog (D/A) converters with steep analog filters. The digital sampling rate established for CD discs is 44.1 kHz, because the industry wanted to be able to record and play back frequencies as high as 20,000 Hz. According to the long-established information theory rules, to be able to do this requires a digital sampling frequency at least twice as high, or 40.0 kHz. So 44.1 kHz was chosen to provide some "clearance" between the highest frequency recorded and the action of the steep filter that must remove all frequencies above the highest audio frequency to "smooth out" the recovered waveform and reproduce it with minimal distortion.

Setting a cut-off frequency for a low-pass filter at, say, 21.0 kHz at the −3-dB point and expecting attenuation at 22 or 23 kHz to be 40 dB or more requires a filter with many "poles" and a very steep slope. Such filters invariably introduce phase distortion and can produce "signal overshoot" (ringing) when the recovered analog waveform consists of steep transients, square waves, or the like.

To produce such "brick wall" filters (as they are sometimes called) requires extreme precision for all filter components. To maintain temperature stability, electronic packaging for the analog filters also becomes extremely bulky.

An alternative approach is one used by Magnavox and several other manufacturers. Three techniques are used to overcome the disadvantages of sharp cutoff filters just above the audio range. The first of these is oversampling, which reduces noise in the audio band by 6 dB. In this technique, the digital signal is sampled at four times the normal rate, which distributes the noise over a four-times broader spectrum than normal.

Digital filtering is used to remove ultrasonic components while maintaining good phase linearity up to 20 kHz. Finally, noise shaping reduces noise in the audio band. Unwanted high frequency noise is then eliminated with simple analog filters that have moderate attenuation slopes.

Published Specs vs. Reality. Reading some of the published specifications for CD players, you might correctly conclude that utopia for audio enthusiasts had truly arrived. "Ruler flat" response from 20 to 20,000 Hz is claimed. The slight attenuation at 18.5 kHz shown in Fig. 1 (−0.8 dB for the left channel and −1.1 dB for the right channel) suggests that the "ruler" is slightly "bent" at one end. However, this response curve is far, far better than anything ever produced from a conventional LP test record tracked by even the finest stylus/cartridge combination.

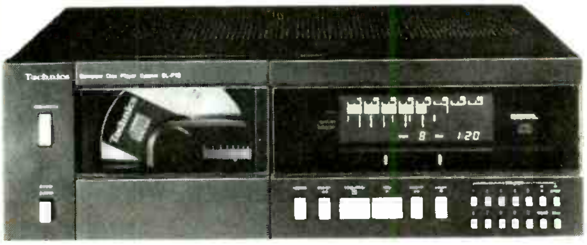
Total harmonic distortion (THD) is usually quoted at about 0.003% to 0.005%. Since most of us have difficulty detecting THD until it reaches at least 0.5% to 1.0%, published THD figures for CD players seem almost irrelevant. In reality, they're not quite that ridiculous, since THD gets *worse* in digitally encoded sound as level *decreases* (the reverse of analog amplifiers, etc.). The quoted 0.005% is for the *loudest* levels of sound the player is capable of handling. Plots of THD versus frequency for that level as well as for lower levels are shown in Fig. 2. As you can see, THD at a −30-dB level is very low but it doesn't have "several zeros after the decimal point" found in the published specs.

IM distortion, which many people consider to be more significant than THD, behaves similarly. On a typical CD player, we measured an IM distortion level of 0.003% at maximum recording level but found that it increased to 0.025% at −20 dB. Since at still lower levels (not provided on even our latest test CD discs, but very prevalent in actual musical recordings) we can expect that THD and IM would rise still further.

Dynamic Forms of Distortion. So far, all we've discussed are static forms of distortion that can be measured with repetitive test signals. With such signals, for all practical purposes, CD players and discs can be said to reproduce waveforms that exhibit negligible differences between themselves and the original sounds picked up by the recording microphones. Unfortunately, music waveforms are much more complicated than test signals.

In an effort to approximate such music signals, the new test records produced by Philips include such music-like signals as square waves, tone bursts, and steep transient pulses. In addition, the test disc includes a pair of tones, one at low frequency recorded on the left channel, the other at a higher frequency on the right channel. The purpose of these tones is to settle the question concerning phase linearity of the various CD players—those that use the sharp cut-off filter only slightly above 20 kHz and those that use the oversampling technique espoused by Philips and Magnavox. We'll discuss this problem more later on. First, let's look at some scope photos of square waves.

A reproduced 100-Hz square wave is shown in Fig. 3A, while in Figs. 3B and 3C, we see square waves that have fundamental frequencies of 1002 Hz and 5512 Hz, respectively. Examining Fig. 4, note that what should have been a single pulse of some short duration, followed by a zero-amplitude baseline for the next 127 time periods (compared with the unit pulse width) turns out to be a pulse followed by a decaying series of "ringing" pulses that obviously weren't in the original test recording. Even the relatively mild 4001-Hz tone



The Technics LS-P10 combines compact-disc techniques with a microprocessor system for programming.

"These new players . . . produce such magnificent sound with such overwhelming dynamic range, that it's not worth quibbling about phase errors at 20 kHz."

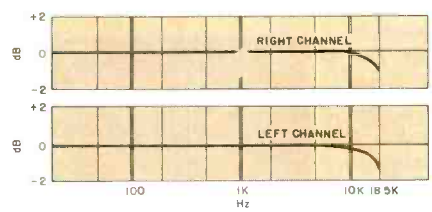


Fig. 1. "Ruler flat" response claimed by some specifications is not always true, as shown here.

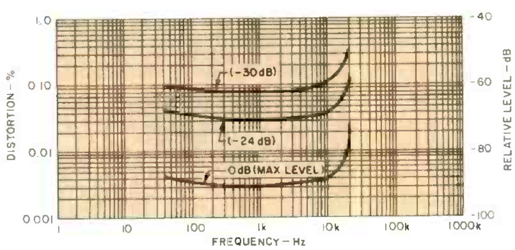


Fig. 2. Harmonic distortion vs. frequency at various recording levels for a typical CD player.

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burst of Fig. 5 (turned on for about 0.026 second) with a repetition rate of 2 Hz, had some trouble settling down to zero after the signal on the disc itself stopped.

As for phase linearity, here's one of the few instances where we could actually see or measure (we didn't say *hear*) a difference between players that use the "brick-wall" filter approach and those that use oversampling. In Fig. 6A, a 2000-Hz left-channel output tone is superimposed upon a 20,000-Hz right-channel tone. The zero-axis positive-going crossing of the lower frequency tone is supposed to occur at exactly the same time as the zero axis positive-going crossing of the high-frequency tone. That's exactly what happens. This perfect phase linearity was observed for a CD player in which oversampling and digital filtering are used.

The same pair of outputs for a player that uses the "brick wall" filter approach, is shown in Fig. 6B. Note that the positive crossings of the zero axis for both tones are no longer at precisely the same spot; some phase displacement has taken place.

Moment of Truth. Having established that there's at least one measurable difference between the two types of players, we set out to conduct a battery of listening tests to find out if we could hear the "subtle" differences referred to earlier. We listened to difficult passages from all two dozen of our CD discs. The recordings that we especially liked sounded *great* on both types of machines! The recordings that we didn't care for (either because they weren't really made from digital master tapes or because we didn't like some of the tinkering that the recording engineers had done) sounded bad on both types of machines!

Taking everything into consideration, the various artifacts introduced at the recording studio are far more significant and tend to mask any subtle differences arising from the two design approaches to CD players we've been talking about. These new players, when playing good CD recordings (of which there are an ever-increasing number), produce such magnificant sound with such overwhelming dynamic range, that it's really not worth quibbling about phase errors at 20 kHz and transient overshoot at frequencies even a dog would have trouble hearing.

To answer the question posed at the beginning, "Are those digital discs all they're cracked up to be?" You *bet* they are, and then some! ◇

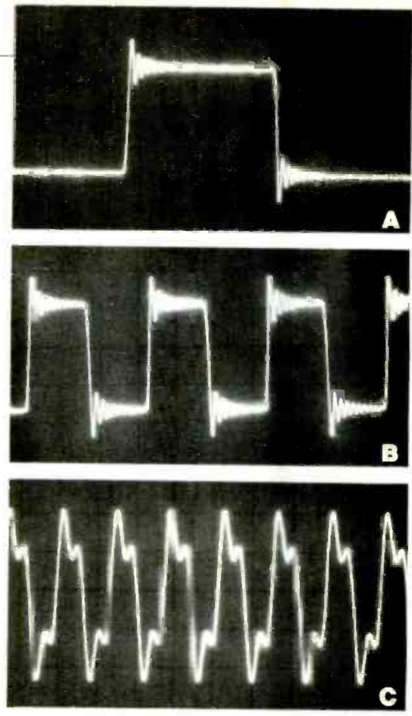

Fig. 3. Square waves reproduced by CD player at: (A) 100 Hz, (B) 1002 Hz, and (C) 5512 Hz.

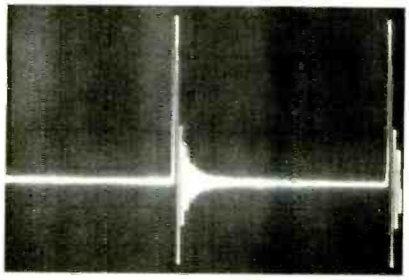

Fig. 4. Single pulse produces ringing.

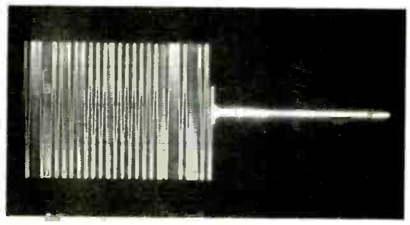

Fig. 5. Tone burst had some after-effect.

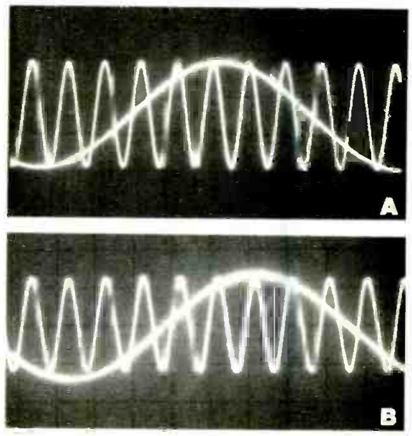

Fig. 6. Perfect phase linearity (A) and minor phase error with "brick wall" filter (B).

KLOSS NOVABEAM MODEL TWO PROJECTION TV

PROJECTION color television for the home isn't novel. But a system the size of a 19" color TV receiver that produces a picture bigger than that of very bulky all-in-one projection units certainly is. Such a product has been developed by Kloss Video Corp.—the Novabeam Model Two.

Kloss is best known for its two-piece projection model that throws a giant 6½' picture onto a big bowed screen. Its smaller and less expensive Model Two shows a 5' 4" color picture directly onto a wall that is painted flat white. (A matte-white screen can be substituted if a white wall is not at hand.) It must stand 4' away from the projection surface. Without the need for a separate slightly curved screen, viewers can see the picture at any location in a room, eliminating a shortcoming of other projection systems that require one to be positioned in a limited central area.

The model's compactness and relatively moderate price have been achieved by clever design and by omitting a built-in TV broadcast tuner. So it really operates as a projection video monitor, requiring a videocassette recorder, TV tuner, or other TV program source to generate picture and sound. It's likely that a person who springs for the higher cost of a projection TV system is already a video fan who owns a VCR, the manufacturer reasons. Kloss offers a separate wireless 105-channel TV broadcast tuner ($219), however, for those who require it.

"Viewers can see the picture from any location in the viewing room"

A $2200 suggested selling price for the Model Two is actually modest on a per-inch diagonal-measurement basis, as prices of projection TV systems go. This is around $1000 less than all-in-one systems that are positioned against a wall and produce a smaller 4' diagonal picture.

General Description. Whereas Kloss's larger two-piece projection system has its three projection tubes beaming directly onto a screen, Kloss borrowed from the all-in-one designs and has its Novatron tubes' outputs shining on a mirror in the Model Two's cabinet lid. The reflected image is beamed to the wall. In its operating position, with projection mirror extended, the monitor measures 31"H × 24½"W × 12"D; with the mirror stowed, the monitor's height is only 21½". The mirror slides into a fixed-angle position when deployed. When stowed, it slides into a horizontal position. (Kloss cautions the user not to place anything heavy on the top of the monitor when not in use.)

All controls, as well as connection from a VCR or tuner, are located on a separate Video Control Center, which is attached to the monitor via a 20' cable through a multiple-pin connector at the bottom-front of the cabinet. It's possible to connect two video/audio signal sources to the remote Video Control Center, and another video/audio signal source can be connected to the projection unit itself. A switch at the bottom of the projection unit is provided for selecting either this signal source or any of those connected to the remote-control unit. Another switch on the remote controller is provided for selecting either of the two video/audio inputs. All audio and video connectors are phono types. Input signals are specified as NTSC Standard at 1 volt peak-to-peak into 75 ohms.

The most critical adjustment for the system involves properly locating the projection console with respect to the reflecting surface. Exactly 48″ separate the front of the cabinet from the wall or projection screen (Fig. 1). The cabinet must be exactly parallel to the reflecting surface.

To aid the user in obtaining the proper alignment, there are two small light-beam projectors built into each side of the cabinet. When a concealed switch on the right side of the projection unit is activated, these light beams project a special alignment pattern on the picture surface (Fig. 2). Incorrect alignment is indicated when two vertical lines appear at each of the two bottom corners of the picture area. When the cabinet is maneuvered back and forth, the set of lines on each side ultimately merge into single lines indicating alignment.

Kloss strongly suggests that the viewing surface be flat and white. A beaded screen, such as used for home movies and slides, is *not* recommended. Where no suitable wall is available, white foam-core artboard, obtainable from art supply stores, is suggested. Bear in mind that the projected image doesn't have a frame around the picture area like conventional TV receivers have and that the picture isn't overscanned. The edges of the picture can, therefore, show some color misalignment. A black frame, made from strips of black masking tape, can be added to the art board to render the effect of any visible misalignment less objectionable.

Low light is desirable when viewing any projection-TV picture. For the Novabeam Model Two, it is imperative. Kloss specifies light output of the system at 200 lumens.

Three Novatron projection tubes are used in the Model Two. They have built-in mirrors and correcting lenses with f0.7 optics and magnetic focusing. Their 30-kV power supply and high-voltage regulator are part of the flyback system. To minimize mechanical adjustments, Kloss developed a "Con-focus" system containing 27 transistors and a number of op amp ICs with more than 40 adjustments. A separate test pattern generator, which provides a dot or a crosshatch pattern, is provided to assist the owner or service technician in performing these adjustments.

A Magnavox high-performance assembly, which includes a comb filter, makes up the video monitor, power supply, and audio sections. It employs a single chroma/luminance IC that performs all standard automatic color control and correction functions. The two-stage audio amplifier drives a 4″ loudspeaker.

All user controls are located on the remote-control assembly that connects to the projection console via a 20-ft-long cable. On the remote-control assembly are controls for power, volume, brightness, contrast, color, and tint, plus a pilot light. A DETAIL control provides a means for peaking video response for maximum picture resolution (sharpness). A slide switch is provided to permit selection of one of the two video/audio inputs that can be connected to the remote controller.

Four potentiometer controls and a pushbutton switch are provided for optimizing convergence, using a unique procedure. When the TEST button is pressed, "crosshairs" appear superimposed on the center of the picture for about 10 seconds. If the crosshairs are pure white, correct convergence is assumed; if not, a viewer can adjust the red and blue vertical and horizontal convergence controls. Convergence near the edges of the picture can be checked and adjusted only from inside the projection console.

Laboratory Measurements. Results of our lab tests on the Novabeam Model Two are summarized in the accompanying table. They're typical of the measurements we obtained in such recently tested color TV monitors as the NEC, Sears, RCA, and Sony. The video bandwidth of 4.1 MHz isn't unusual with a comb filter, and the dc-restoration and linearity figures are also as excellent as can be expected from a high-performance monitor. Except at the left side of the picture, we found the convergence to be excellent.

When the horizontal convergence controls on the video control unit were adjusted, convergence at the center of the picture was lost. We didn't adjust the secondary controls in the projection unit, although we feel certain that observed misconvergence could be rectified using the controls on the "con-focus" circuit board. In any event, the misconvergence could be observed only with a dot pattern; it wasn't apparent in a TV program picture.

(continued overleaf)

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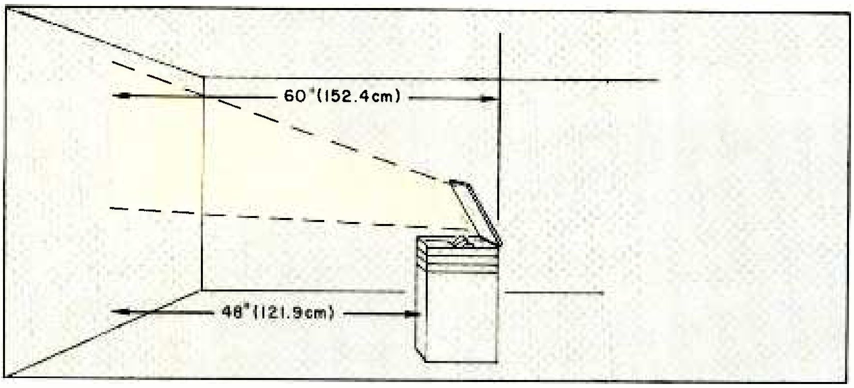

Fig. 1. The projection console must be located just 48" from wall or screen.

We observed no pincushion effect, and the edges of the projected picture were absolutely straight—something that cannot be seen on direct-view monitors because the CRT is overscanned. Color-bar and grey-scale patterns were both reproduced very well.

Optical measurements proved that the Owner's Manual instructions had to be followed exactly. The main effort, focusing the picture on the wall, required positioning the projection unit 48" from the wall. We determined that maximum deviation from this specified measurement for correct alignment was ½".

Maximum brightness at the center of the picture, in near total darkness, was 11 foot/lamberts, which is slightly less than Kloss's literature specified but was within acceptable tolerance limits. We compared brightness of a TV picture with a projected 16-mm film and noted slightly greater brightness when viewed in a near-totally darkened room with the picture occupying the same area as with the Novabeam Model Two. With moderate ambient lighting, the Novabeam Model Two's picture appeared to be brighter.

User Comment. Giving the drawbacks first, one has to push the 74-lb console from its stored location to the required position 4' from the wall. The console can be difficult to move around, particularly on a carpet. Kloss provides special carpet-penetrating feet that can be adjusted individually to level the projection unit after it has been correctly positioned.

Also, the 20' cable between control unit and projector can be a nuisance. It's about ½" in diameter and isn't very flexible. Just having the cable on the floor is likely to present a problem for anyone who tries to walk around the darkened viewing room.

On the plus side, the especially high brightness level from Kloss's three projection tubes makes it possible to show a good picture on a wall instead of using a special projection screen. This is a marvelous achievement. However, it doesn't do this without trading off something. In this case, it is the inherent inability to reject ambient light, which a projection screen does, in part. As a result, the Model Two must be viewed in a darkened room to obtain good contrast.

TEST MEASUREMENTS
KLOSS NOVABEAM MODEL TWO TV PROJECTOR

Parameter	Measurement
Video bandwidth to CRT (−6 dB);	4.1 MHz
Dc restoration:	95%
Horizontal linearity:	95% left, 100% right
Vertical linearity:	90% top, 100% bottom
Convergence:	90% at worst screen area
Gray scale (test pattern):	100%
Dc regulation, B+: (105 to 130 V ac)	96%
High-voltage regulation (105 to 130 V ac)	98%
Dimensions:	21½"H X 12"D x 24½"W
Weight:	74 lb
Power rating:	95 W

How dark is "dark"? The question is purely subjective. Moving a shaded 100-W table lamp around our viewing room, keeping it 4' or more from the projection console, there was no noticeable reduction in picture quality. The video washes out when a fair amount of light is in the room or light strikes the picture directly (as from daylight streaming through a section of a window). In a darkened room, however, subjective evaluation by our group of experienced TV studio technicians resulted in unanimous positive reactions. Picture brightness and quality compared favorably with other projection-TV systems with which they were familiar. Color fidelity was judged excellent.

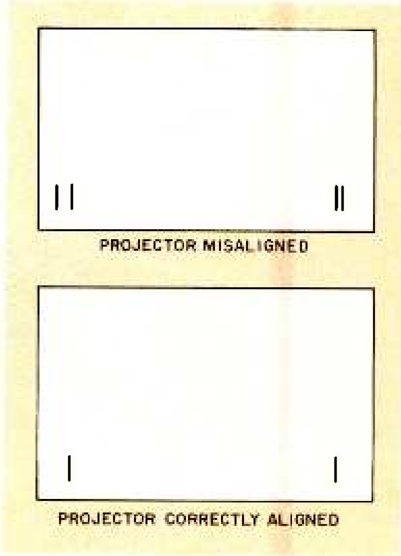

Fig. 2. A switch on the console projects the alignment pattern on screen.

The major favorable comment was on the freedom from distortion and the 180° viewing angle. It was possible to view the projected picture without loss of brightness, focus, or linearity from a 180° arc, centered on the rear of the projection console. Optimum viewing distance varied from 5 to 10 feet from the projection console, depending on the viewer's preference.

In video, big is better when resolution, brightness, and contrast hold up. The Novabeam Model Two is an excellent system, capable of throwing a 3' × 4' picture on practically any flat white surface. In the dark (preferably in a small room) the picture itself is the brightest we have seen for a projection system and the 180° viewing angle is a most worthy first. The lower price is appealing, too. —*Walter Buchsbaum*

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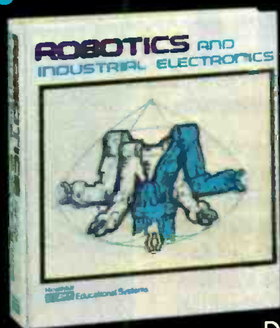

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JULY 1983

DATA STORAGE IN A NUTSHELL

From cassette to optical disk, here are insights to mass data storage choices for computerists

By Les Solomon and Stan Veit

YOU can tell the cut of a personal computerist by the mass storage device he uses. Magnetic cassette tape or plug-in solid-state cartridges mark one as either a neophyte or a financially strapped person. Disk drives identify the more serious microcomputer user. For the latter, one's rank can be distinguished too by the type of disk media used (flexible disk or hard disk).

The need for memory storage that can be saved, modified, and retrieved at any time often depends on your computing quest. Is it gaining a smidgen of computer literacy and having fun playing games? Do you wish to be creative in programming as well as playing games? Or is increased productivity your goal?

Let's examine each memory storage option, digging into choices you have even within each category, as well as looking at what's coming up fast.

Cassette Tape

The earliest microcomputers relied on punched paper tape, where the code for each character was represented by a hole for a logic 1 and absence of a hole for logic 0. It worked, but, oh what drawbacks: The medium was bulky; paper damage was disasterous; punched information could not be modified; it performed s-l-o-w-l-y and noisely; and, finally, a Teletypewriter was rather costly and cumbersome.

No wonder manufacturers and users quickly turned to cassette tape and the omnipresent, cheap audio cassette machine. Of course, these machines were designed to record and play back sound, not digital data. Designers reasoned, however, that the same problem was solved for telephone lines, where digital data was converted to audio tones of selected frequencies, one high and one low to represent 1s and 0s. So a bevy of frequency shift keying (FSK) tape systems were introduced, hardly any of which was compatible with another.

In one representative system, called the Kansas City Standard, four cycles of a 1200-Hz tone were used as a logic 0, while eight cycles of a 2400-Hz sine wave were identified as a logic 1. This allowed a very slow data transmission rate of 30 characters per second (actually, 27 ch/s if one excludes error checks) that could be handled reliably by a broad spectrum of low-cost audio-cassette machines with their attendant speed variations and high-frequency noise.

Radio Shack uses another type of recording for its TRS-80 models called saturation recording. Here, data pulses and clock pulses are utilized, the former sandwiched between the latter for a logic 1. If the pulse is absent, then it is seen as a 0. Since only one pulse is needed to represent one bit, it is clearly a faster data-transfer system than, say, the KC system, which requires four or eight cycles for one bit. Should one solitary pulse be lost, however, the whole bit is gone, which makes the system less reliable than the KC.

Commodore, in turn, uses a digital format rather than an audio one. Here, the heads are turned on and off for varying time periods to produce magnetic pulses on the cassette tape. The system measures the width of the pulses, interpreting a longer pulse as a 1 and a shorter one as a 0.

Cassette tape is still used as a mass memory storage system because it is so low in cost and can really hold a lot of data (up to 500 kilobytes on a C60 cassette). But since it operates in serial fashion—one bit following another— it is a time-consuming method on low-speed systems. Also, the approach does not lend itself to changing files. Everything takes forever, it seems.

There are magnetic digital tape systems that do not share the foregoing deficiencies, of course. The reel-to-reel tape systems used in data-processing centers employ seven- or nine-track formats; transfer data at very high speeds (say, 6400 bits/inch); and can start and stop on a dime whether in forward or reverse directions. But we're talking here about big bucks and lots of physical space. Smaller digital tape systems are around, too, that utilize cassette tapes, have built-in microprocessors and memory, and naturally have an operating system to tell the processor what to do. Typically, they're about seven times faster than the TRS-80 tape system is, use two tracks, and are software controlled. Cost, though, is about the same as a floppy-disk drive, with storage capacity around that of a quad-density disk. Also, ¼" digital tape cartridge systems are commonly used to back up hard disks since high-density types can match the disk's storage capacity, it is a very-low-cost medium on a per/byte basis, and can be removed for storage pur-

poses (until recently, Winchester disks were not removable).

Disk drive systems combine many of the good attributes of these systems. It's not surprising, therefore, that they have become the most popular form of mass storage for microcomputer users who want to do any earnest computing, whether it's word processing, financial analysis, maintaining data bases, or any similar applications.

Floppy-Disk Systems

Big Blue (IBM) introduced disk technology some 15 years ago in the form of an 8″-diameter, paper-thin platter with a magnetically coated surface similar to that of magnetic tape. It is magnetic tape in the round, so to speak. Unlike a phonograph record, it doesn't have sufficient body to be stiff. If you hold one between your fingers, it'll flop over as if it were a Salvadore Dali watch. To overcome this problem, IBM ingeniously ensconced it in a plasticized jacket that, when inserted into a drive system, enabled the platter to rotate at 360 rpm while the jacket is held stationary.

A slot opening in the jacket permits a read-write (R/W) pickup head to contact a selected section of the magnetic disk, much as audio tape heads touch audio tape. A single index hole opening through the jacket and the disk enables a photoelectric circuit to detect the beginning of the first sector and synchronize tracks (which are circular, not spiral).

The concentric tracks are divided into equal-size arcs called sectors; think of them as slices cut in a pie, with each cut representing an inter-sector gap where recorded information is not carried. The standard 8″ format contains 77 circular tracks cut up into 26 sectors. This could be roughly translated into a capacity of 256K bytes. But each sector has to have identification data recorded on it, which is done with a formatting utility program. This eats up three tracks, reducing the available recording space to about 246K bytes.

Such a system is called "soft sectoring." In contrast, "hard sector" disk systems have an index hole for *every* sector, leaving external hardware and software to handle header identification information. As a result, hard sectoring is more efficient than soft sectoring. Nevertheless, soft sectoring is easily the most popular.

The beauty of this sector/track system—called direct random access—is its speedy location of data. With sectors, the same amount of data is made available on each track and each sector, in small chunks. Furthermore, the electronic/mechanical design enables an R/W head to home in on a block of recorded data amidst hundreds of kilobytes in a fraction of a second. This is made possible by pinpointing where the head should move through a track and sector address. Time is not wasted by passing through a load of data serially, as is required with magnetic tape systems.

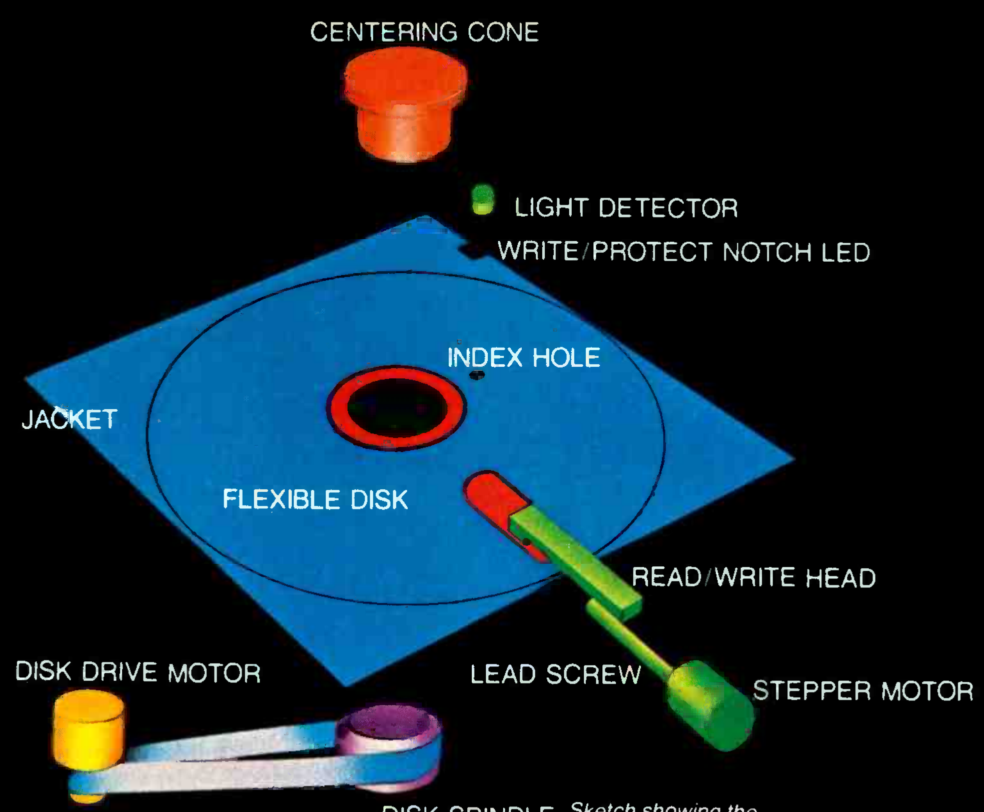
Shugart Associates opened new vistas for personal computer users in 1976 when it introduced the 5¼″ mini-floppy or diskette. True, the smaller format was slower and did not store as much data as the 8″ disk did, but who was counting when the cost was so much lower and the advantage over cassette tape was enormous?

The original mini-floppies held only 50 bytes of formatted data on 40 tracks, but that was not enough for the complex software that was starting to appear. The designers went back to the drawing board and came up with schemes to double, triple and quadruple the data-handling capacity of the small disks. By using denser recording techniques and both sides of the disks, they can now put more than 360,000 characters (up to 90 typed pages) on a 5¼″ disk, and the end is not yet in sight.

How is this done? The disk is no bigger, the rotational speed of 300 rpm in most cases stays the same, and yet they keep putting more data on smaller diskettes. The answer lies in the recording techniques and the mechanical precision of the mechanism.

When the diskette is purchased, none of the tracks or sectors is on the recording "film." The pattern of tracks and sectors must be put on the disk by running a Format program. On a single data track in one sector, of a soft-sector disk, there is a recorded identification header to identify the track and sector, an error-checking code for validating the data when recorded, the space for the data itself, and finally, following the data, is a postamble that repeats the error-checking code.

Gaps are left on each side of the data



Sketch showing the basic mechanical operation of a floppy-disk system.

area to allow for minor positioning errors of the head. There are also much larger gaps left between sectors to prevent overlap between sectors. The data itself is recorded in blocks within the sectors. These may be 128, 256, 512, or 1024 bytes wide, depending on the number of sectors used.

The most important factor in achieving a high-density recording scheme is the method of recording the data. The simplest method of direct recording on a magnetic medium is by pulsing a recording head to produce a flux change (resulting in a tiny magnetized area) on the surface of the diskette for each logic 1. Lack of such a magnetic pulse indicates a logic 0. When the pickup moves over the same area, the magnetized spot induces a current in the head, which is amplified into a pulse. Various coding methods that employ variations of this principle are used for recording data.

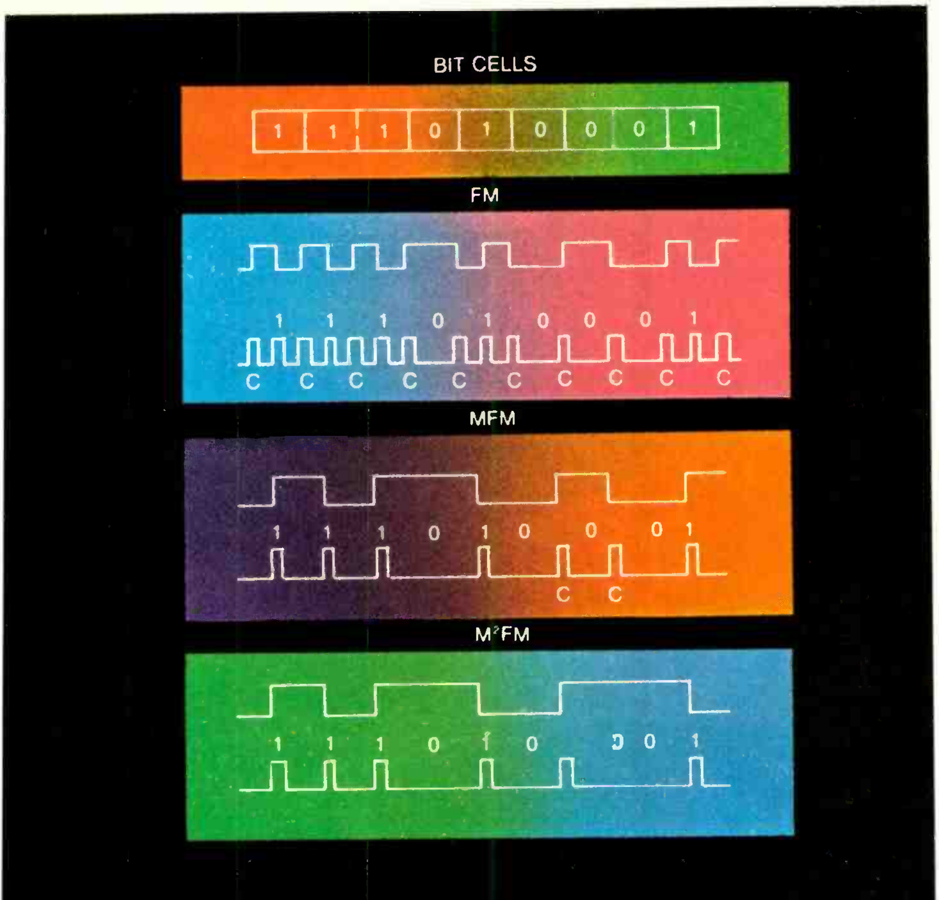
The simplest data recording method is called FM Recording. It uses bit cells to define the data bits. The leading edge of a clock pulse marks the boundary of each bit cell. Within the cell, the presence of a pulse (a flux change) indicates a 1 and the absence is a 0. This is called FM because there is a *frequency* of two pulses read for a one (the leading edge, plus the data pulse) whereas for a zero, there is only a *frequency* of one pulse (the leading edge of the clock pulse). This is a highly reliable method of recording data because each bit is bounded by the clock pulse. The problem is that the clock pulses must be separated from the data and discarded. This takes time and, even worse, it takes up space on the disk.

In the quest for greater recording density, designers realized that they could record a lot more data if they could eliminate the clock pulses. The scheme would use a pulse in the middle of a bit cell as a 1 and a no pulse condition to represent a 0. The trouble with the scheme would occur when several zeros were adjacent. The system would receive no pluses, it would lose synchronization and be unable to distinguish the next pulse cell after the string of zeros.

The MFM (Modified FM) code scheme overcomes this problem by using the leading-edge clock pulse as in FM recording, only for the *second adjacent* 0 and all *subsequent* 0s. This eliminates all the clock pulses for 1s and for 0s bounded by 1s because the ones are a self-clocking signal. As illustrated, the nine bits of data require 14 pulses and 14 flux changes for the FM method, but only 7 pulses and 7 flux changes for the MFM method. Since 7 flux changes are half as many as 14, twice as many data bits can be recorded in the same linear distance on the track. This results in doubling the recording density in the same space, and is called double-density.

There is an additional refinement of the Modified FM recording scheme that writes a leading-edge clock pulse only if the previous bit cell contains neither a 1 or a clock, and if the present bit cell contains a zero. This eliminates the clock bits of every adjacent zero. Only six pulses and six flux changes are needed to record nine data bits, and an additional amount of data can be recorded.

There is a price to pay for this extra space on the disk. It requires much more circuitry on the disk controller—the electronic interface between a disk



Signals involved in single-density (FM) and double-density (MFM) recording techniques.

drive and a computer—to write the data and clock pulses correctly. Even more circuitry is needed to separate clock pulses from data pulses after they have been read. The electronic circuit most often used to separate the data and clock pulses is a phase-locked oscillator (PLO). Today both the data separator and the disk controller itself have been incorporated into VLSI chips such as the Western Digital 1771 now in general use. However, the latest trend is to use a data separator that is not part of the controller IC.

Another important factor in the operation of the disk is the movement of the heads as they move in and out under the control of the disk controller. There are several ways that the actual movement of the heads is accomplished. In some drives, the head is mounted on a cartridge that slides on rails. Some drives use a head mounted on a lead screw, others use a cam actuated head movement, while still others employ a flexible metal band to move the heads. No matter what the mechanical means of head actuation, the time required is a vital factor in the operation of the drive.

Total access time for the disk depends upon the distance the head has to move, plus the length of time that the head must wait for the correct sector to spin around and be under the head. These two elements are called head positioning time and rotational latency. The head positioning time is divided into two factors: *move time* (for the heads) and *settling time*. Settling time is the time it takes for the vibration caused by head movement to subside. Maximum move time occurs when the heads have to move from the outermost track to the innermost track.

Rotational latency (often just called latency) is greatest when the head reaches the correct track and data has just passed the head position. The head must wait until the data makes a complete revolution and returns beneath the head. Thus, speed of the disk drive determines the amount of latency.

The faster the disk rotates, the less time the head must wait for the data. Whereas rotational speeds for floppy disks range from 360 rpm for 8″ drives to 300 rpm for 5¼″ drives, hard disks rotate about 10 times as fast as floppy drives, typically 2400 to 3600 rpm. When the latency factor is smaller, the system can read or write more data in a given time. This is not of special importance in discussing floppies, but when using hard disks, where data size is millions of bytes, the latency factor is indeed vital.

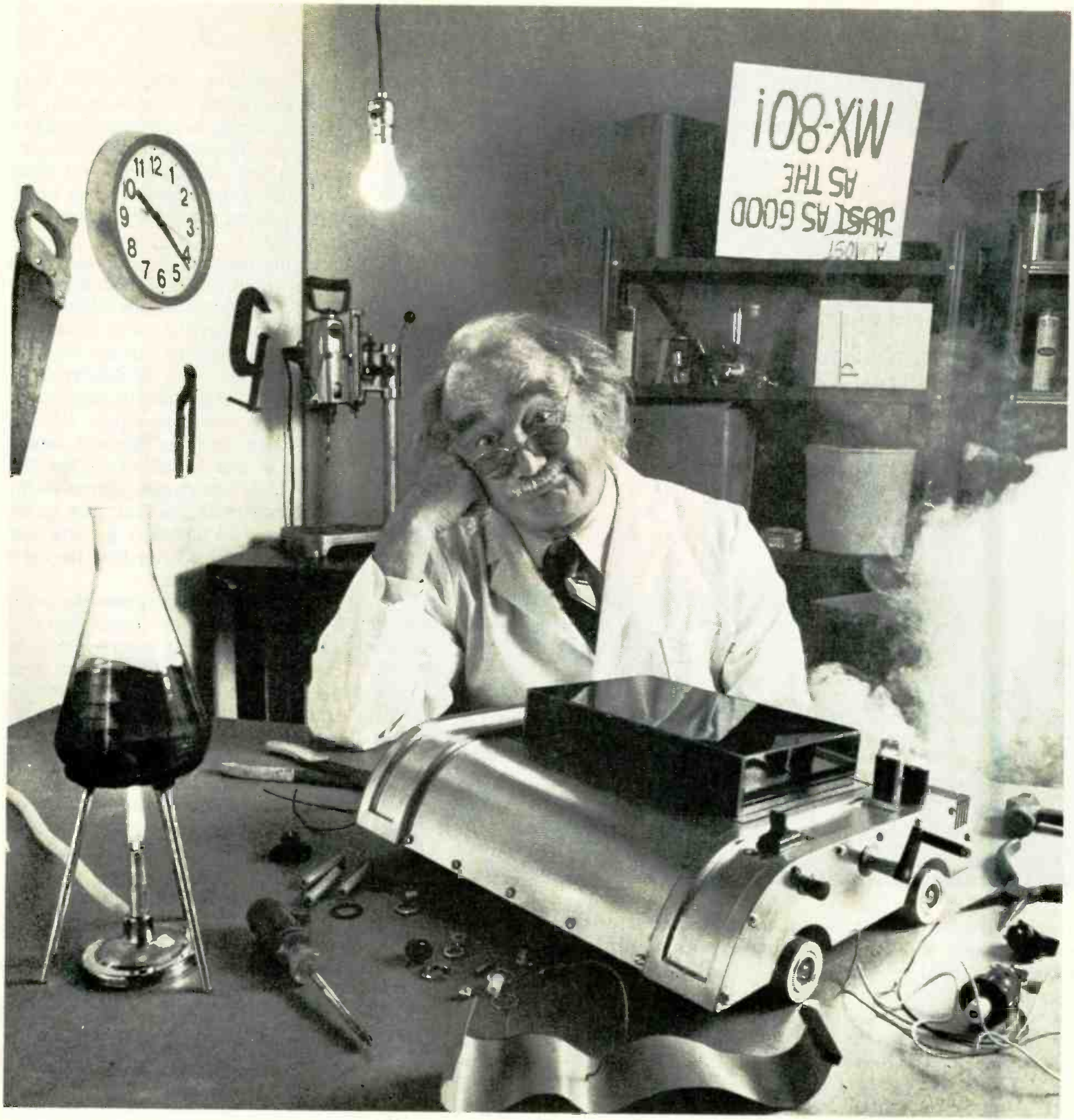
As the demand for increased data storage grew, disk manufacturers produced double-sided, double-density, disk drives. These have two heads, one located on either side of the diskette. This gives four times the density (quad density) of a single-density, single-sided diskette. In order to reduce latency, seek access time, a different format scheme is used. Track one is the first track on the bottom side of the diskette, while track two is the first track on the top. The track numbers go back and forth from bottom to top from the outer track to the inner track.

A disk controller directs the entire data storage system in conjunction with a software operating system. One disk controller can usually control more than one disk. It directs read/write operations and head positioning, identifies the tracks and sectors, checks and corrects errors, and interfaces the disk storage system with the CPU and memory. Data is written and read in serial format, but the controller converts it to put it on the CPU data bus. Once the serial-to-parallel conversion has been performed, the controller generates an interrupt of the CPU so that it can transfer data, or it accesses the memory directly. Owing to high-speed data transfer between the CPU and the disk system, **direct memory access** (DMA) is often used. This is controlled by a special DMA chip, which controls the data bus and effects data transfer directly to the computer memory.

Micro Floppies. With the introduction of reduced-size portable computers, and the trend to smaller packages, disk size has dropped to 4″ and under, with 3¼″ and even a 2″ floppy-disk drive in the test phase.

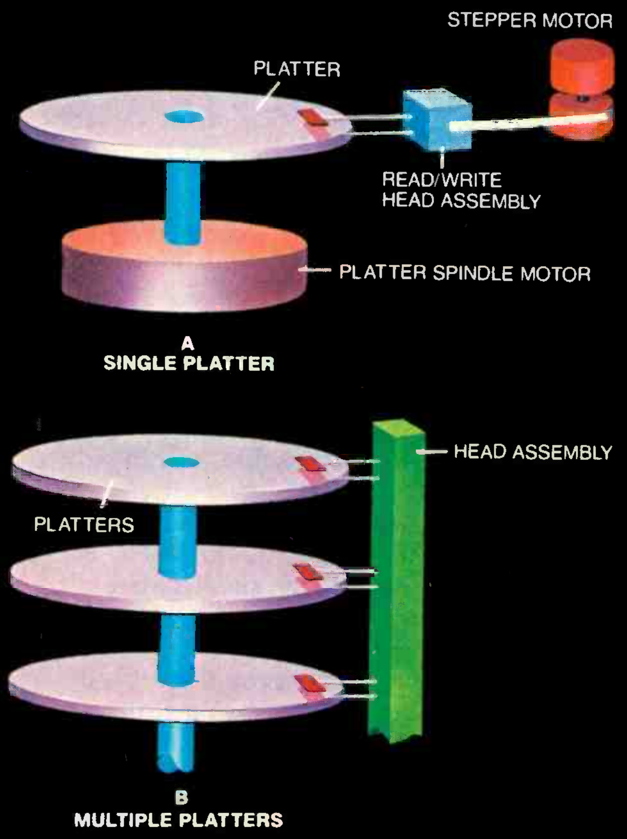
The move toward a new small size started with Hitachi (3″) and Sony (3.5″). A number of American disk-drive manufacturers joined the fray, some adopting one version and some another.

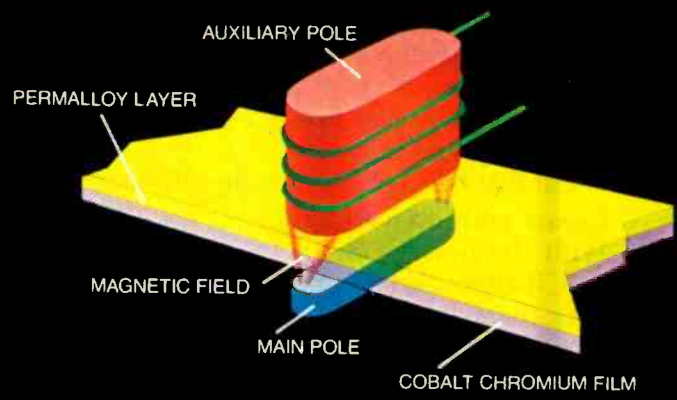
A Micro-Floppy committee was formed to look into standards. This committee had certain ideas in mind, including an automatically closed shutter (cover over the read/write head slot), 50-microinch-thick magnetic media, 300 rpm for compatibility with existing



For everyone who's tried to top the MX-80, bad news. We just did.

Epson.





Shown at left are a single-platter hard-disk system (A) and a multiple-platter arrangement (B).

Typical design of a read/write head for perpendicular recording is shown above.

5¼" systems, and head-positioning systems that did not exceed current technology. Neither the Hitachi nor the Sony disk fully met all the suggested "standards."

Amdek Corp. is also marketing a 3" drive that is slightly different than the Hitachi one. Only two specifications differ. These are: 80 tracks/side vs. 40 for Hitachi, and a density (bpi) of 4473/8946 (single/double density) vs. 3125/6250 for Hitachi.

The 3" diskette is packaged in a hard plastic shell measuring 3.2" wide by 4" deep, by 0.2" thick, which is compact enough to fit in a shirt pocket. The drive is standardized to 5¼" format specifications (300 rpm, 40 tracks/side, 100 tracks/inch, 250 kilobits/second transfer rate). Specification details include conventional FM (single density) and MFM (double density) encoding. The diskette will have an unformatted capacity of 250K bytes in single density (125K bytes/side) and 500K bytes in double density (250K bytes/side). In the single-density mode, the data-transfer rate will be 125K bits/second, with 250K bits/second in the double-density mode. There are 40 tracks per side with a track density of 100 tracks per inch.

The 3.5" disk packaged in a hard plastic shell is 3.54" by 3.70" by 0.133" thick. This form factor has three well-known supporters: Tandon, Sony/Mitsusbishi, and Shugart.

Both Tandon and Sony use 3.4" diameters, while Shugart uses 3.5". Tandon uses 40 tracks/side, Sony has 70, while Shugart features 80 tracks/side, although all three use 135 tracks per inch. Rotational speed for Tandon and Sony is 600 rpm, whereas Shugart retains the 5" drive speed of 300 rpm. There is a difference in access time and in average time track-to-track, too. The number of bytes per disk in single/double density is 875K for Tandon, 218.8/437.5K for Sony, and 250/500K for Shugart. Tandon uses both sides of the diskette, while Sony and Shugart are single-sided.

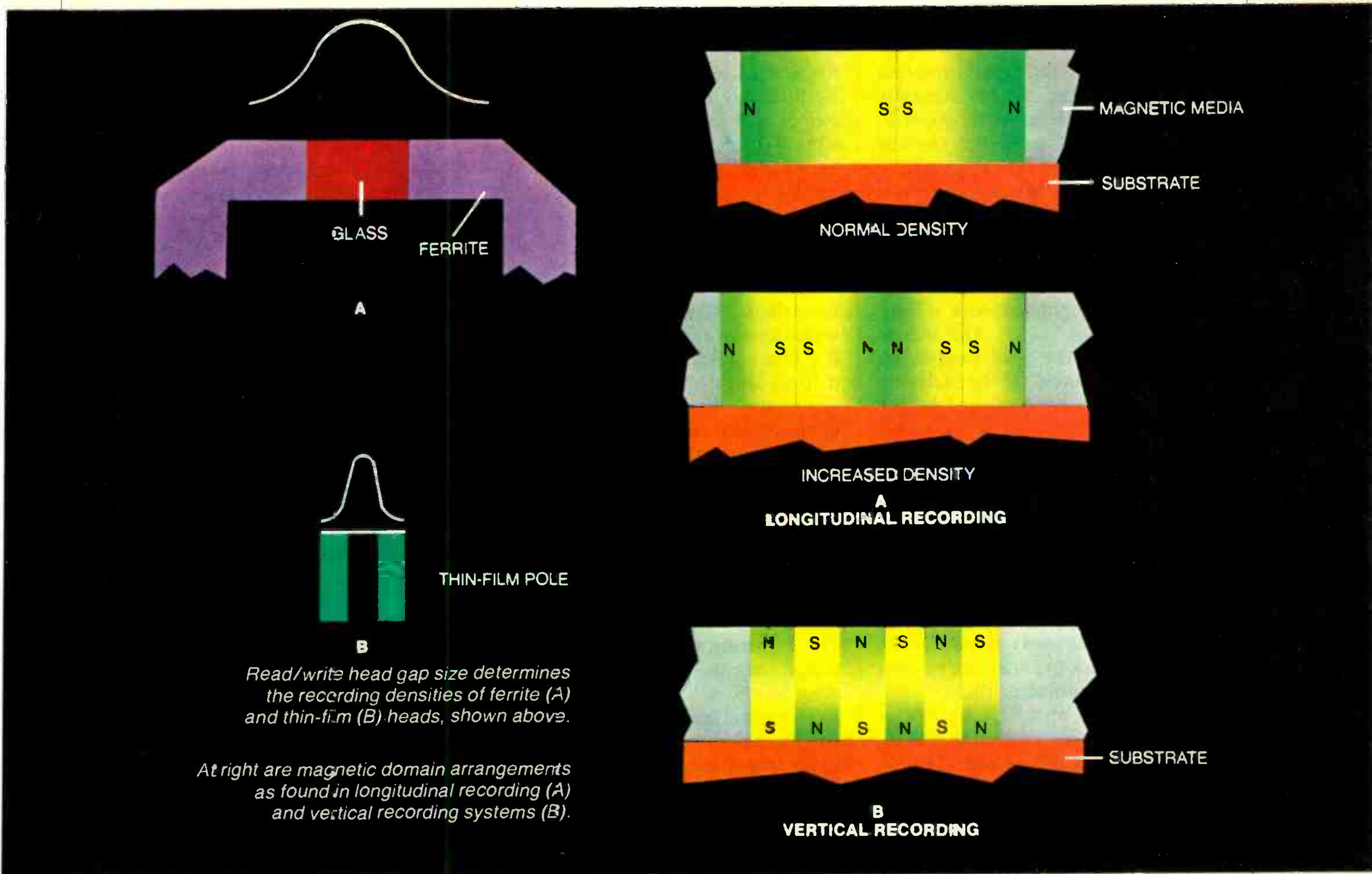
Although the Shugart 3.5" drive is compatible with conventional 5¼" systems, the Sony drive is not. Tandon has one drive that is compatible with the conventional 5¼" drives and one compatible with the Sony drive.

The relatively unknown 3¼" disk system from Tabor and Seagate has a cartridge size of 3.27" by 3.43" by 140 tracks/inch, and a rotational speed of 300 rpm. The diskette supports 500K bytes on its single surface. It is compatible with conventional 5¼" drives. Unlike the 3" and 3.5" diskettes, this one has a flexible enclosure.

Even smaller in size is the TEC America 2" system, whose disk diameter is a mere 2.64". It has one spiral track and operates at 405 rpm. The diskette holds 16K bytes on its single side and is not compatible with 5¼" systems. This disk system must be used with a dedicated system.

Meanwhile, IBM recently announced its Model 0341 4" diskette drive that uses a 4" IBM DemiDiskette—its first entry into the floppy business, the first 4" system, and the first to use a plastic chassis. Unformatted capacity of the hard-jacketed diskette is 358K bytes.

In place of the usual lead screw or band read/write head positioner, the Model 0341 uses a precision cam head positioner with a number of precision-machined dents to step the head to any



Read/write head gap size determines the recording densities of ferrite (A) and thin-film (B) heads, shown above.

At right are magnetic domain arrangements as found in longitudinal recording (A) and vertical recording systems (B).

track. This system records on one side of the diskette, which has 46 tracks with track zero reserved for system use, and five sectors on track 45 reserved for reassignment of defective sectors. Two recording formats are available: 256 bytes/sector with 921 sectors allowing 235,776 bytes capacity; and 512 bytes/sector with 501 sectors and 256,512 bytes capacity. Diskettes written on one drive can be read on another if they both use the same format.

FM encoding is used, and clock and data transitions are written on the full length of each track. Since there is a rotational speed difference between the inner and outer tracks (415.4 and 261.7 rpm respectively), an 8048 CPU is used to maintain a constant linear velocity (48.6 ips) between the inner and outer tracks. This maintains the bit density at a constant level.

After inserting the diskette into the drive, an operator handle must be moved to its closed position. The 0341 does not automatically sense the presence of a diskette, so the user must attempt a read operation to determine if there is a diskette loaded in the drive.

Unlike other diskettes, the IBM DemiDiskette does not have a mechanical or electrical index mechanism. Therefore a track format can begin at any point on the track with two requirements—the track must be written across its entire length, and no sector can overlap another. The drives measure 6.65″L × 4.53″W × 2.62″D, and weigh 1.94 lb. A specially designed LSI chip is said to have been designed to allow the Model 0341 to interface with most computers.

Hard Disks

As the demand for greater mass storage grew, designers turned to small versions of a hard-disk design originated by IBM. The first of these fixed hard disks had two platters (disks) that each held 30 megabytes (30-30), from which the name, Winchester, evolved. The technology used is similar to the large (14″ diameter) hard disks that had been used for years for mainframe computers, except that these disk drives used hard disks that revolved in a sealed environment. Normally, the read/write heads in a hard-disk system do not contact the magnetic media. Instead, the heads "fly" a few micro-inches above the surface on a cushion of air generated by the rotation of the disks.

The new small Winchester disks were 8″ in diameter and held 10 megabytes or more of data. Often, multi-disk (platter) units were built with up to 80 megabytes in the total assembly.

Developers continued to improve the design, packing more into the disk and reducing the physical size of the drive.

Today, 5¼″ or smaller Winchester drives are available with up to 40 megabytes of data storage. (The average is 10 megabytes.) These have track densities of about 250-300 tracks per inch compared to 48 or 96 tracks for small floppy disks. To accomplish this, the platters use thin plating for the magnetic media and even the read/write heads. The heads "fly" above the recording surface at heights of 20 to 50 micro-inches to reduce seek and latency times.

Winchester Mechanical Design. In the one platter hard disk illustrated earlier, there are two read/write heads—one for each disk surface. The air movement generated by the rapidly rotating platter causes the aerodynamically shaped read/write heads to fly about 20 to 50 millionths of an inch above the platter surface. This can be compared to an airplane flying at Mach 2 about one inch over a choppy sea.

The platter/head assembly and the associated mechanical linkages are mounted within a sealed, almost airtight enclosure equipped with a very fine-particulant air filter. The platter drive motor and the head stepper are mounted on the outside of the enclosure to allow heat to be dissipated in the atmosphere.

In the multi-platter Winchester shown previously, a single spindle drive motor rotates all the platters simultaneously. All the read/write heads move in and out together. This allows sets of data tracks (six tracks for the three-platter arrangement shown) to be considered as a data "cylinder." The DOS (disk operating system) is written so that each six-track cylinder can be considered as one continuous track.

Track densities up to 250 to 300 tpi (tracks per inch) can be used in a Winchester, compared with 48 and 96 tpi for a typical 40- or 80-track 5-$^1/_4$" floppy. It is because of this density that head positioning in a hard disk is so critical. Since the plastic disk base used in floppy diskettes is subject to mechanical change due to temperature, moisture, etc., data can become erratic. To avoid these possible mechanical changes, hard-disk platters are made of metal.

In 1979, IBM introduced Whitney technology to hard disks. This approach uses a small, low-mass ceramic slider having a deposited thin-film permalloy read/write head. The head is thus allowed to "fly" closer to the disk surface, making possible greater data-storage density (2½ times a Winchester) and about $^2/_3$ the average access time (16 μs vs. 25μs).

The 5¼" Winchester is not the smallest, as there are several companies testing under-4" hard-disk drives. Syquest, for example, has had a 3.9" hard disk for months. A Scottish company called Rodime has produced its RO-352, a two-platter, 3.5" hard disk that can store 10 bytes formatted in a space measuring 1.625" × 4" × 5.25". This means two of these small drives can be mounted in the same space as a half-height 5¼" Winchester to provide 20 M bytes of storage.

Most hard-disk (Winchester) drives have the platters and read/write heads sealed in a relatively airtight enclosure. If a nonremovable hard disk "crashes" it likely must be replaced by a skilled serviceman from the company that made the disk system; in this complicated and expensive repair, the data may not be restored. Accordingly, backup storage is usually required and another medium must be used. Some systems use floppy disks or streaming tapes as the backup device.

Now there is a new class of hard-disk drives that uses removable cartridges. These operate similarly to a video cartridge that is plugged into a video recorder.

Therefore, a single drive can have an almost unlimited amount of storage space available, theoretically eliminating the need for a backup for data-saving purposes. There are some problems however. Removable hard disks are more expensive than either floppies or tape. Moreover, though there is an ANSI standard for the mechanics of the removable Winchester cartridges, there is no standard for the media recoding format. Thus, a cartridge from one manufacturer may fit in another manufacturer's enclosure but may not run.

A removable 5¼" hard-disk cartridge has typical access times of about 75 milliseconds, up to three faster than a floppy disk. This means that, in one second, cartridge drive can transfer up to 5 megabytes compared with the approximate 250,000-byte transfer of a floppy. Most cartridges can handle up to 10,000 insertions and removals from the enclosures.

One company (Seagate) makes a hard-disk system that uses **only** removable media—no fixed disk, just the removable package. Another manufacturer (New World Computer) features a low access time of some 8 μs due to its use of 32 read/write heads. SyQuest's SQ306 hard-disk system features a disk only 100-cm (cigarette size) square that can store up to 5 megabytes. The drive of the small system is a mere 1.625" high.

Memorex uses a combination of 5¼" fixed and removable hard disks having a capacity of 10 and 15 megabytes formatted. Its Model 410 uses 5-megabytes fixed and 5-megabyte removable media, while the Model 415 uses 10-megabyte fixed and 5-megabyte removable media. The trend these days is to increase the amount of data that can be recorded on either a hard or floppy disk without making drastic changes to the system. The approaches range from new developments in thin-film read/write heads, through new materials and manufacturing techniques for diskettes.

New Techniques

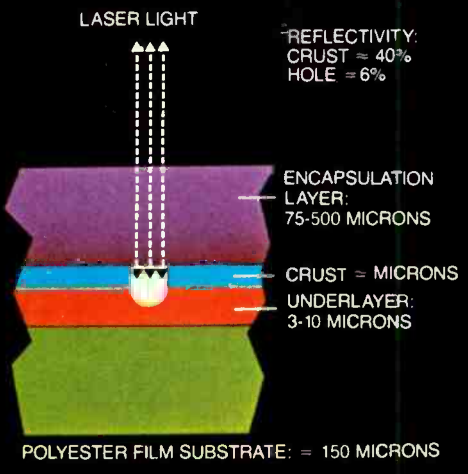
Perpendicular Recording. A major effort is being made to create an entirely new recording technique called perpendicular (or vertical) recording. The key to this lies in magnetizing the tape perpendicular to the surface, rather than along the surface as conventionally done in longitudinal recording. The result is to "squeeze" the width of each magnetic domain to allow much more information per unit length of media.

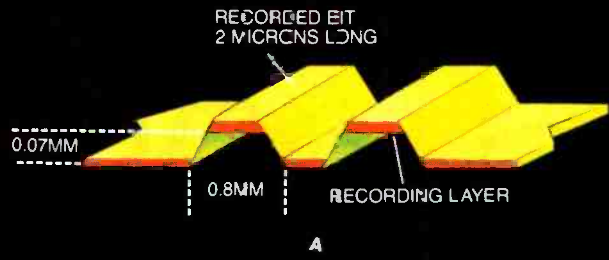
How dense can it get? Laboratory Densities of 80,000 to 100,000 bits/inch have been achieved in the laboratory. This is a tenfold improvement over conventional longitudinal recording, which has taken more than 25 years to reach 10,000 bits/inch. It has been estimated that a 5-¼" hard or floppy disk will reach 20,000 to 40,000 bits/inch very soon. Sony Corporation recently demonstrated a digital/audio system using vertical recording of some 440,000 bits/inch.

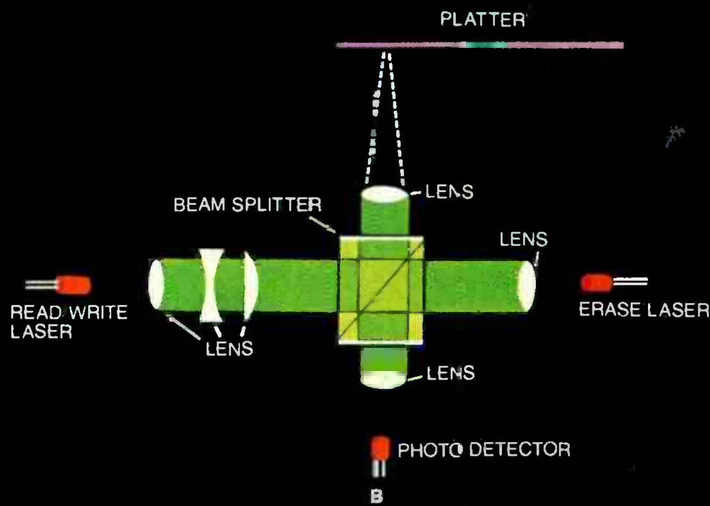
Toshiba is currently working with a 3.5" floppy-disk system using a high-resolution ring head having a gap of 0.4 millionths of an inch. A cobalt-chromium film is used on a diskette that has a linear bit density of 50,000 bits/inch, and 144 tracks/inch. The storage capacity of this 3.54" by 3.6" by 0.118" floppy (although encased in rigid plastic) diskette is 3 megabytes!

As an overview, here are the estimat-

Syquest's 3.9" removable hard-disk system.







As shown above, in optical recording, the laser "blows" a hole in the crust producing an optical discontinuity.

On some optical disks, data is recorded on lands as shown at right (A). A typical optical read/write system is shown at (B).

ed maximum recording densities that can be attained using different recording technologies: Under laboratory conditions, longitudinal magnetic recording techniques using thin-film heads can achieve up to 15,000 bits/inch and 800 tracks/inch. In longitudinal recording using thin-film disks and ferrite heads, 25,000 bits/inch and 1200 tracks/inch can be expected. Compare these to perpendicular recording, where 100,000 bits/inch and up to 1200 tracks/inch can be expected. Compare these to perpendicular recording, where 100,000 bits/inch and up to 1200 tracks/inch may be commonplace.

Thin-Film Heads. Almost all of the commonly used floppy diskettes are coated with a gamma form of ferric oxide. This is the brownish coating used as the magnetic media, which can be seen at the head slot on a diskette cover. Diskette heads are made of ferrite having a glass-filled gap. These "workhorse" read/write heads have been constantly improved over the years, until today they have just about reached their switching limit.

To lay down more tracks/inch, the head must be made very thin. Because the ferrite wears so fast, a head made of this material cannot be made thin enough to work at 1000 tracks/inch or more and last for any period of time. A problem also exists with the magnetic media itself. If the tracks are made narrower so as to pack more data on the diskette, the media will not record with acceptable data error rates.

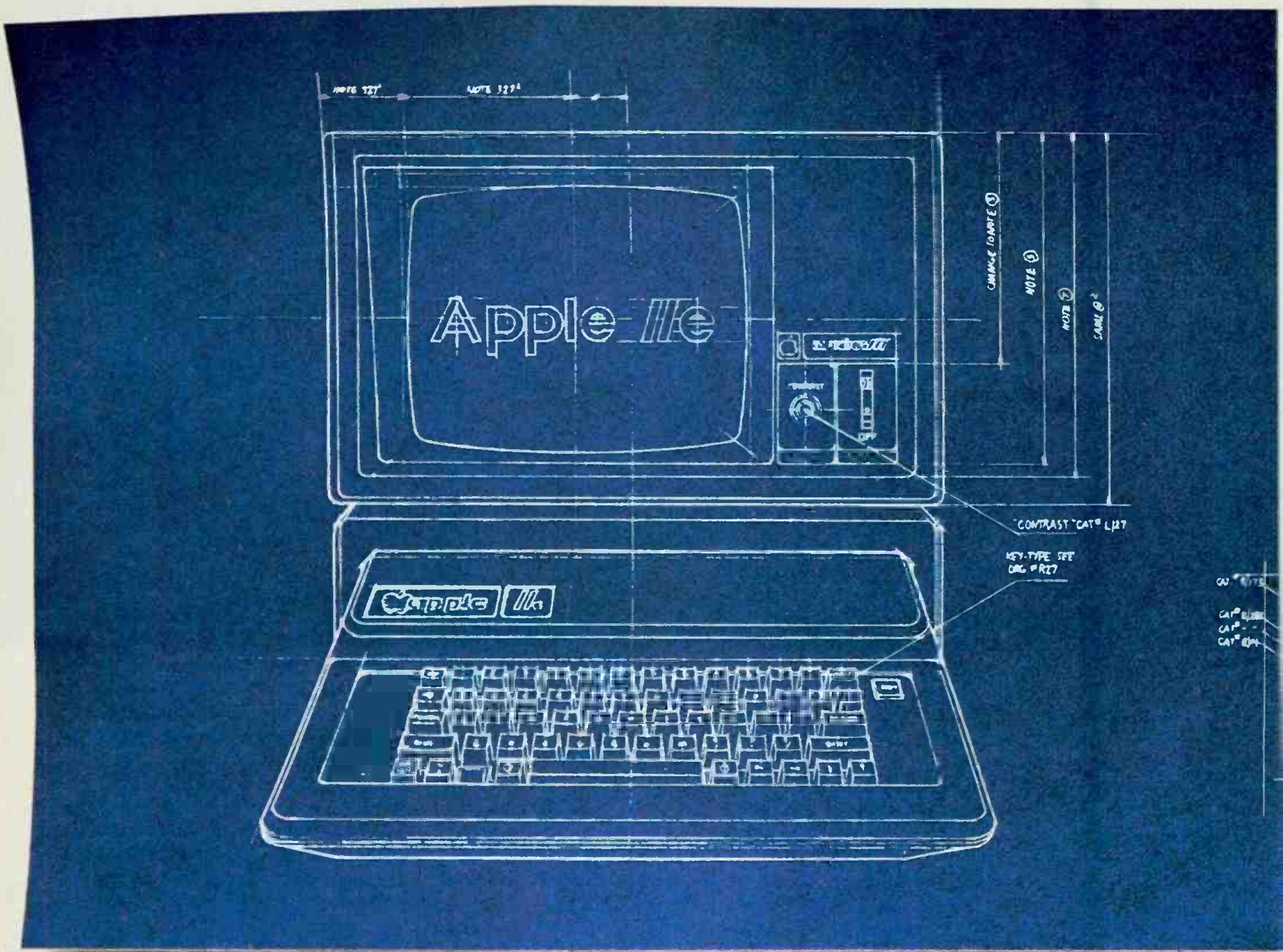
It has been found that cobalt makes an excellent magnetic media for the narrow track approach since it has a better magnetization property than ferric oxide. However, some manufacturers are loath to use cobalt because of the expensive techniques required to deposit it on the carrier.

One solution to the ferrite head problem is to use a "thin film" head. These heads are fabricated from a nickel-iron alloy called Permalloy, which is plated onto a silicon substrate, along with a copper "coil." During manufacture, the Permalloy can be plated to almost any desired width because it is totally supported by the mechanically strong substrate. The sharper magnetic flux curve of the thin-film head approach allows as much as 25,000 magnetic transitions per inch as compared to the ferrite head with its maximum of about 10,000 magnetic transitions per inch.

In longitudinal recording, the ratio between domain length to width (the longer and thinner the domain, the less likely that opposing poles will neutralize each other), tends to make the very small magnetic domains de-magnetize themselves. If density of the longitudinal recording is increased to support more data, the domains get smaller, and the probability of de-magnetization (possibly resulting in loss of data) results.

Vertical recording results in a different magnetic domain arrangement. In this approach, magnetic domains are arranged at right angles to the substrate; and the higher the density, the narrower the magnetic domains. The domain length is determined by the magnetic media coating thickness. The main problem is in the read/write head and its associated positioning system since the head must consist of a pole at right angles to the diskette so that the mag-

It's the same old Apple II.



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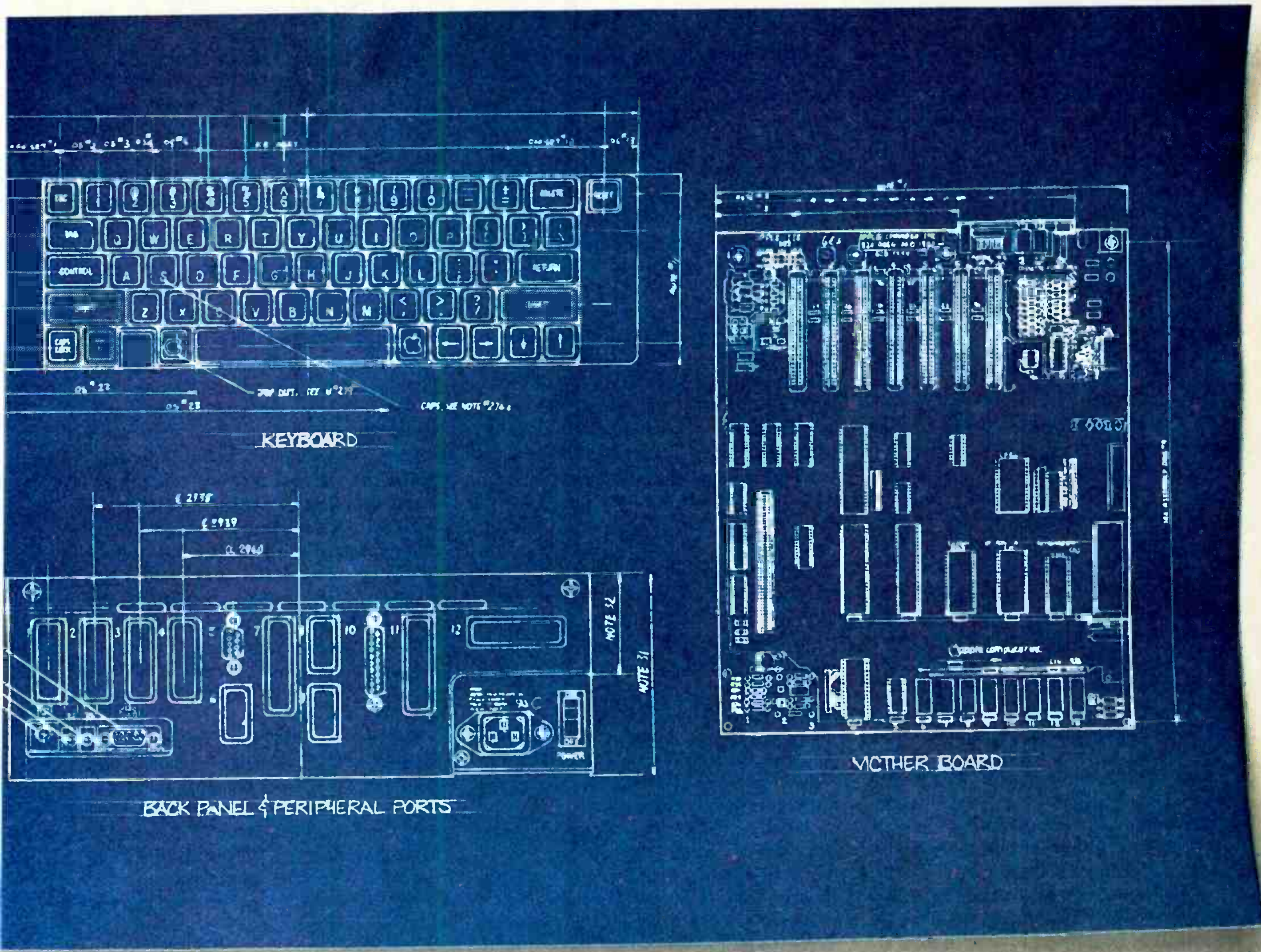

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netic field passes through rather than along the magnetic media.

Since the trailing edge of the magnetic field determines the state of the recorded data, the pole used for writing could have a relatively large gap along the track, but the read head must have a very small pole. Since the smaller the magnetic field, the lower the output of the read head, some form of amplifier must be built into the read head to increase the signal level without degrading it.

To conclude, how does perpendicular recording compare with state-of-the-art semiconductor technology? Well, a 64K RAM chip measures about ¼" on a side, so it should be feasible to produce 16 such 64K RAMs on a square inch of silicon. Thus, using semiconductor technology, 16 × 64,000 or 1024 × 106 bits per square inch can be created. Compare this with the 108 bits per square inch of longitudinal recording and 1010 bits/square inch of perpendicular recording.

Optical Mass Storage. In the constant search for denser mass data storage, several new techniques are being investigated. Probably the method that will reach the market first is the use of optical disks. Although currently used to store both video images and wide-frequency stereo audio, the optical disk lends itself readily to mass data storage, and appears to be very close to production for use in this area.

If you can imagine a single, relatively small disk that can store up to 2 gigabytes, thus replacing 12,500 floppy disks each storing 160K bytes, or 400 conventional 5-megabyte Winchester disks, at a fraction of the price, you can understand why manufacturers are experimenting with prototypes of this very dense recording medium.

This approach is viewed by many people as the mass-storage medium of the future. In support of this, there is already a move to create standards for this new technique. These proposals include mechanical, optical, read/write, and environmental parameters. Two platter sizes have been proposed—one at 305-mm (12.2") outside diameter having a 35-mm (1.4") center drive hole. At present, optical disks are being made in 14"-and-down sizes, with a number of experimental units less than 5" in diameter.

In essence, this mode of recording is based on converting the signal to be stored into a bit pattern, then using this pattern to modulate a laser to distort a film deposited on the platter into a pattern that represents the data to be stored. On playback, the platter distortions are illuminated with a read laser (usually the same one as used to write the pattern) with the reflected bit pattern converted back into the signal used as the original input source.

There are several approaches to recording data on an optical disk and all depend on changing the reflectivity of the spots where the write laser beam impinges. One approach uses the laser to burn tiny holes along a track on the recording media, another uses the laser to produce "bubbles" on the media, while a third uses the laser to cause a reflective change where the laser beam impinges on the media surface. The first is currently used to record movies on video disks.

The bulk of the current optical-data disk prototypes use the hole-burning technique in a layer of tellurium—a nonmetallic element having a melting point of 450°C. Other sensitive layers such as silver halide, or gold/platimum alloys have been tested, as well as some polymer/dye combinations.

Drexler Technology recently patented a new approach. On top of a polyester film substrate are three layers: a protective coating in the form of a thick transparent plastic overlayer, a crust consisting of silver grains of filmentary and spherical shapes dispersed in an organic colloidal matrix, and an underlayer that is formed from the same organic colloid, but devoid of silver particles. The underlayer thermally insulates the reflective crust and increases the laser recording sensitivity. Physical support is provided by a thick polyester film.

Data is recorded when the laser beam melts holes in the reflective surface of the crust. Since the organic colloid matrix melts at 200°C it permits the use of a relatively low-power semiconductor laser. Digital data bits are decoded as the absence or presence of holes, as determined by the intensity of the reflected laser light. Typically, the semiconductor laser has a beam diameter of 5 to 8 μm, a pulse length of 150 to 600 μs, delivers about 5 mW to the absorbing surface, and operates between 440 and 830 nm. An experimental 30-cm (12") disk using this technique stored some 1.25 gigabytes, while a 12-cm (4.8") disk stored 200 megabytes—both on one side.

Tests have shown that 5 megabits of data can be stored on a 1.25-cm by 7.5-cm length of this new media. It has been laid down as a strip on a bank credit card and was found to be able to store some 200K bytes of data. It has been suggested that, if the plastic credit card were covered on both sides by the new recording media, it could store about 5 megabytes of data. Of course, this opens up a completely new area of portable mass storage.

Just about every disk manufacturer and many research establishments are investigating other optical media.

Using a low-cost semiconductor laser, 3M's evaluation 12" platter has a storage capacity of some 1.6 gigabytes/side. Data is written on the three-layer, 4-mm thick recording media using a 9-mW laser to burn 1 micrometer diameter pits into a proprietary refractory layer. The data tracks are 1.6-μm apart, with the platter spinning at 900 rpm. In the video area, Matsushita has demonstrated a still-frame video recorder that can store 15,000 images on one side of an 8" tellurium-layered diskette.

When you consider the enormous amount of data that can be stored in a relatively small area using optical techniques, you can see why this method of mass data storage is being so thoroughly investigated, and why it may appear on the microcomputer scene soon.

Optical disks are permanent storage devices in the same sense as a ROM. Once the data has been (literally) burned into the recording media, it cannot be erased. However, there is current research investigating media that can be burned, erased, and reburned with new data. One experimental approach uses data storage at one disk temperature, with erasure occurring at a slightly higher temperature. Of course, this introduces and undesired complexity—a disk having a temperature-controlled enclosure.

Clearly, the future of computer mass storage technology is churning, and new methods such as smaller devices/media will take their place alongside established ones. ◇

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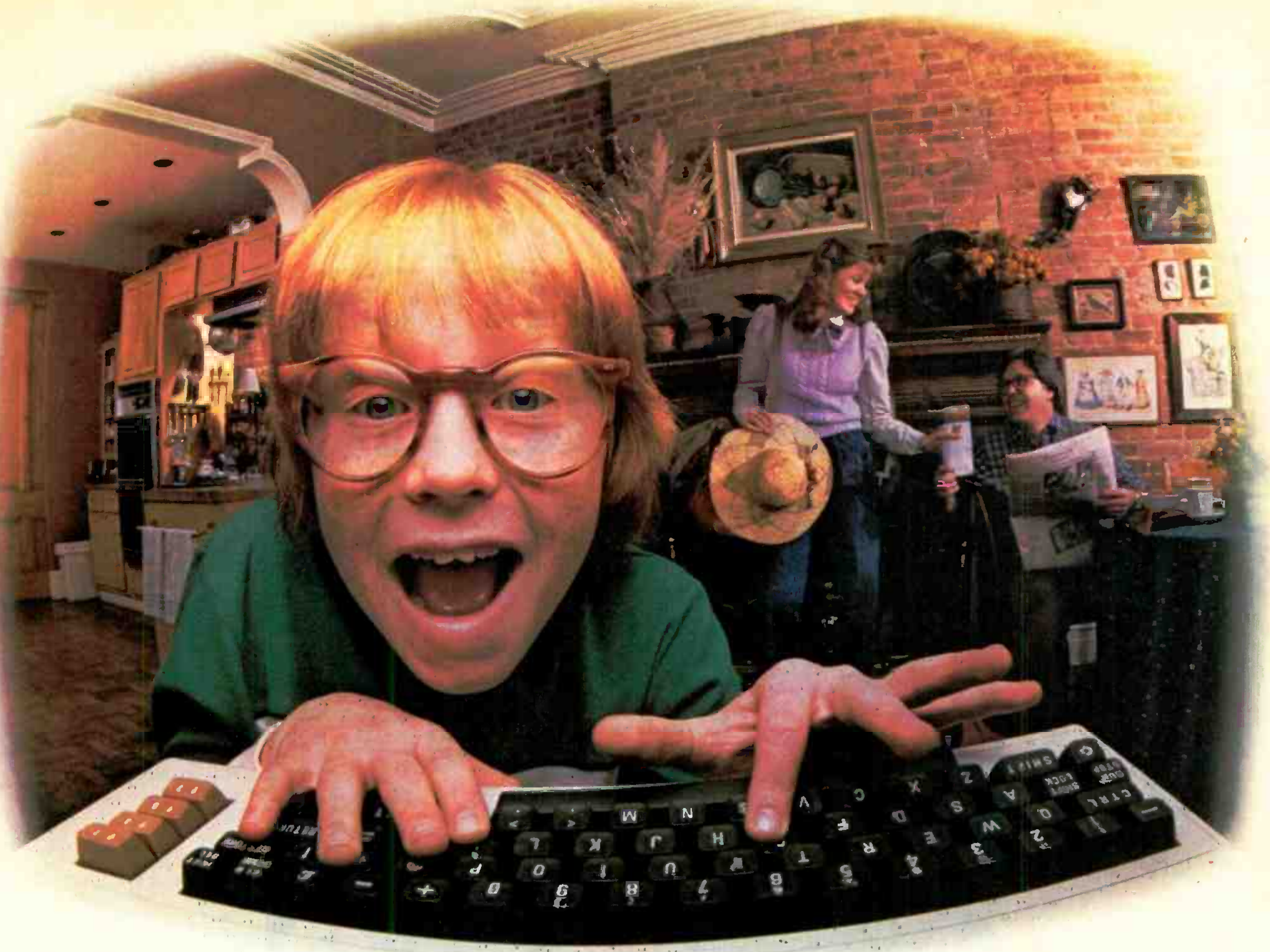
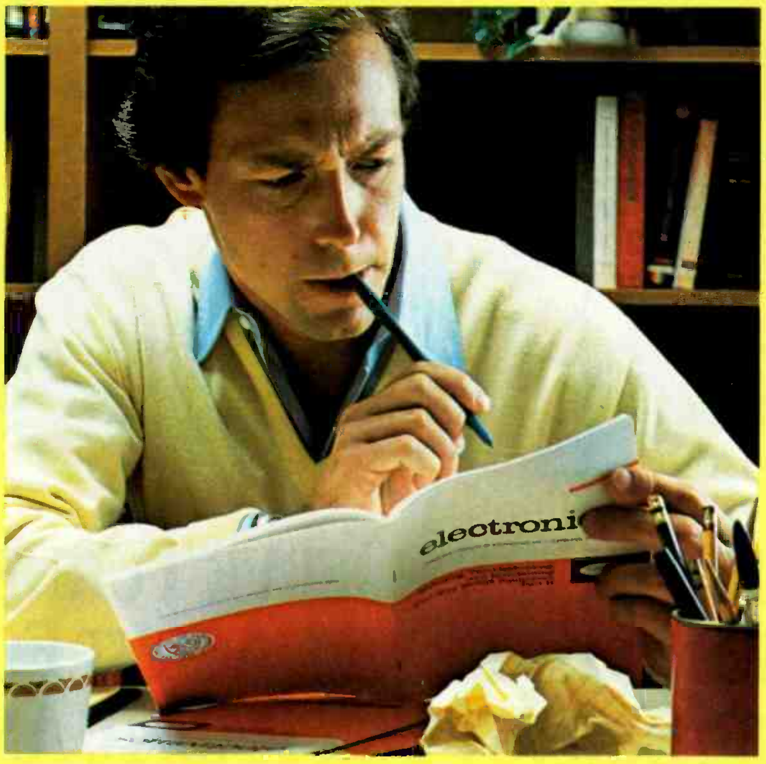
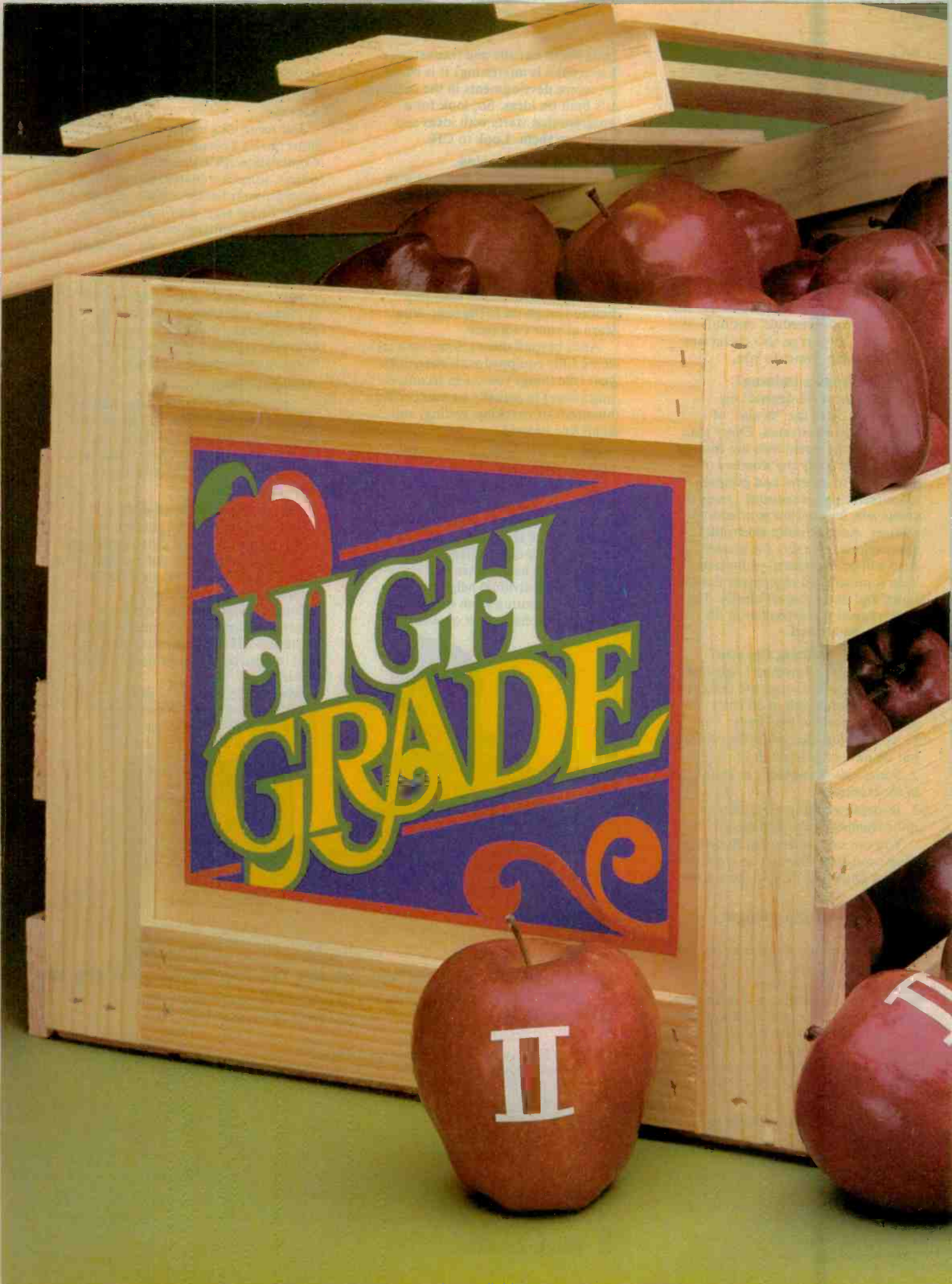


Learning electronics is no picnic.



At any level it takes work and a few sacrifices. But with CIE, it's worth it.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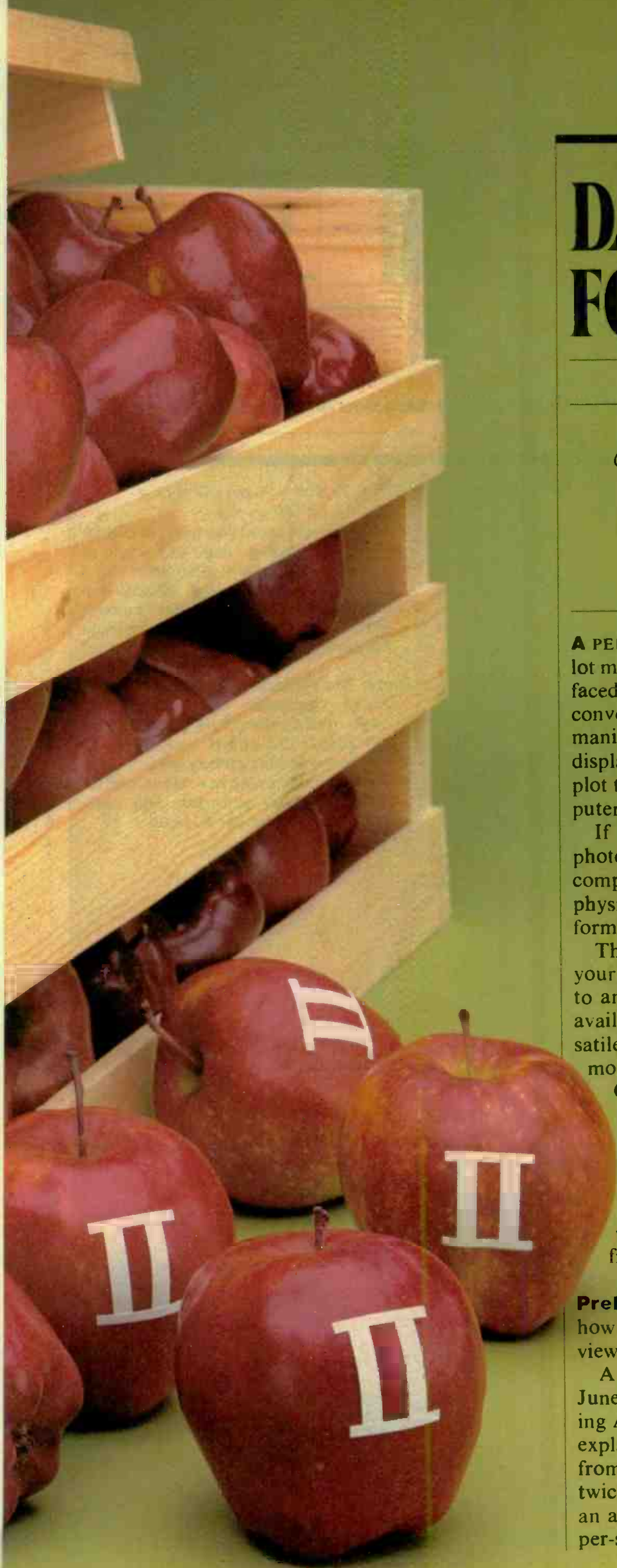


High-Grade

DATA CONVERTER FOR THE APPLE II

By Robert C. Nicklin

Part I: Analog/digital and digital/analog conversion increase the usefulness of your computer by allowing it to accept, manipulate, and display all kinds of physical data

A PERSONAL computer like the Apple II can be used to do a lot more than play games and calculate payrolls. When interfaced to analog-to-digital (A/D) and digital-to-analog (D/A) converters, your computer can capture waveforms, perform manipulations and mathematical operations on them, and display the new or changed waveforms on an oscilloscope or plot them on a chart recorder. Used in this manner, the computer becomes a "smart" storage scope.

If instead of a waveform you substitute the signal from a phototransistor, strain gauge, pressure transducer, etc., your computer can be made to sense and store information about physical variables. It can then display this information in a form and at a rate that's convenient for you.

The Data Converter presented here makes it possible for your computer to perform these functions. It can be adapted to any computer that has eight data and one control lines available at an I/O port. An additional circuit board, the Versatile Interface Adapter (VIA), was designed to interface the module to the Apple II computer. Together, the VIA and Converter equip the Apple computer to capture up to 17,000 data points per second from an ac or dc analog signal; amplify the incoming signal by up to 500 times; and output analog signals at rates up to 33,000 data points per second. In addition, an audio amplifier and speaker and two bidirectional digital I/O ports are provided. All operations of the Data Converter can be called from BASIC.

Preliminary Discussion. Before we get into the specifics of how the Data Converter accomplishes its task, let's briefly review how analog-to-digital conversion is performed.

A general discussion of A/D conversion appeared in the June 1982 issue of this magazine under the title of "Processing Analog Signals for Digital Systems." Briefly, this article explained how a waveform can be faithfully reconstructed from a series of samples when the sampling rate is at least twice the highest frequency present in the waveform. Hence, an analog/digital converter that samples at a 17,000 times-per-second rate can be used for signals whose highest frequency components don't exceed about 8.5 kHz.

Signal resolution is determined by the number of bits used by the A/D converter. An 8-bit converter, such as that used in the Data Converter presented here, can resolve a voltage range into 256 discrete intervals or 0.4% parts. A 9-volt reference, for example, sets a 0-to-9-volt range, with a resolution of 35 mV (9/256). If the signal is amplified 500 times, each interval represents 0.07 mV (35/500).

The same considerations apply to the

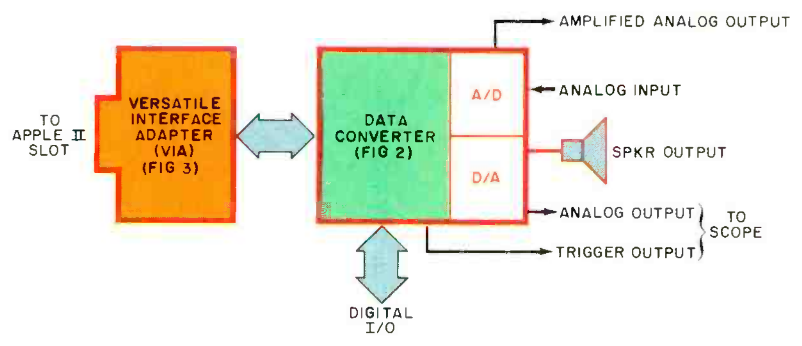


Fig. 1. Block diagram showing connections between major units.

PARTS LIST

B1—9-V transistor battery
B2—4.5-V battery (3 AA cells in series)
C1—100-pF, 25-V disc capacitor
C2—220-µF, 6-V electrolytic
C3,C5—0.1-µF, 25-V disc capacitor
C4—330-pF disc capacitor
D1—1N914 diode
IC1—TL092 dual op amp
IC2—AD7574 A/D converter
IC3—AD558 D/A converter
IC4—7416 open-collector hex inverter
IC5—LM386 audio amplifier
IC6—6522 PIA
IC7—Quad AND-gate
J1,J2,J5,J6,J7,J8—Phono jack
J3,J4—Banana jack (one red, one black)

All resistors are ¼-watt, 10% tolerance:
R1,R4,R8—10 kilohms
R2—1 megohm
R5,R6—1 kilohm
R7—5 kilohms
R9—50 kilohms
R10—100 kilohms
R11—500 kilohms
R12—200 kilohms
R13—2.2 kilohms
R15—1.5 kilohms
R3—10-kilohm trimmer potentiometer
R14—10-kilohm, audio-taper potentiometer
S1—Sp6t nonshorting rotary switch
S2—Spdt switch
S3—Dpdt switch
SPKR—Small 8-ohm loudspeaker

SO1,SO3,SO4—16-pin DIP socket
SO2—14-pin DIP socket
Misc.—Printed-circuit boards (2) or materials for fabricating same; 24" length of 16-conductor ribbon cable with 16-pin DIP header at each end; suitable-size enclosure; battery holders; control knobs (2); hookup wire; solder; machine hardware; quick-set epoxy cement; etc.

Note: The following are available from Nalan Computer Specialties, Box 1426, 106 Highland Park Lane, Boone, NC 28607: VIA board, including one cable, for $49.00; complete Data Converter kit, including machined and labeled chassis, batteries, and software on diskette, for $149.00.

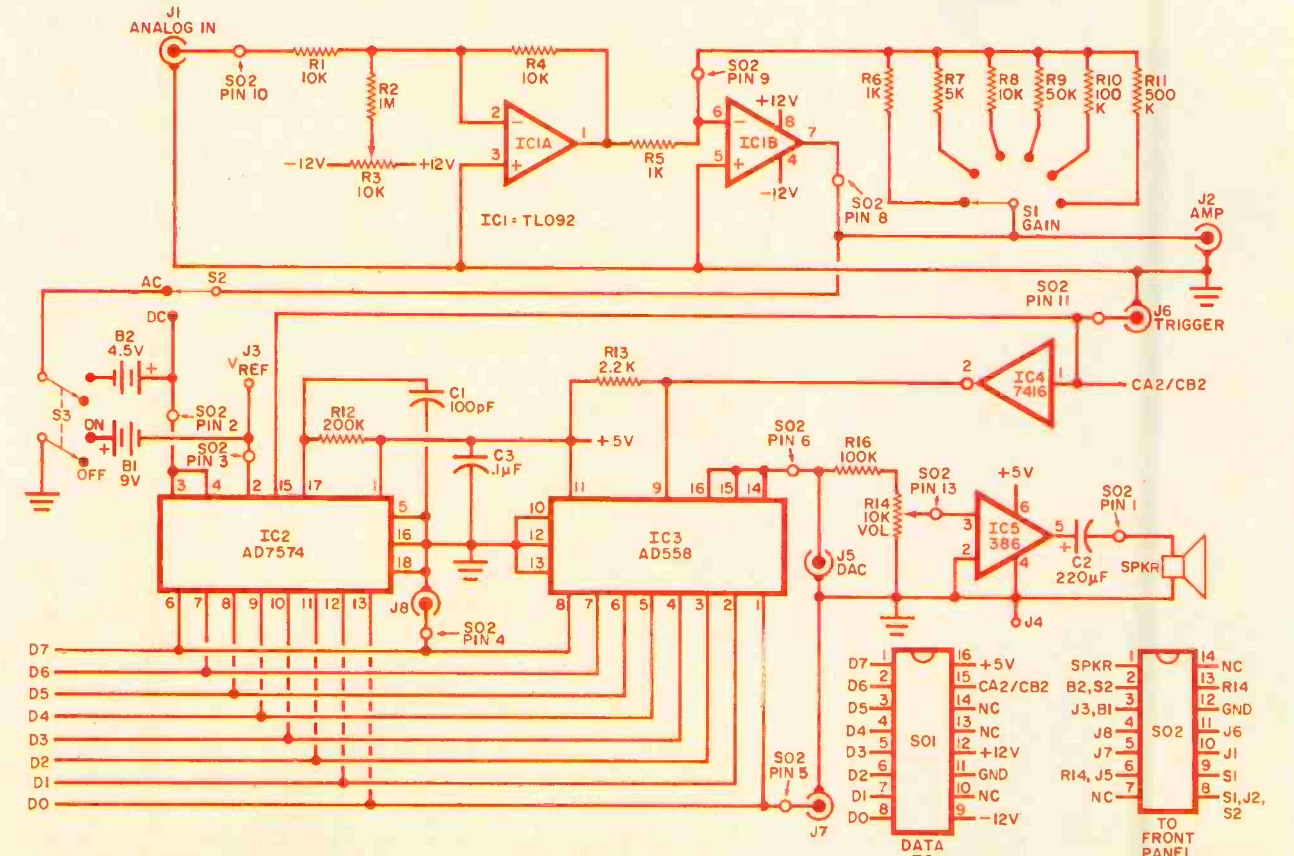
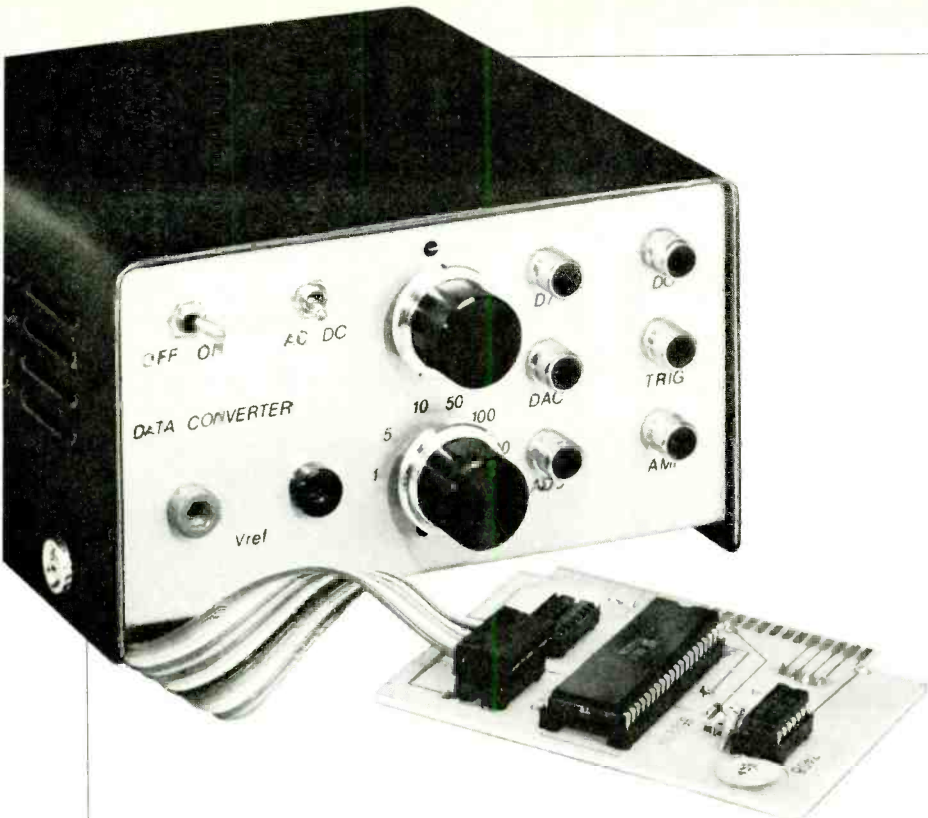


Fig. 2. The Data Converter contains D/A and A/D circuits and an amplifier.



D/A converter. The 8-bit device used in the Data Converter features 256 steps and, with its internal voltage reference, has a range from 0 to 2.56 volts. Consequently, each step represents 0.01 V (10 mV). With an output rate of 33,000 samples per second, the D/A converter could produce waveforms with frequency components to about 16,500 Hz.

Circuit Description. The Data Converter (Fig. 1) employs the Versatile Interface Adapter (VIA) designed to plug into any Apple II expansion slot. The converter interconnects with the VIA through a 16-conductor ribbon cable terminated at both ends with a DIP plug to provide eight bidirectional data, one control, and +12-, −12-, and +5-volt lines. The VIA contains two 8-bit bidirectional ports, each with two control lines. Only one port is used in this project, leaving the other available for a second converter or other I/O device.

Contained in the Data Converter are a variable-gain signal amplifier, D/A converter with analog and speaker outputs, A/D converter that includes an amplified analog output, and a control panel. A trigger signal for an oscilloscope is also provided.

As shown in Fig. 2, the incoming analog signal at *J1* goes to the inverting (−) input of unity-gain buffer *IC1A*. Potentiometer *R3* is used to preset the zero offset to the buffer. The output from *IC1A* goes to *IC1B*, and the gain of the stage is set by GAIN switch *S1* (gains are 5, 10, 50, 100, or 500). A monitor point or optional output is provided at *J2*.

After amplification, the output at pin 7 of *IC1B* goes to AC/DC selector *S2*. With *S3* set to ON and *S2* set to DC, a negative reference from *B1* is applied to pin 2 of *IC2*. Input range is, therefore, 0 to 9 volts (V_{REF}). Setting *S2* to AC places *B2*, with half the voltage of *B1* (4.5 V), in series with the signal. Hence, with a V_{REF} of 9 volts and *B2* at 4.5 volts, a range of +4.5 to −4.5 volts is obtained, allowing signal peak-to-peak amplitudes up to this level to be digitized.

Conversion time for the synchronous clock oscillator inside *IC2* is about 20 µs with the values specified for *C1* and *R12*. With Chip-Select (CS) pin 16 of *IC2* tied to ground, operation is controlled by Read pin 15. Depending on which port (A or B) of the VIA is used, pin 15 will be controlled by the CA2 or CB2 signal. The eight data lines (D0 through D7) go to pins 6 through 13 of *IC2*. Three-state buffers in *IC2* use the data lines when required, since D/A converter *IC3* also shares the same lines.

D/A converter *IC3* requires no external components to operate. Pins 1 through 8 connect to the data lines, while pins 14, 15, and 16 tie together to provide a 0-to-2.56-volt output at *J5* (DAC) and the top of VOL control *R14*. Normally, +5 volts is applied to pin 11 of *IC3*; if this potential is raised to between 11.4 and 16.5 volts and pin 14 is tied to ground, the A/D output will be in the 0-to-10-volt range.

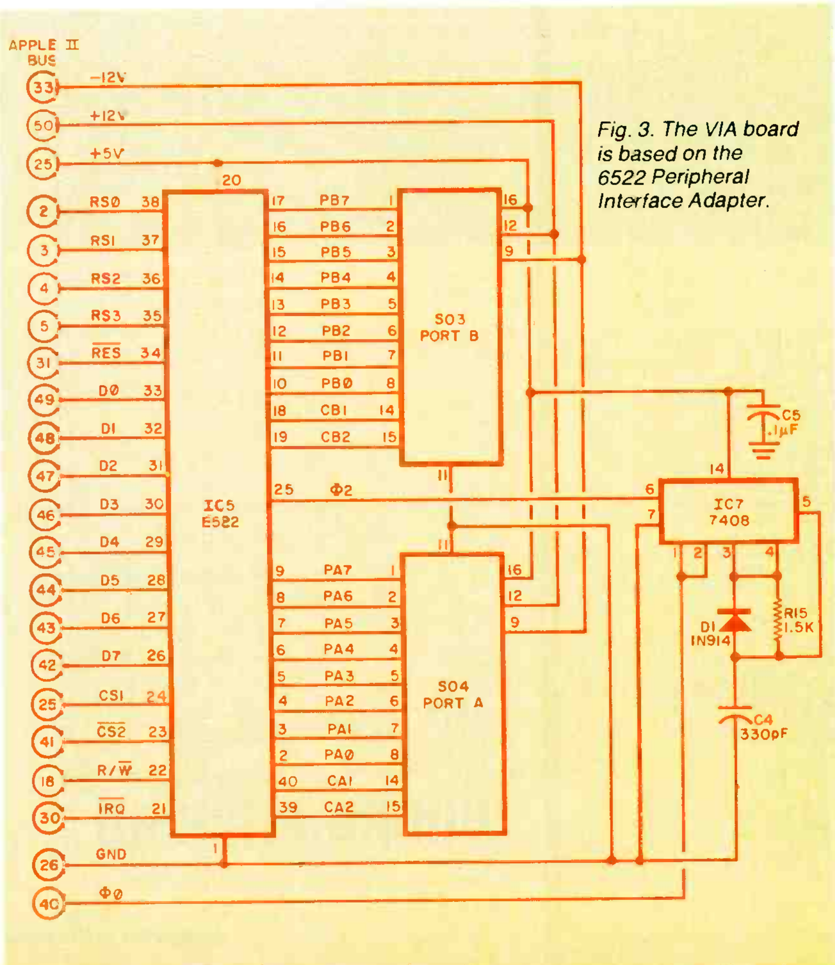


Fig. 3. The VIA board is based on the 6522 Peripheral Interface Adapter.

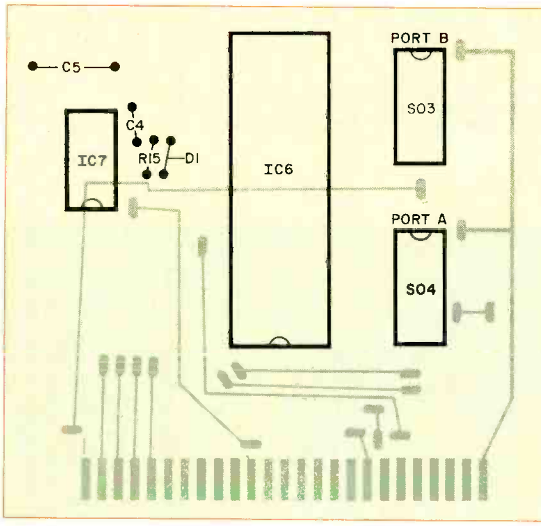


Fig. 7. Component layout for the Apple interface adapter.

Chip Select pin 10 of *IC3* is tied to ground and operation is controlled by the signal at Chip Enable pin 9. One element of open-collector inverter *IC4*, inverts the phase of the CA2 or CB2 control signal before supplying it to pin 9 through load resistor *R13*. Since *IC2* is read when its Read goes low, and *IC3* runs when its Chip Enable goes low, inversion of the common control signal keeps the two ICs from operating at the same time.

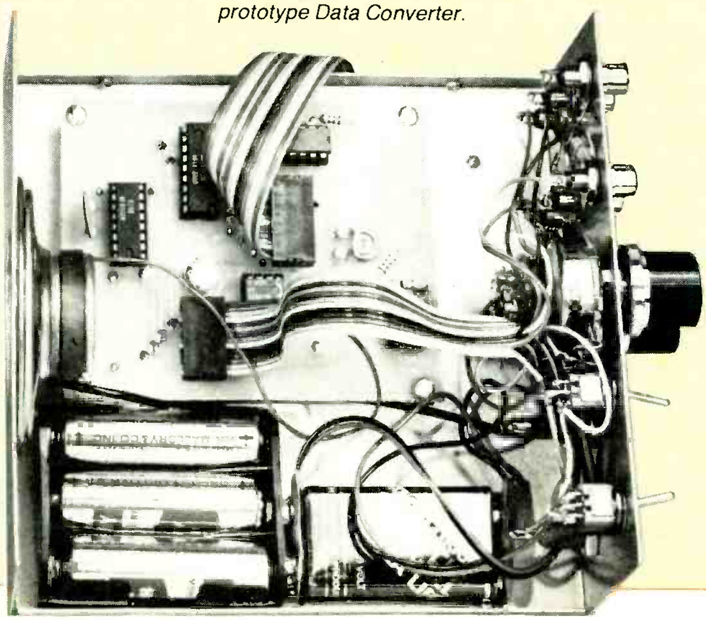
The audio signal selected by VOL control *R14* goes to audio amplifier *IC5*, the output of which is coupled through *C2* to drive a small loudspeaker.

The Data Converter connects to the VIA board through 16-pin DIP header *SO1*, which carries the data, control, voltage, and ground lines. Interconnection between the Data Converter and its front-panel components is via 14-pin DIP header *SO2*. (Connections in the circuit for this header are shown with circles in Fig. 2.)

The VIA board for the Apple II, shown in Fig. 3, is based on the 6522 PIA Peripheral Interface Adapter. Data lines D0 through D7 go through either Port A as PA0 through PA7 with control lines CA1 and CA2 or through Port B as PB0 through PB7 with control lines CB1 and CB2. Each port connects to the following circuitry through connector *SO3* for Port B or through *SO4* for Port A.

Integrated circuit *IC5* expects to receive the phase-2 clock signal from the 6502 CPU in the Apple computer from bus connector pin 40. However, this signal isn't available from the Apple bus or any other easily accessible location in the Apple computer. To overcome this obstacle, phase 0 and the delay introduced by the *IC7* circuit are used to provide the required clock signal for *IC5*. The values specified for *C4* and *R15* cause this circuit to delay the phase-0 clock signal by 180 ns, making the 6522 "think" it's getting the phase-2 clock signal from the Apple computer. A discharge path through *D1* is provided for capacitor *C4*.

Photo showing inside of the author's prototype Data Converter.



Construction. The Data Converter is best assembled on a printed-circuit board, preferably a double-sided design to keep layout area to a minimum and obviate the need for a multitude of jumpers. You can fabricate your own pc board using the etching-and-drilling guides in Fig. 4 and the component mounting diagram in Fig. 5. Sockets are recommended for the ICs, and careful attention must be paid to component orientation during installation. Once this board is wired, it can be mounted in an enclosure of suitable size, with *B1* and *B2* fastened to the bottom of the box via battery holders and quick-set epoxy cement.

The enclosure's front panel can be machined to accommodate *J1* through *J8*, POWER switch *S3*, AC/DC switch *S2*, RANGE selector *S1*, and VOL control *R14*. Use a lettering kit to label the front panel, and install control knobs on the shafts of *R13* and *S1*.

Front-panel components connect to the Data Converter pc assembly through a multiple-conductor ribbon cable. One end of this cable should be soldered to the appropriate lugs on the panel-mounted components, the other end to the appropriate *SO2* pins on the pc assembly.

Assembly of the Apple interface adapter can be on any Apple-compatible prototyping board. Alternatively, you can fabricate your own double-sided pc board, using the etching-and-drilling guides in Fig. 6. Again, during wiring of this board (see Fig. 7 for details), it's recommended that you use sockets for the ICs.

The interface adapter assembly connects to the Data Converter through a length of 16-conductor ribbon cable with 16-pin DIP sockets at each end. This cable plugs into the system between *SO1* on the Data Converter and *SO3* (Port B) or *SO4* on the interface adapter.

(To be continued)

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Desktop APPLIANCE COMPUTERS

Two modestly priced small computer systems, both with bundled software

By Stan Veit

Cromemco and Morrow Designs are two of the pioneering companies that have taken advantage of new integrated-circuit technology to vastly increase the capabilities of the microcomputer. Both have introduced "appliance-type" computers. That is, they include machines, software, and instructions that can be unpacked from a carton(s), connected, and immediately used with little or no previous instructions, just like any other household or office appliance.

These new systems go far beyond having just a bevy of software packages and a menu to select them. They provide an interface between the user and the software that makes running the programs easy and nonthreatening.

It is obvious that buying and using one of these systems will not automatically turn the owner into a programmer—this requires study and practice. But there is enough easy-to-use software for anyone who can read the instructions to do word processing and prepare and use an electronic spreadsheet for financial work. In addition, both systems have forms of BASIC and provisions for other languages to enable even the proficient programmer to use them as general-purpose computers.

Cromemco C-10

The $1785 Cromemco C-10 Super Pak includes a video monitor with a 12" green-phosphor screen for full 80-character by 24-line display; a detached keyboard; one disk drive with storage capacity for 379,312 characters; and an internal, single-board computer with a Z80A microprocessor and 64K bytes of user memory.

The software package would cost more than $1000 if purchased separately. It consists of the WordMaster word processor, the PlanMaster spreadsheet analysis program, and the MoneyMaster stock and bond analysis program.

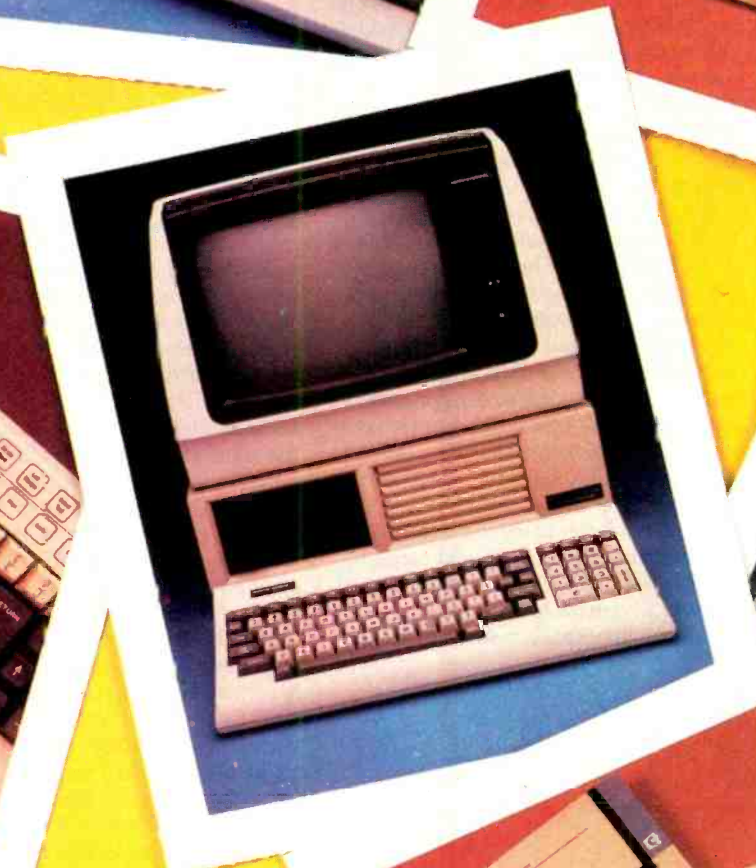
Cromemco has also included structured BASIC and a Full Screen Editor for users who want to develop their own software. It also has a ROM-based operating system that is operational when power is applied. It is called CROS and it has the additional function of providing communications through a modem or permitting the C-10 to be connected as a "smart terminal" in a multi-user system.

Underlining all these software systems is the standard Cromemco operating system called CDOS, which is an enhancement of CP/M-80 and is compatible with that "almost universal" system. This adds the capability of including other languages and software systems to the C-10 as the occasion demands. The user is not "locked-in" to the software supplied with the package. Both FORTRAN and COBOL are available in C-10 format. Such popular software packages as WordStar, CalcStar, Data Star, Mail Merge and dBase II can be purchased for the C-10 since most of the software distributors support the Cromemco $5^1/_4$" double-density, double-sided format.

Using the C-10 Computer. The main unit looks like a video terminal with a detachable keyboard. The video components are mounted directly under the CRT and there is a shelf just below that on which the single-board Z80A computer is mounted. This main computer is a marvel of intregrated design. Through the use of Large Scale Integrated (LSI) circuits, the chip count of the C-10 has been reduced to 39 ICs including the 64K memory. This directly contributes to the low cost and high reliability of the system.

The rear panel of the computer board is accessible at a set-back on the rear of the Monitor/Computer unit. It contains a female "stacking-type" connector. The cable for the first drive plugs into this connector and the connector on the cable for the second drive plugs into the back of the first connector in a stacking arrangement. The keyboard connects to the computer through a coiled telephone type cord. A telephone modular plug is on each end of the coiled cord. There is an RS232C female "D" connector (DB25S) for the printer cable. Cromemco has an adapter for the Smith-Corona TP-1 Daisy Wheel Printer, and the latter is then sold as the Model CLQ Printer.

There is another "D" connector on the rear panel. This is for connection from the C-10 to either another computer or to a modem. When the system is connected to a modem, a Model CBL-CM cable is used; when connected to another computer, the cable is a CBL-CS. Both of these cables are supplied by Cromemco as an option. All of the connections are provided with screw fasten-



ers. The drive cable uses thumb screws for positive connection. The power switch is mounted on the rear CRT overhang and it can not be closed by accident. Another option provided for the C-10 is the Model CST Ergonomic Stand. This stand elevates the CRT and makes the screen much easier to see from any position. I did not have this stand and I missed it. There are two adjustable feet on the front of the main in making its software easy to use than Cromemco has. The C-10 software package was designed for that machine and, therefore, all of it can fit on one diskette and is available from a single menu. If additional software is used it must be accessed from outside the main menu.

Morrow uses standard software packages designed to be used on all CP/M computers. They therefore use the Pilot language to build an interactive interface program. This allows the user to operate the system without learning the CP/M operating system. I have used several "front end" CP/M interfaces designed to operate the system from selection menus. This one works well but not as easily as others, such as CPM+.

Another feature of the Morrow Micro Decision is the use of "virtual drive" This is a system of declaring the presence of a drive that actually does not exist. As a result, you can reassign Drive A to act as a drive to "double" as another drive while still serving as Drive A. This has some advantages. For example, if you run out of space when using WordStar on a two-drive system, you are in trouble because WordStar does not permit you to swap diskettes while editing. With virtual drive, you can write your excessive file to a nonexistent drive, swap the diskette that is currently in Drive A and save the text on that drive.

WordStar then operates as if you had a three drive system. Of course, you really don't have three drives, but by swapping the disks in Drive A you simulate one. The bad part of this system is the method used to copy disks. It forces you to use the virtual drive even though you have two drives and could do it much easier.

When I started the Micro Decision, there was a pause during the time the system was doing a self-check. It then announced that the memory checked OK. Having passed the memory test, the system displayed the Micro Decision Micro Menu, which permits the user to perform all kinds of CP/M operations without really knowing the CP/M system. These include:

0. CREATE A WORKING OR SYSTEM DISKETTE
1. RUN A PROGRAM
2. DISPLAY A DISKETTE DIRECTORY (DIR)
3. VIEW OR PRINT A FILE (TYPE, PIP)
4. COPY A FILE (PIP)
5. FORMAT A DISKETTE (FORMAT)
6. MAKE A BACKUP DISKETTE
7. CHECK DISKETTE FILE SIZE
8. OTHER OPTIONS (REN,ERA,STAT)
9. EXECUTE A CP/M COMMAND
   ESC EXIT TO CP/M

The Pilot program guides the user through the complications of the CP/M system and, after a while, it becomes second nature. The user therefore learns CP/M while working with the system. As an experienced CP/M user, I had to resist the urge to get out of the Pilot system and directly operate from CP/M. It can be done; so that, once CP/M is learned, one can indeed operate on his own.

Since I have used WordStar for many years I am hardly able to evaluate it as a new user, but the built-in menus and defaults in WordStar make it very easy to use when you ignore all the "bells and whistles" and just edit text. The LogiCalc program is also one I have been familiar with for a long time. I have always considered this spreadsheet from Software Products International of San Diego, CA one of the better ones on the market. The manual supplied with the system is a good teaching tool and a new user should have no trouble learning it. The Correct-it Spelling Checker works well. I am accustomed to using SpellStar with Word Star, but I have nothing negative to say about this program. I used the BaZic language for some problems but find it hard to get acquainted with. I feel that it was only included to increase the size of the software package.

Conclusions. I only wish I had started in computing with either of these systems. They give the user a chance to use the system for meaningful work with a minimum of pain. In time, the user may outgrow the easy menus and other crutches, but he will not easily outgrow the system. I like both of them and would recommend either to anyone who wants to get into computing without the games and colors of "home computers." Both Cromemco and Morrow have provided full-sized systems for a very moderate price. In comparing the two of them, I feel that the Cromemco is easier to use and is smarter-looking right down to its slick-paper, colorful manuals. The Morrow, in turn, has the edge in software, expansion capability, and sharper video.

One additional conclusion concerns the Smith Corona TP 1 which we used to test both of these computers. It is slow and noisy but it does an outstanding job of producing good looking text for a low price. That is enough reason to buy it. ◇

PROGRAM ANY WAVESHAPE YOU CAN IMAGINE

A voltage-controlled oscillator circuit with RAMs synthesizes waveshapes without using complex filters

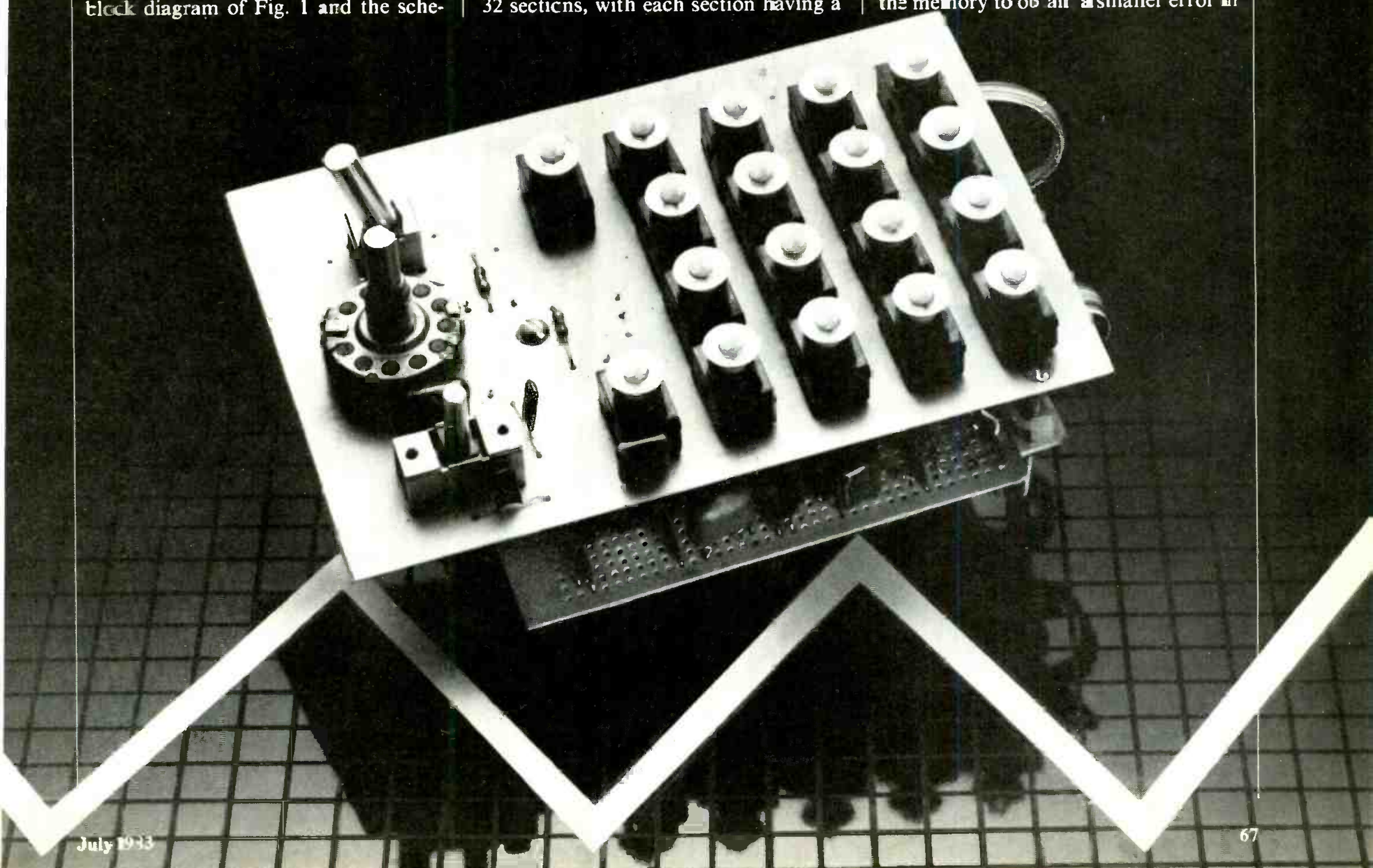
By R. S. Lasher

USING a programmable voltage-controlled oscillator (vco) makes it possible to synthesize almost any waveshape without having to pass a fundamental waveform (square, triangle, or sine) through a filter. The circuit shown in this article uses two computer RAM chips to "construct" a waveshape preprogrammed by the user and was designed to replace a conventional voltage-controlled oscillator in a synthesizer. With a few simple revisions, it is possible to use this circuit as a versatile sequencer. The circuit utilizes CMOS devices for high speed and low operating power.

Circuit Operation. As shown in the block diagram of Fig. 1 and the schematic of Fig. 2, the circuit includes five basic building blocks: the vco, a 6-bit counter, a memory, a keyboard and encoder, a digital-to-analog converter, and an output stage. The vco is a precision circuit that produces a square-wave output whose frequency is linearly proportional to the input voltage level. The operating point of *IC1* is determined by *R11* and switch-selected *C1*, *C2*, or *C3*. Three frequency ranges can be selected by *S2*: 100-10,000 Hz for audio, 1-100 Hz for very low frequencies, and 0.1-1 Hz for sequencer applications.

The square-wave output from pin 7 of *IC1* is divided by 32 in *IC2* to form a six-bit address for memory *IC3* and *IC4*. This divides the desired wave shape into 32 sections, with each section having a unique voltage level. The voltage level of each section is loaded into the memory formed by *IC3* and *IC4*, two random-access memory chips. (A 15-bit number signifying a specific voltage level is stored at each memory address.) As each address is called in order by *IC2*, the output changes to the voltage level preprogrammed by the user.

The effective size of the memory is 6 bits by 5 bits but can be expanded to 7 bits by 5 bits. However, it was found that, if the memory is expanded past 6 bits, the frequency of the vco is much higher than the maximum operating limits. If the circuit is going to be used only on the lower two frequency settings of *S2*, it is possible to expand the memory to obtain a smaller error in



the final output. It should be kept in mind, however, that for each address of memory, a voltage level will have to be keyed in. This will make it necessary to key in 128 numbers.

Digital-to-analog converter *IC5* changes the digital output to an analog current signal. The latter is then converted into a voltage signal suitable for use in a voltage-controlled synthesizer by op amp *IC6*.

To enter a waveform into the memory, the memory should be switched into the WRITE mode by applying a high (via *S2B*) to pins 8 and 6 of *IC8*. The 6-bit counter, *IC2*, should be reset to zero by applying a high to pin 2 of *IC2* via *S4*. The 16-key keyboard is decoded by *IC7*. As a key is closed, *IC7* sends a data available signal to *IC8A*. If READ/WRITE switch *S2* is in the WRITE mode, a high is passed to *IC8*, and the gate will produce a low at pin 10 when the data is to be written into the memory. This is done because, if the data or the address is changed while the memory is in the WRITE mode, the data could be lost. Therefore, after the data is stabilized, the READ/WRITE signal is brought low to begin the next address.

The keyboard is comprised of 16 keys, used to program *IC3*, and SHIFT key *S3*, which will program *IC4*. The SHIFT key allows the use of just 16 keys instead of 32. The 16 keys are debounced by an internal circuit of *IC7* and *C5*. This capacitor also controls the time delay between the data output signals and the data-available signal, since *C6* controls the sampling rate of *IC7*.

When there are no keys depressed, the output enable, pin 14, is forced into a low state. This forces the data output pins into a high-impedance or a three-state mode. When a key is depressed, the data-available signal goes high and, if the READ/WRITE switch is in a WRITE position, *IC8* produces a low signal. This enables the output pins into their respective levels, depending on which key is depressed.

Construction. The oscillator can be wire-wrapped using lengths of wire that are as short as possible. Keep in mind that, when an output frequency above 10 kHz is desired, there will be a signal above 500 kHz passing through the *S2* circuit, so keep these leads as short as possible. Handle all CMOS chips with care to prevent static breakdown. A grounded metal enclosure should be used to reduce any r-f interference generated by *IC1*.

"A number of vco's can be used to create a series of waveforms that will generate avant garde music."

The power supply can be any source of voltage between ±4 and ±6 volts dc, with a typical circuit that can be used shown in Fig. 3.

Use. The circuit can be used in either of three modes: as a vco, as an envelope generator (which is essentially a low-frequency signal), or as a sequencer. Other than the programmability, there is very little difference between this vco and any other.

To program the circuit, use a graph having 32 divisions vertically (voltage) and 64 divisions horizontally (time) and sketch the desired waveform between these bounds. With READ/WRITE switch *S2* set to WRITE, depress *S4* to RESET the system to zero, then use the keyboard to enter the voltage value at each horizontal division. If the voltage scale exceeds 15 units, use the SHIFT switch (*S3*) to add 16 to the key number.

To convert the circuit to a sequencer, break the connection between pins 2 and 3 of *IC2*, and connect pin 3 to parallel-connected pins 1 and 2 of a spare gate within quad gate *IC8*. This forms an inverter. Connect the output of this inverter at pin 3 to pin 13, one input of another spare gate within *IC8*.

Remove the lead coming from *S2A* at pin 1 of *IC2*, and connect the switch lead to pin 12 of *IC8*. Both inputs to this gate are now made. The output at pin 11 will be the inverse of the clock signal when the counter is in the first 64 counts. When the seventh bit goes high, the gate (*IC8*) will be inhibited and the count will stop if pin 11 of *IC8* is connected to pin 1 of *IC2*.

To start the sequence, apply a high to pin 2 of *IC2* via RESET pushbutton *S4*. This will reset the counter and force the seventh bit low, allowing clock signals to pass through *IC8*. Counter *IC2* con-

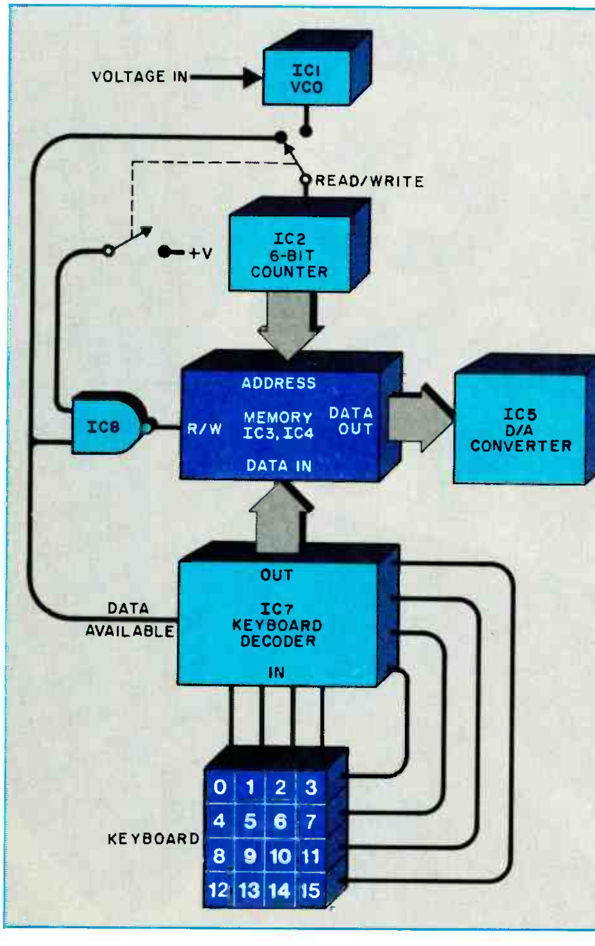


Fig. 1. The circuit includes a vco, 6-bit counter, memory, keyboard, d/a converter, and output stage.

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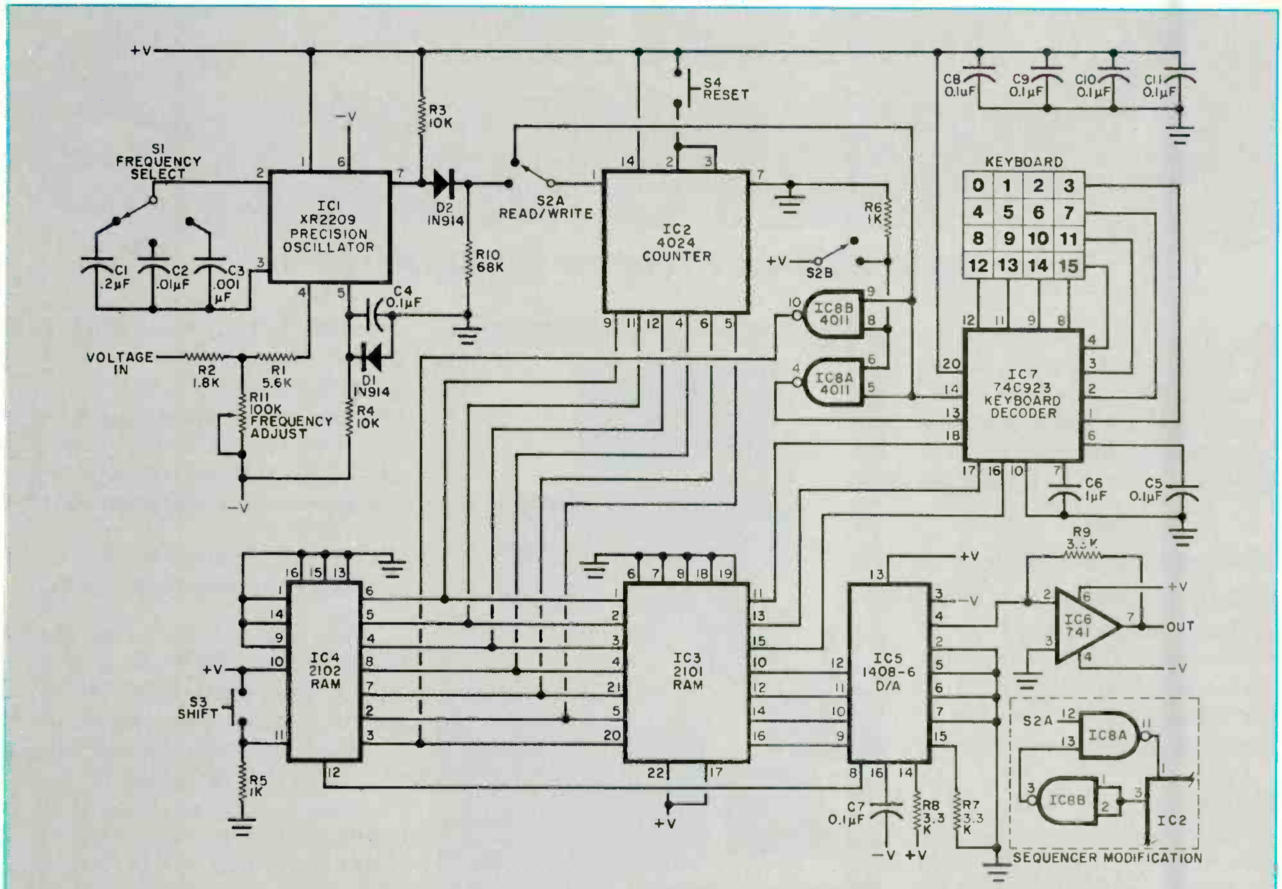

Fig. 2. The vco produces a square-wave output whose frequency is proportional to the input voltage.

PARTS LIST

- C1—0.2-μF capacitor
- C2—0.01-μF capacitor
- C3—0.001-μF capacitor
- C4,C5,C7 through C11—0.1-μF capacitor
- C6—1-μF capacitor
- D1,D2—1N914
- IC1—XR2209 precision oscillator (Exar)
- IC2—4024 7-stage binary counter
- IC3—2101 256 × 4 static RAM
- IC4—2102 1024 × 1 static RAM
- IC5—1408-6 digital-to-analog converter
- IC6—741 op amp
- IC7—74C923 keyboard encoder
- IC8—4011 quad 2-input NAND gate
- R1—5-kilohm resistor
- R2—1.8-kilohm resistor
- R3,R4—10-kilohm resistor
- R5,R6—1-kilohm resistor
- R7,R8,R9—3.3-kilohm resistor
- R10—68-kilohm resistor
- R11—100-kilohm potentiometer
- S1—Sp3t rotary switch
- S2—Spdt switch
- S3,S4—Normally open pushbutton switch
- Misc.—16-key keypad, hookup wire, suitable enclosure, mounting hardware, etc.

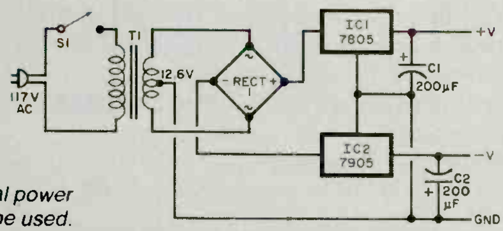

Fig. 3. A typical power supply that can be used.

PARTS LIST

- C1,C2—200-μF, 25-V capacitor
- IC1—7805 5-V positive regulator
- IC2—7905 5-V negative regulator
- RECT1—1-A bridge rectifier
- S1—Spst switch
- T1—12.6-V, 500-mA transformer

tinues to count until the seventh bit goes high, inhibiting the clock signal.

Both the programmable vco and the sequencer can be used in a number of ways. For example, the vco can be programmed for any waveform the user can imagine, making it ideal for music synthesis. The user can define the required waveform so that a vco (voltage controlled filter) is not required. This allows for re-programming the same sound without having to consider programming a vco. A number of vco's can be used to create a series of unique waveforms for *avant garde* music. On the other hand, the sequencer can be used to program any function that uses a voltage as a control. ◇

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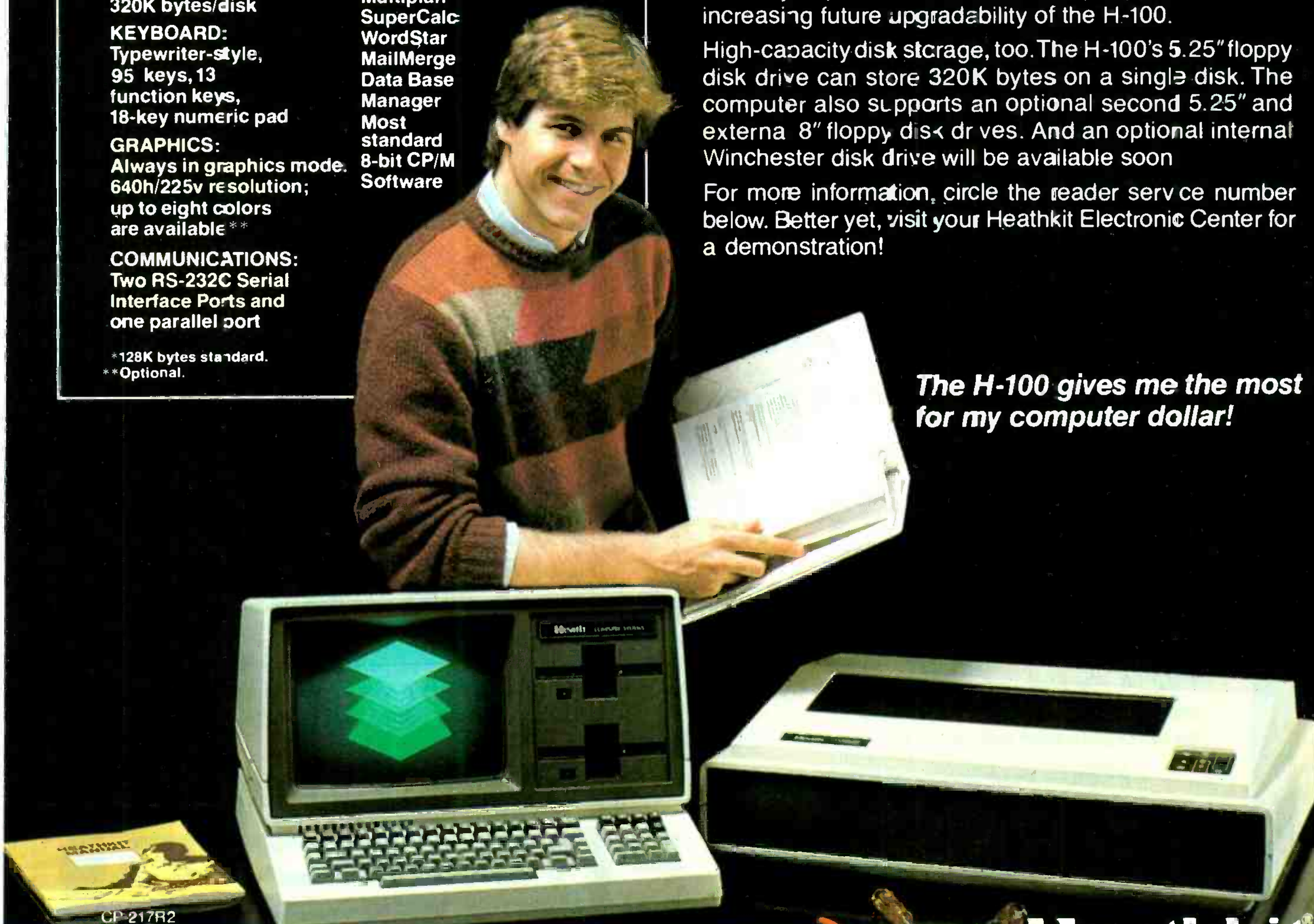

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The Soul of CP/M

PART 3

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

UP to this point in our series on the soul of CP/M, we've concentrated on the basic functions. With this installment, we get into the skeleton structure of this versatile and powerful operating system —Disk System calls.

Overall Picture. You can do some interesting things with the system calls you've learned so far, but with *disk* system calls you can do a great deal more. In fact, for most serious computer operations, you can't get by without using disk system calls. Most applications programs, not to mention operating systems and languages, are stored on disks. In short, then, understanding the CP/M disk system is indispensible if you want to write progams that make use of the full capability of CP/M.

CP/M disk system calls are amazingly powerful. When you used the console system calls, you were dealing with single characters or character strings. With disk system calls, you can handle whole *files* at a time, without having to worry about how CP/M and your computer actually read and write to and from the disk. Also, your program will read and write files with any computer or disk system, as long as it's running under CP/M.

One of the wonderful things about CP/M is that you can write programs in 8080 assembly language, which will do almost anything you want with the disk drives—*without* having to know anything about tracks, sectors, or anything else of a technical nature. All you really have to understand are records and files.

Files. From a user's viewpoint the fundamental unit of information of a disk is a "file". You're already familiar with files and how they're named, such as "test1.ddt". A file is simply a lot of bytes stored on the disk and can be almost as small or as large as you want it to be. Minimum size is 256 bytes, and maximum is more than 8-million bytes!

Because CP/M can handle very large files, it must be able to break them into smaller sections to fit the computer's memory, which is much smaller than the 8-million-byte maximum and smaller than the space on a typical hard or 8" floppy disk. A typical computer has 65,536 bytes of RAM, some of which is used by CP/M itself and a high-level language like BASIC (if needed), which makes much less than the 64K maximum RAM available for file space. All told, then, there may be no more than a few thousand (or hundred) bytes left over for storing data from the disk. So, a file is broken down into smaller units called "records," only one of which is loaded into memory at any one time.

Record. CP/M uses a fairly small record of 128 bytes.

Talking to BDOS. When it's reading or writing information from and to the disk, the Basic Disk Operating System (BDOS) uses two areas of memory to communicate with the program calling it—the DMA buffer and the File Control Block (FCB), as shown in Fig. 9. Understanding the DMA and FCB and how they're used is the key to understanding CP/M disk system calls. DMA and FCB are located at 005C and 0080 in memory, just below the start of TPA at 0100. This puts it in the "zero page" portion of memory, which starts at 0000H and ends at 00FFH.

DMA Buffer. When you want to read (load) a file from disk into memory, you set aside a 128-byte place in memory called the "DMA buffer". (DMA stands for Direct Memory Access.) The DMA buffer is usually located at memory 80H, which is called the *DMA Address.*

Once the DMA buffer is set up, the first record of the file is read into this space. When your program has completed its task with this record, it reads the next 128-byte record, processes it, and so forth until the end of the file is reached.

File Control Block (FCB). For CP/M to tell your program what file to read, a way is needed to pass file names from your program to CP/M so that BDOS can take care of the tedious details of finding the record you want, reading it off the disk, and putting it in memory in the DMA buffer. This is simply a 36-byte section of memory where we can put the file name. CP/M also uses FCB to store information about where the file is located and some other things. FCB is usually located at memory address 5C, just below the DMA address.

Disk System Calls. Before a program can read from or write to a file, BDOS must figure out where the file is on the disk, using the "Open File" system call.

Open File. When this call is executed, BDOS finds the addresses of the various parts of the file, called *allocation units,* and records them in FCB for later reference. Since we have only the one FCB at this point, only one file can be open at any one time.

Here's a short program that opens a file using this system call:

```
mvi   c,f    put f in register C for
             Open File
lxi   d,5c   put address of FCB into
             register DE
call  5      call BDOS
cst   7      return to DDT
```

Type this program in using DDT and save it as "test100.ddt". When you execute it with a -g100, you should hear your disk drive click and see DDT print out the usual asterisk and ending address (*010B).

You've just told BDOS to open the file whose name is in FCB. We don't know what name is in FCB, if any, since we haven't put anything in it ourselves. Whatever is in FCB, even if it's a string of blanks or 0s, BDOS will attempt to find a file by that name. If it finds it, BDOS will open it by recording the numbers of its allocation units in FCB; if not, the drive will still click as BDOS searches the directory for the file name.

It isn't difficult to see what's in FCB. From DDT, type d5c,7f. If nothing's in FCB but 0s, your printout will be as shown in Fig. 10. The first line shows memory locations from 5C to 5F, the second line locations from 60 to 7F. A name would be in here somewhere if there was one. In this case, there's no name.

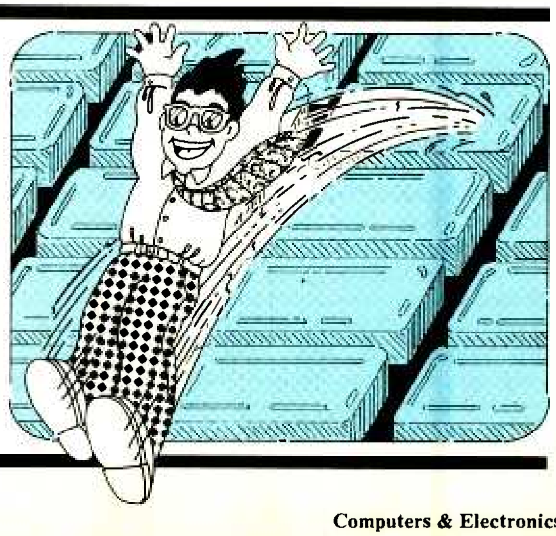
You can always make sure a file name is placed in FCB simply by calling up DDT with the name of another program. For example, assuming you've saved test 100.ddt, you can put its name in FCB as follows. First exit DDT by typing a -g0. Get back into DDT, and at the same time load the new program into TPA at 100H and *leave the name of the program in FCB.* Type "ddt test100.ddt" after the A>. Now look at FCB (Fig. 11). There's the name of the program, starting at location 5D and ending at 64. The numerical ASCII values of the characters are shown on the left, the actual characters on the right. Since TEST100 is only seven characters long, the last space in this eight-space field is filled with a blank (20H) at location 64. File extension DDT occupies locations 65, 66, and 67. If we now run our program with a g100, it will find an existing file—namely, itself—in FCB and open it.

We can tell if the Open File system call has been successful in finding the file whose name is in FCB by making use of the "directory code," which is returned in register A following the call. To use this feature, we must add a few lines to our program to print out the number returned in register A:

```
0100 mvi  c,f
0102 lxi  d,5c
0105 call 5
0108 mvi  c,2    set up Console Out
010A adi  30     add 30 hex to register
                 A to get ASCII
010C mov  e,a    put result in reg E
010D call 5      call BDOS
0110 rst  7      return to DDT
```

Enter this program using the "a" option in DDT, save it as "test101.ddt" and call it back with "ddt test 101.ddt". Run it with a g100. You should read

"Jump to subroutine"



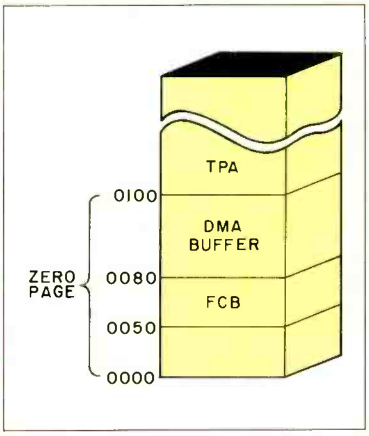


Fig. 9. BDOS uses both DMA and FCB to communicate with the program.

"3*0110" on-screen. The numeral 3 preceding the asterisk and ending address is the number printed out by your program and what was in register A on completion of the Open File call. It might also be a 0, 1, or 2; any of these means that the file whose name was in FCB was found by the Open File call.

Input (i) Command. It would be more convenient to place other file names directly into FCB, without having to enter them when calling DDT. We can, using the "i" (for input) command. Suppose you have a program on-disk called TESTPROG.TXT and you're already in DDT and want to put this name in FCB. To do so, simply type "itestprog.txt".

Let's see if this really works. First, use the Fill command to put FFs in FCB to make sure there's nothing in it. Then use "i" to fill in a program name, as in Fig. 12. Notice that bytes 0 and 12 at locations 5C and 68, which are the drive number and *current extent*, are zeroed out by the "i" function. A 0 drive number stands for the default drive, which is the one we're on unless otherwise specified. The current address is 0 unless we're reading from a file more than 16,384 bytes long.

You can check to see if your Open File program can find a program on the disk. Use "i" to insert the name of your program and then run it:

```
-itestprog.txt   existing program name
-g100
-3*0110          3 means it was found
-
```

If the name was successfully found, the program would print out a 0, 1, 2, or 3. If you had typed in a name that doesn't exist on the disk, the printout on line three would have been "/*0110", with the slash indicating a failure to find the requested file name.

After opening a file, we want to read it into memory so that it can be examined, printed out, and sent to the desired destination by your program. We also want to be able to do this from DDT, because the "i" makes it easy to set up FCB for a particular record. Unfortunately, there's a small problem with using DDT at the same time DMA is used in its normal location, from 80 to FF, because DDT uses this area for its stack. The two areas can't occupy the same place at the same time.

An easy solution to this dilemma is to read only very short records into DMA. Since DDT's stack grows downward from FF and records are read into DMA's buffer at 80, moving upward toward FF, use of short records can avoid conflict.

Create a very short record by calling up a word-processing program and typing in some characters. Don't type more than an 80-character line. End your line with a RETURN and save it as "short.txt". This is a one-record file, which will show up in the directory as a 2K file but will actually occupy a single 128-byte record space.

Read Sequential Record. This system call looks a bit like Open File, except that it reads a *record* instead of a whole file. With it, you can start off reading the first 128-byte record in a file and proceed through each sequential record until the end-of-file is reached. The call knows when an end-of-file is reached in either of two ways. It can find an "end-of-file" mark in the file (possible only with text files), which is a 1A.

The second and more important way is for Read Sequential Record to keep track of how many records it has read so that it knows if it has read the last record. Since CP/M keeps track of how many records are in a file and stores this information in FCB when the file is opened, this is fairly simple to do. The total number of records in a file is stored in byte 15 decimal of FCB, and the number of the next record to be read is stored in byte 32. By comparing these two numbers, Read Sequential Record knows when it has read the entire file.

If Read Sequential Record finds an end of file, it sets register A to a non-0 value on its return. Otherwise, register A is set to 0, for a successful read.

Reading a Record. Here's a routine to read into DMA the record we created above:

```
-a100
0100 mvi  c,f     open file
0102 lxi  d,5c    set FCB address
0105 call 5       call BDOS
0108 mvi  c,14    read record
010A lxi  d,5c    set FCB address
010D call 5       call BDOS
0110 rst  7       return to DDT
-save test 102.ddt
```

```
-d5c,7f
005C 00 00 00 00 ....
0060 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ................
0070 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ................
```

Fig. 10. Printout of FCB when there's nothing in it.

```
-d5c,7f
005C 00 54 45 53 .TES
0060 54 31 30 30 20 44 44 54 00 00 00 00 00 00 00 00 T100 DDT........
0070 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ................
```

Fig. 11. Program in FCB that was saved under test 100.

```
-f5c,7f,ff
-d5c,7f
005C FF FF FF FF .....
0060 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ................
0060 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ................

-itestprog.txt

-d5c,7f
005C 00 54 45 53 .TES
0060 54 50 52 4F 47 54 58 54 00 FF FF FF FF FF FF FF TPROG..........
0070 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ................
```

Fig. 12. Using the input command to place file names in FCB.

Before running this program, you must be sure that (1) your file SHORT.TXT file is on-disk and (2) that you've put the name of this file into FCB by typing "ishort.txt" from DDT. Run the program with a -g100. The disk drive should click. Type a "d" to look at the DMA buffer, which should display what is shown in Fig. 13 when the buffer's contents are dumped.

The record ends on line 00C0 with the codes for carriage return and linefeed (0D and 0A). Anything after this can be whatever happened to be contained in the buffer before the record was read in, although you could guarantee 0s as shown by using "f" to fill the buffer before executing the program. Note that, following a string of 00s, some hex numbers appear on line 0F00; these numbers are inserted by the DDT stack process.

Up to this point, we're safe only if we are dealing with very short records. What we need now is a way to avoid the conflict that results when the DMA buffer and the DDT stack try to share the same space. CP/M offers a solution with the Set DMA Address system call.

Set DMA. This system call is easy enough to use:

```
mvi c,1a   set up for Set DMA Address
lxi d,400  move DMA address to 400
call 5     call BDOS
```

We choose 400 hex as the new DMA address simply because it's high enough in memory so that it won't interfere with our program at 100 hex. We could put DMA anywhere we want as long as it doesn't interfere with our program or the CP/M operating system (or DDT if we're using it).

Let's incorporate these program lines into our read record program:

```
0100 mvi  c,f    open file
0102 lxi  d,5c
0105 call 5
0108 mvi  c,1a   set DMA address to
                 400
010A lxi  d,400
010D call 5
0110 mvi  c,14   read record
0112 lxi  d,5c
0115 call 5
0118 rst  7      return to DDT
-save test 103.ddt
```

Use this program to read in the first record of any file you want, no matter how long it is, as follows:

1) Load the program with DDT with "test103.ddt" after the A>.

2) Put the file name of the program you want to look at in FCB with "-iprogname.ext." (fill in the name of the file you want).

3) Run the program with a -g100.

4) Check DMA buffer with a -d400 to see that what was in the record was read in correctly.

If you wish to read a more-than-one-record file, simply repeat steps 3 and 4. Each time you execute the program, a new record will be read into the DMA buffer, where you can look at it with a -d command. Any record can be examined this way, whether it contains text, hex values, or whatever.

Two things are missing from our program—the checks to see if the file we're opening exists and if the record we've read is valid or an end-of-file. Modify the program so that it prints out the directory codes in register A, first when it returns from opening the file and then when it returns from reading the record:

```
-a100
0100 mvi   c,f    open file
0102 lxi   d, 5c
0105 call  5
0108 mvi   c,2    print resulting
                  directory code
010A adi   30
010C mov   e,a
010D call  5
0110 mvi   c,1a   set DMA to 400

0112 lxi   d,400
0115 call  5
0118 mvi   c,14   read record
011A lxi   d,5c
011D call  5
0120 mvi   c,2    print resulting
                  directory code
0122 adi   30
0124 mov   e,a
0125 call  5
0128 rst   7      return to DDT
-save test104.ddt
```

With this program, we can tell if the file we're trying to read exists and if we've read a valid record or an end-of-file. Let's try this program on "short.txt" we created before. Load it with DDT and then set up FCB with the "i" instruction and run the program:

```
-ishort.txt
-g100
30*012B
```

The 30 on the last line is interpreted as follows: 3 (or 0 or 1 or 2) informs us the file was found; 0 tells us the record was correctly read. Now we can dump the contents of DMA to see that the record is really there (Fig. 14). If we attempt to read the next record of this file, we find that a directory code of 1 (in the 31 on the bottom line) is returned, indicating an end-of-file:

```
-g100
31*012B
```

Continuing to attempt to read records from the file will yield the same result.

Try this program on some existing and nonexistent files. Check the contents of DMA with the "d" command before and after reading a nonexistent file. They don't change because there's nothing in the file. Read a file with a

```
-d80,ff
0080 4E 6F 77 20 69 73 20 74 68 65 20 74 69 6D 65 20 Now is the time
0090 66 6F 72 20 61 6C 6C 20 67 6F 6F 64 20 6D 65 6E for all good men
00A0 20 74 6F 20 63 6F 6D 65 20 74 6F 20 74 68 65 20 to come to the a
00B0 61 69 64 20 6F 66 20 74 68 65 69 72 20 63 6F 75 id of their coun
00C0 6E 74 72 79 2E 0D 0A 00 00 00 00 00 00 00 00 00 try.............
00D0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ................
00E0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ................
00F0 00 00 00 00 00 00 00 00 C1 D6 9B D4 42 D4 44 00 ................
```

Fig. 13. Contents of the DMA buffer.

```
-d400,47f
0400 4E 6F 77 20 69 73 20 74 68 65 20 74 69 6D 65 20 Now is the time
0410 66 6F 72 20 61 6C 6C 20 67 6F 6F 64 20 6D 65 6E for all good men
0420 20 74 6F 20 63 6F 6D 65 20 74 6f 20 74 68 65 20 to come to the a
0430 61 69 64 20 6F 66 20 74 68 65 69 72 20 63 6F 75 id of their coun
0440 6E 74 72 79 2E 0D 0A 00 00 00 00 00 00 00 00 00 try.............
0450 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ................
0460 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ................
```

Fig. 14. Another dump of the DMA buffer.

```
-d80,ff
0080 41 42 43 44 45 0A 0D 1A 51 01 CD 8C 00 C3 51 01 ABCDE...Q......Q.
```

Fig. 15. The DMA buffer shows the first record of a file.

fairly small number of records and observe how DMA changes for each succeeding record. Observe the directory code change from a 0 to a non-0 value when the last record is reached.

Using this program with the DDT dump function, you can explore how a variety of files are stored on the disk. You can see what the contents of your files really are, rather than what your applications programs tell you they are.

Writing to Disk: The next area we'll cover is that of random records, where "random" means that it's possible to read from and write to *any* file without starting at the beginning and reading all records until you get to the one you want.

To read a record from a file, you must first use the Open File system call to tell BDOS from what file you want to read (the file name passed in FCB) and figure out where the various records of the file are so they can be easily accessed by subsequent Read system calls. BDOS then writes the locations of the records in FCB in the area called "allocation units."

When we want to *write* a new file, the procedure is somewhat different. Since the file doesn't yet exist, it can't be opened but must be "made." To do this, we use the Make File system call.

Make File system call records the new file name in the disk directory so that BDOS knows what to do with subsequent Write Record system calls. Using Make File assumes that the file whose name is being made doesn't already exist. If a name does exist, CP/M won't allow you to make another file with the same name.

Make File is similar in format to Open File. The returned directory code is different in that a value of FF, meaning "unsuccessful," is returned only if the directory is full—a rare occurrence. Otherwise, a 0, 1, 2, or 3 will be returned as in Open File.

Write Sequential Record. Before the Write Sequential Record system call can be used, several conditions must be met:

1) The name of the file to be written must be in FCB.

2) The file must have been initialized with a Make File call. (It's also possible to use the Write Sequential call with an *existing* file that has been initialized with an Open File call.)

3) The record to be written must be in the 128 (hex) byte DMA buffer. If the DMA buffer isn't in the usual (default) position at 80 hex, a set DMA system call must be issued to put it in the appropriate place in the system.

The format of the Write Sequential system call is similar to the Read Sequential Record call. The directory code returned in register A is different in that a non-0 value indicates the disk is full.

Like the Read Sequential system call, Write Sequential writes to the first record of the file the first time it's called, writes to the second record the second time it's called, and so on.

CR Byte is number 32 in FCB and is located at memory location 7C in Fig. 9 (if FCB is in its usual place). The purpose of this byte is to keep track of what record is currently being written from (or read to) by a sequential write (or read) operation. When you execute a call to the Sequential Write system call, the record in the DMA buffer will be written to the record number in this cr byte. After either a write or a read operation, the number in cr is incremented so that the next record will be written to the next record in order.

This byte is typically set to 0 by the user at the same time the file is opened (made) so that the first record will be written into record 0, the second into record 1, and so on. You might be wondering what happens if a file has more than 256 records, since this is all that can be described in a single byte. When the cr byte overflows (goes from 127 to 128 decimal or from 7F to 80 hex) a new "extent" is automatically opened. The reason why overflow doesn't occur at 255 instead of 127 records has to do with allocation units, sectors, and the way records are stored on the disk.

Extents. An extent is 128 records. Extents are necessary because of the way CP/M keeps track of where the various records of a file are stored on the disk. The cr byte in FCB is incremented each time a record is read or written sequentially, until the value in cr reaches 127 decimal, at which point a new extent is opened. This means that the value in cr is reset to 0 and another byte in FCB is incremented—the "ex" or "current extent" byte, which is number 12 and is located at address 68 hex. This byte, too, is normally set to 0 when a file is first made or opened for sequential operations.

After you've opened, or made, a file and started writing to it with Write Sequential calls, BDOS takes care of figuring out where on the disk each record is to be written. This "map" of the disk showing where the various records of a file are stored is kept in memory as long as the file is currently being written to (open). If you don't close a file before powering-down your computer, this mapping information will be irretrievably lost. To make sure this doesn't occur, use the Close File system call.

Close File. When Close File is executed, CP/M takes the mapping information, temporarily stored in memory, and writes it onto the disk in a region called the "disk directory." When you next try to read this file, BDOS looks for the file name in the disk directory and writes the information it finds there back into memory, which is accomplished with the Open File call.

Sequential Record Program. We're now ready to put together the three system calls just described into a program to write something to the disk:

```
-a100
0100 mvi   c,1a   set DMA address
                  to 400
0102 lxi   d,400
0105 call  5
0108 mvi   c,16   make file
```

"Jump on zero"

```
010A lxi   d,5c
010D call  5
0110 mvi   c,15   write file
0112 lxi   d,5c
0115 call  5
0118 mvi   c,10   close file
011A lxi   d,5c
011D call  5
0120 rst 7        return to DDT
-save test105.ddt
```

Before we can execute this program from DDT, there are a number of things that must be done. First, make sure there's no file on your disk with the name "newfile.txt." Next, insert the file we're going to be creating into FCB, using the "i" operation. Third, we must put something in the DMA buffer so that we can write it onto the disk, using the "s" operation.

Call test105.ddt after the A > prompt. Then type in the following:

```
-inewfile.txt        put file name in FCB

-s400
0400 08 41           ASCII values for: A
0401 DC 42           B
0402 D3 43           C
0403 01 44           D
0404 67 45           E
0405 3A 0A           linefeed
0406 00 0D           carriage return
0407 53 1A           end-of-file mark
0408 9F
```

In this listing, the second column is whatever was already in the buffer; the third column is the numbers you type in. We end our message with a carriage return and a linefeed so that when we print out the record it won't be overprinted by the next line. Most importantly, the last character of our record is an end-of-file mark (1A hex) to tell BDOS that the record is finished when we go to read it back.

Run the program and then exit to CP/M to see if the file is in the directory:

```
-g100
*0120
-g0
A > dir newfile.txt
A: NEWFILE.TXT
```

So far, so good. Now, let's see what's really in the record, using CP/M's TYPE function:

```
A > type newfile.txt

ABCDE
A >
```

There it is! This is the first file you've written to the disk with your own program.

There's another way to examine the contents of newfile.txt to see if it's really there. Call up DDT along with newfile.txt by typing "newfile.txt" after the A > prompt. When DDT is loaded, dump the DMA buffer, which is where the first record of a file is loaded, when the file is called with DDT (see Fig. 15).

"Jump on not zero"

Random Records. If you want to read or write a file sequentially from beginning to end, you use the Read Sequential and Write Sequential system calls. These calls can also be used if you want to read or modify a record in the middle of a file, although the procedure would be cumbersome because of the way record numbers are specified in FCB. The special byte in FCB that indicates what record is currently being written is used for this operation.

When 127 decimal records have been written, the byte in FCB overflows and is reset to 0 and another byte (the current extent byte) is automatically incremented. Because of the need for two separate bytes to specify what record you want, disk access to a particular record is somewhat more awkward than it might be. For instance, if you had a program that wanted to read the 300th record in a file, it would have to first figure out what extent this record is on by dividing 300 decimal by 128 decimal, which results in 2 with a remainder of 44. Your program would have to set the extent byte to 2 and the current record byte to 44 (2C hex). This isn't impossible, but it does complicate things. So, starting with release 2.0 of CP/M, Digital Research has provided a set of system calls that use a single 16-bit value to specify the record number.

Bytes 33, 34, and 35 at locations 7D, 7E, and 7F constitute the "random record number" and are called r0, r1, and r2, respectively. The last byte, r2, isn't used in CP/M but is used in MP/M. In CP/M, it must always be set to zero to avoid generation of error messages. Bytes r0 and r1 constitute the 16-bit record value (see Fig. 16), r0 representing the least-significant and r1 the most-significant byte.

Using random reads and writes requires one more step than for sequential reads and writes. The program must place the 16-bit number of the record to be accessed into r0 and r1 before the read or write takes place.

Random Read. When BDOS executes the Read Random system call, it first looks at the record number in r0 and r1 to determine what record the program wants to read. It then figures out what extent the record is in and the record number in the extent and sets these bytes in FCB. Then it reads the record just as with the Sequential Read Call.

An important difference between a random and sequential system call is that the former does *not* automatically advance the record number each time it's called. So, if you do a Random Read, followed by another Random Read, you'll be reading the same record twice unless your program has incremented the random record number in r0 and r1 before the second read.

Since Random Read automatically sets the current-extent and current-record bytes in FCB, you could then do a Sequential Read to read the same record again, followed by subsequent records, if you wished. This gives you the capability to plunge into the middle

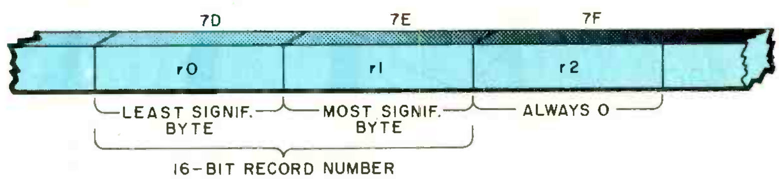


Fig. 16. Bytes r0 and r1 constitute the 16-bit record number.

of a record with random access and then read a number of records, starting at that point, with sequential access.

The Return Code returned in register A following this call can have a number of non-0 values, depending on the type of error encountered. These include: 01 attempt to read unwritten data block; 04 attempt to read unopened extent; and 06 attempt to read past end of disk (r2 not set to 0).

Here's a short DDT program for reading a random record:

```
-a100
0100 mvi   c,1a   set DMA to 400
0102 lxi   d,400
0105 call  5
0108 mvi   c,f    open file
010A lxi   d,5c
010D call  5
0110 mvi   c,21   read random
0112 lxi   d,5c
0115 call  5
0118 mvi   c,2    print error code
011A adi   30
011C mov   e,a
011D call  5
0120 rst   7      return to DDT
-save test106.ddt.
```

Bring this program back into memory with DDT. Use "i" to set the file name of a file you know has a number of test records in it. Then use "s" to set a record number in r0 and r1 that you know is in the file. In other words, don't make the record number so large that it doesn't exist—if sample.txt is 12 records long, put in a smaller number:

```
A > ddt test106.ddt

-is ample,txt    a file you know has
                 more than three
                 records
-s7d
007D 00 03       least significant two
                 digits.
007E 00 00       most significant two
                 digits
007F 00 00       always 0
0080 00
```

Column two contains whatever was there to start, while column three contains the numbers you enter. Execute the program and then examine the DMA with a d400 to see what has been read into memory. Now change the r0 byte in 7D to some other record number, like 2 or 4. If you have a file you know is longer than 256 records, you can change both r1 and r0. For record number 350, for example, you'd convert to hex number 015E and then put 5E into r0 and 01 into r1 at locations 7D and 7E, respectively.

Read a number of records by changing the record number and observe what happens. Ordinarily, the return code printed out by the program will be 0, but if you attempt to read a nonexistent record, you'll get one of the codes referred to above.

Write Random. This call is similar to Read Random except, of course, that the record to be written must already be in the DMA buffer. Error codes are the same, too, except that there is the additional 05 that indicates that a record cannot be written due to directory overflow.

As with Random Read, the current record and current extent bytes are changed to correspond to the random record number given, but none of these numbers is incremented.

Writing to a New File. Here's a short DDT program that demonstrates how the Write Random call can be used. Because this program assumes that you want to create a new record, it uses the Make File system call. Note that it's necessary to close the file after writing to it.

```
-a100
0100 mvi  c,1a   set DMA to 400.
0102 lxi  d,400
0105 call 5
0108 mvi  c,16   make file
010A lxi  d,5c
010D call 5
0110 mvi  c,22   write random
0112 lxi  d,5c
0115 call 5
0118 mvi  c,2
print return code
011A adi  30
011C mov e,a
011D call 5
0120 mvi  c,10
close file
0122 lxi  d,5c
0125 call 5
0128 rst  7
return to DDT
-save test107.ddt.
```

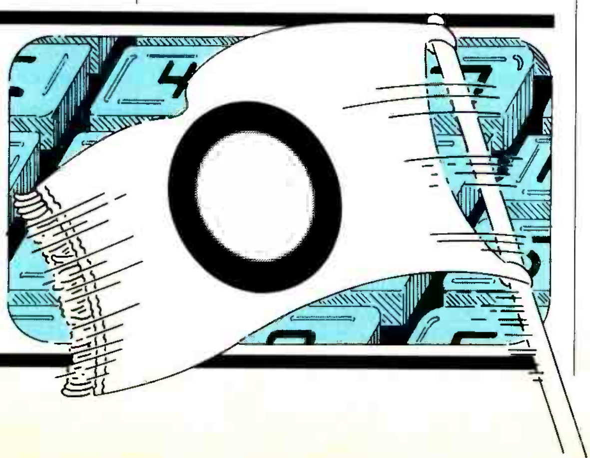
Load this program in with DDT and use "s" to fill the DMA buffer from 400 to 47F with whatever ASCII characters you want. Since we're starting a new file, we assume we're going to write to the first record, whose number is 0000. So, use "s" again to fill in 0 values in r0, r1, and r2. Then use "i" to set the name of the new text file (you can call it newfile2.txt) into FCB, and then run the program. Exit from DDT and check the directory to see if the new file is there. Print it out using TYPE; it should be the same as whatever you put in the buffer.

Writing to an Existing Record. If you want to write to an existing record, you must use the Open File system call, instead of Make File, just as you did with sequential writes. Here's how to modify the program to do this:

```
-a100
0100 mvi  c,1a   set DMA to 400.
0102 lxi  d,400
0105 call 5
0108 mvi  c,0f   open file.
010A lxi  d,5c
010D call 5
0110 mvi  c,22   write random
0112 lxi  d,5c
0115 call 5
0118 mvi  c,2    print return code
011A adi  30
011C mov e,a
011D call 5
0120 mvi  c,10   close file
0122 lxi  d,5c
0125 call 5
0128 rst  7      return DDT
-sav  test108.ddt.
```

Reload this program using DDT and try it out, using the same steps as in writing a New File. As with the Read Random call, you must be sure that the record number you put in r0 and r1 actually exists.

"Zero flag"



In Conclusion. In this part, we've introduced CP/M's disk calls, limiting our discussion to only the basic calls and operation from the DDT utility. In the concluding part of this series, we'll discuss CP/M's Basic Input/Output System (BIOS), which constitutes the innermost Soul of CP/M. ◇

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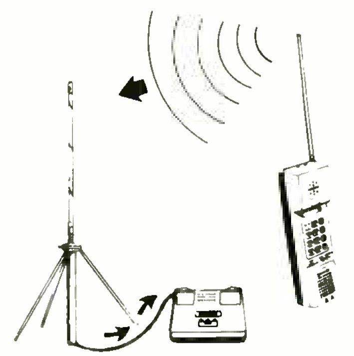

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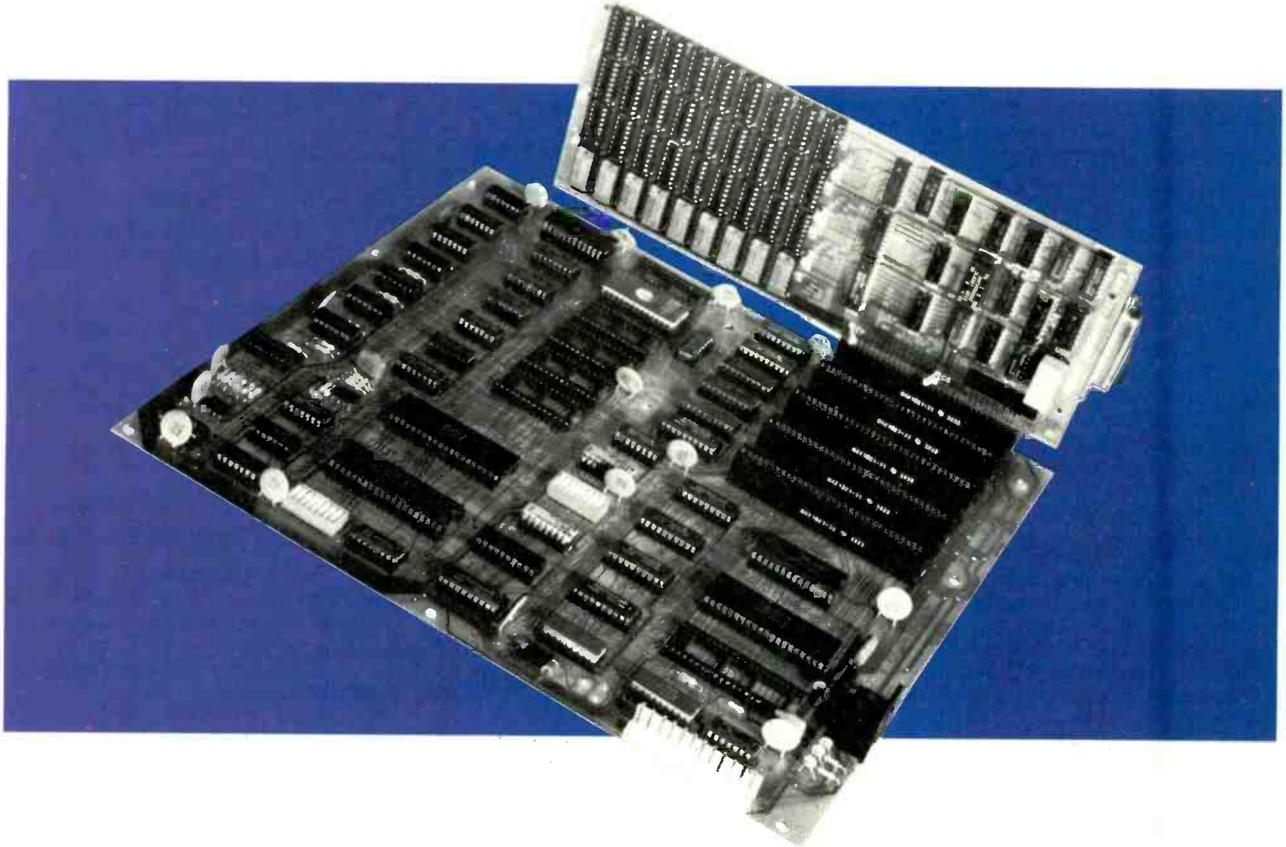
16-BIT MICROCOMPUTER TECHNOLOGY

Part 5: The Dynamic RAM and Asynchronous Communications Port

By George Meyerle



THE fifth part of our series on the construction of an 8088-based micro-computer compatible with the IBM-PC wraps up our discussion of the major circuit elements of the system.

64/256K Dynamic RAM Section. The use of dynamic RAM in open bus systems has caused many problems in the past. The IBM approach, however, uses the system board to control refresh via the DMA controller plus the addition of a 9th bit for parity-error testing. Hopefully, this puts to rest the objections of even the most critical skeptics. The only negative point is that, due to refresh requirements, the system is slowed down by about 7%.

To better understand the concept of dynamic RAM, let's examine the principal elements of a RAM chip (Fig. 24). The 64 RAM chips used in this design are organized as 64K by 1 data bits. The memory cells actually consist of 65,436 tiny capacitors (arranged in a 256-row by 256-column matrix), with one capacitor for each memory location. When a capacitor is charged up, the cell is considered to be storing a "one", when a capacitor is discharged, the cell is storing a "zero." Since the capacitor is not perfect, it will eventually lose its charge, thus changing the value of the stored data. This is of course, unacceptable and is prevented by *refreshing*, which is simply a system of recharging or discharging the capacitors periodically before the data values change.

The RAM chips, using sense/refresh amps, automatically refresh an entire column of addresses during a row address read. Each row is read every 2 ms by the DMA controller, which performs a dummy read every 15 μs on a different (1 of 256) row address. Note that 16 address lines are necessary to address 64K bits and that the RAM chip has only eight address inputs, labled MA0 through MA7. This means that the memory board must multiplex the 16-bit address bus into two 8-bit slices and generate address strobe signals RAS and CAS (row and column address strobes), which are used to latch first the row address and then the column address into the RAM chips.

Referring to Figs. 25 and 26, you'll note that RASON and $\overline{\text{CASON}}$ are generated during all memory read or write cycles. $\overline{\text{CASON}}$ is delayed by 100 ns relative to RASON and continues 20 ns after RASON. The 60-ns $\overline{\text{ROW}}$/COLUMN delay output controls the address multiplexer logic, which presents the RAM chip with first the row addresses and then the column addresses. These addresses are then latched into the RAM chip logic by the $\overline{\text{RAS0}}$ through $\overline{\text{RAS3}}$ and $\overline{\text{CAS0}}$ through $\overline{\text{CAS3}}$. The CAS signals, which are not required during refresh (to save power), also act as a chip select, enabling the read and write functions.

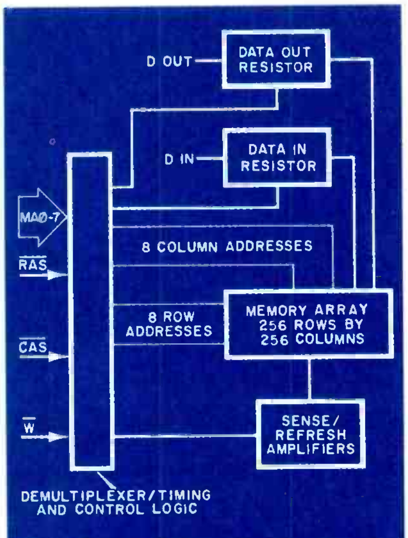


Fig. 24. The principal elements of a dynamic RAM chip.

Refreshing occurs even if the board is not addressed because $\overline{\text{DACK0}}$, which is generated by the DMA controller, generates the $\overline{\text{RFSH}}$ signal, which acts as the $\overline{\text{RAS}}$ signal during refresh. $\overline{\text{RAS0}}$ through $\overline{\text{RAS3}}$ and $\overline{\text{CAS0}}$ through $\overline{\text{CAS3}}$, are only generated when the board and corresponding memory bank (0 through 3) are selected. When writing to RAM a parity bit is generated by the 74LS280 (9-bit parity generator/checker), which is written to RAM as a ninth data bit. When the data is read, the parity bit is checked by the 74LS280, which forces the entire system to stop if a parity error has occurred. The RAM chips are read during the rising edge of $\overline{\text{RAS0}}$ through $\overline{\text{RAS3}}$ at which time the data must be valid. RAM chips that are slower than 250 ns cannot be used. The actual write timing occurs sometime after $\overline{\text{CAS}}$ and is determined by the RAM chips. All that is required is that the data bus be stable during the write cycle.

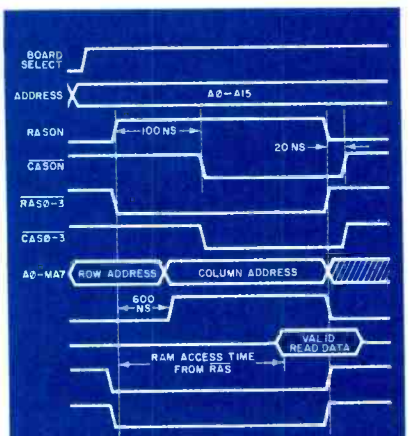


Fig. 25. Timing chart for the 64K dynamic RAM chip.

8250-B Asynchronous Communications Port. The final major circuit block that we'll discuss is the 8250-B asynchronous communications port. This serial I/O port, which is the major link between the computer and the outside world, is part of this kit project, though an option with an IBM-PC.(It's essential if a modem, serial printer, or terminal emulation software is to be used.) The Explorer 88 also has a BIOS program that can be used with either a standard video terminal or an IBM-compatible keyboard and either a color or monochrome video board.

The 8250-B performs serial-to-parallel conversions on data received from peripheral devices and parallel-to-serial conversions on data received from the CPU. The functional characteristics such as the band rate selection, parity generation, error detection, are programmed into the port by the initialization program executed during power-up or system reset.

The monitor program used in the Explorer 88 programs the 8250 to be a standard terminal interface with the baud rate determined by the switch settings on *S1* (see Part 1; Fig. 5). If an IBM compatible keyboard is used, the 8250-B is not initialized until activated by a user program. It is important to realize that the functional characteristics of the 8250-B, being under software control, can be changed at any time by the user. The 8250-B is connected to the system as an I/O port at addresses 3F8-3FF. These are the addresses reserved by IBM for the first of two serial communicastions ports. If you wish to change the port address, it is suggested that you use 1F8-1FF. (Simply invert address line A9 going to the 74LS30 port decoder shown in Part 3, Fig. 16, and add the necessary initializing software.)

To get an idea of just how powerful this chip is, here is a look at some of its features:

- Adds or deletes start, stop, and parity bits to or from a serial data stream
- Independently controlled transmit, receive, line status, and data set interrupts
- Programmable baud-rate generator with 18 steps from 50 to 56000 baud (only supported to 9600 baud by IBM)
- Includes all modem control functions
- Fully programmable serial interface characteristics with 5-, 6-, 7-, or 8-bit characters; even-, odd-, or no-parity bit

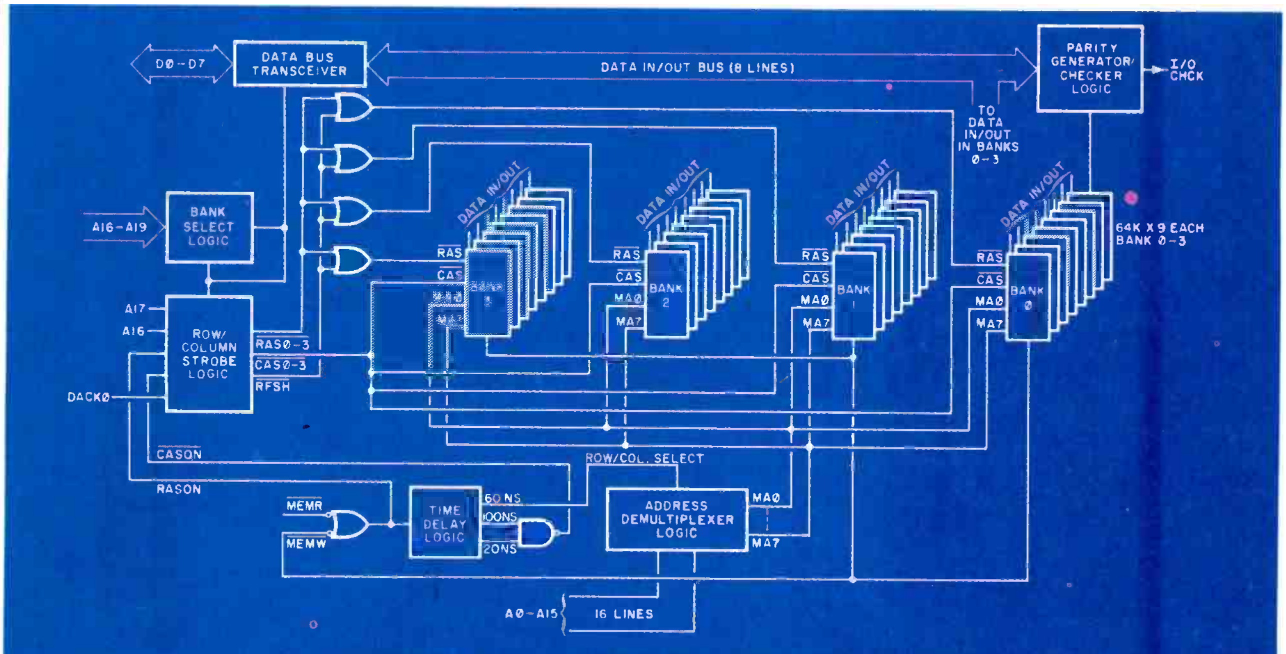


Fig. 26. Distribution of the controls and signals to the four banks of the RAM.

generation and detection; and 1-, 1.5-, or 2-stop bit generation

- Complete status reporting capabilities
- False-start bit detection
- Internal diagnostic capabilities with loopback for link fault detection
- Prioritized interrupt controls
- Requires only a crystal and line drivers to connect to any EIA RS232 peripheral.

Referring to the block diagram of the 8250-B (Fig. 27), the bi-directional data bus is used to load control words, load and receive data, and read status registers. The interrupt line is programmed to go high whenever a key is pressed. This signals the CPU that a character has been entered at the Keyboard. The interrupt line can also be programmed to be active when there is a receiver error, empty transmitter holding buffer, and modem status. The interrupt activity is controlled by the interrupt enable register, which is programmed during system start-up or reset. The $\overline{\text{I/OR}}$, $\overline{\text{I/OW}}$, and address lines A0 to A2 are used to read and write data, control, and status to and from the port. There are eight additional lines that are connected to the RS232 interface drivers. Their functions are as follows:

SOUT: Serial data is outputted to a peripheral via this line. This output, in keeping with the standard for ports that are considered an output type, is connected to *J2*, pin #2 (*J2* refers to the DB-25 connector on the 64K RAM/R5232C port board). Note, however, that a terminal, which is also considered an output type, expects to find data inputted at its pin#3. This means that leads #2 and #3, connecting the terminal to the port, must be flipped or reversed.

SIN: Serial data to the port is inputted via this line. It is connected to *J2*, pin #3.

The remaining six lines are considered control or handshaking signals.

RTS: (*J2*, pin #4, *Request to Send*) This output line, when high, informs the modem or data set that the port is ready to transmit data.

DTR: (*J2*, pin #20, *Data Terminal Ready)* When high, this line informs the modem or data set that the port is ready to communicate and receive data.

DSR: (*J2*, pin #8, *Data Set Ready)* This input signal, when high, informs the port that the modem or data set is ready to communicate. The program tests the contents of the modem-status register, which, when ready, reveals if the modem or data set is ready to communicate and if there has been any change in status since the last reading.

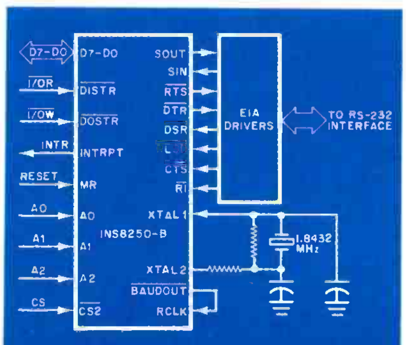


Fig. 27. Block diagram of the 8250-B.

CTS: (*J2*, pin #5, *Clear to Send)* This active-high input signal is a modem-control signal that indicates if the modem will accept data from the port. The modem-control register also records if the input has changed state since the last reading of the register.

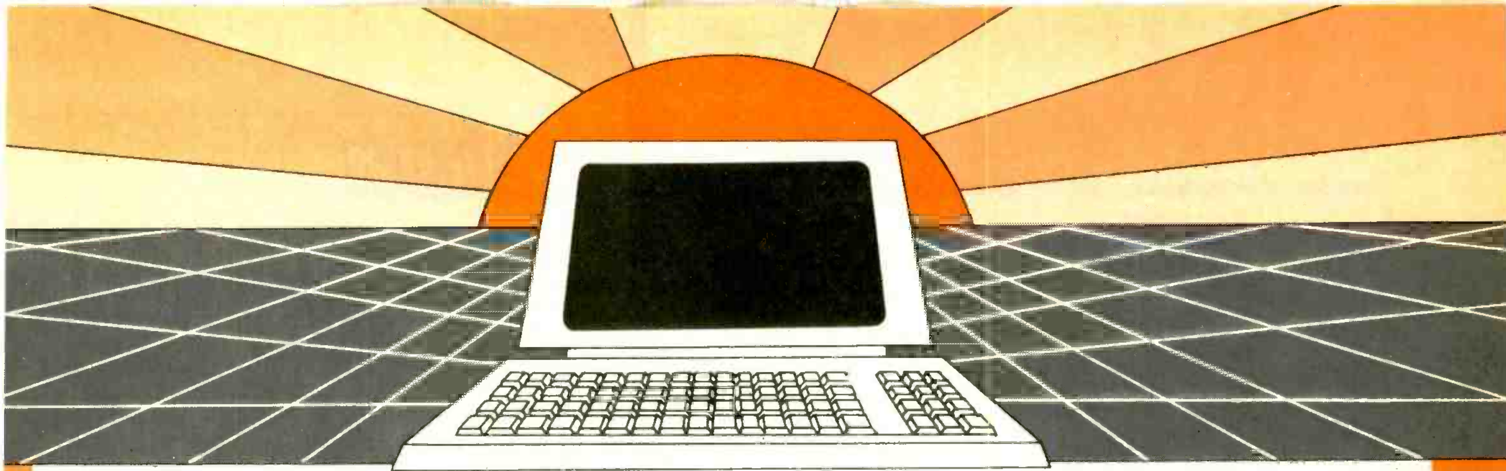
CD: *Carrier Detect (*also referred to as RLSD *Receiver Line Signal Detect)* This active-high signal indicates that the data carrier has been detected by the modem or data set. The status register, as above, reveals both the current status and if any carrier losses have occured since the last reading. The ability to detect carrier loss, is of course, vital when establishing reliable modem communications.

RI: *(Ring Indicator)* This active-high signal indicates that a telephone ringing signal has been received by the modem. The modem status register again reveals if a ring was detected since the last reading of the register.

It is important to remember that the pin numbers are different when connecting this port to devices that are not of an output type. Check the pin designations carefully before making any connections.

This completes our discussion of the major hardware elements of the Explorer 88. In future issues we will discuss other aspects of the system.

(To be continued)



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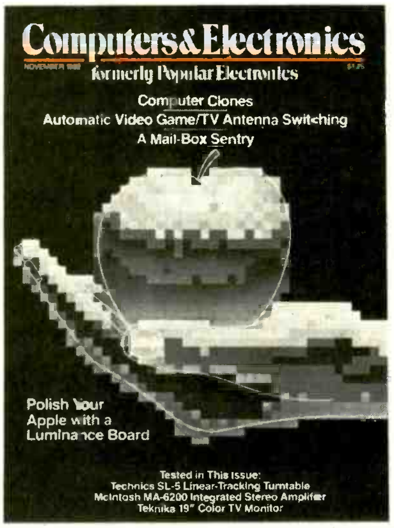

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By Forrest M. Mims, III

A Solid-State Heat Pump

THE only time I ever bridged a couple of leads from a germanium transistor across the poles of a 6-V battery (mistakenly, of course), the transistor became so hot it glowed bright orange. The incident sticks in my mind because I burned my fingers yanking the transistor away from the battery leads.

Excessive heat has always been the scourge of solid-state devices, but there's another side of the solid-state thermal coil. Certain kinds of semiconductor junctions become icy cold when a current is passed through them. Let's examine some of these devices—beginning with one that can burn your thumb while freezing your finger.

The device is a cream-colored wafer a bit larger than a postage stamp and about 4 mm thick. From it emerges a pair of wires, one red and the other black. When these wires are connected to a 6-V battery, one side of the wafer becomes very warm, even hot. Remarkably, the opposite side becomes very cold. If the air is sufficiently humid, frost will appear within seconds.

This extraordinary wafer is known as a *thermoelectric module*. However, it might more appropriately be termed a *solid-state heat pump*. Its operation is completely reversible, too. When the connections to the battery are switched, the hot side of the wafer becomes cold and the cold side becomes hot. Moreover, the module will generate an electric current when its two opposing surfaces are maintained at different temperatures.

The phenomena I've described are collectively known as the *thermoelectric effect*. While most people knowledgeable about electronics know about the heat and power generation aspects of the effect, surprisingly few are aware of the cooling phenomenon.

The cooling ability of a thermoelectric module can be easily demonstrated with the help of some commonly available hardware. Figure 1 is a photograph of the 801-2003-01 module made by the Cambion Division of the Midland-Ross Corporation (Cambridge Thermionic, 445 Concord Ave., Cambridge, MA 02138). An extruded aluminum heat sink and a small aluminum box attach to opposite sides of the module with a rubber band (Fig.2). Heat-sink compound ensures a good thermal bond between the module and the two attachments.

The heat sink, which should be attached to the hot side of the module, is placed in a shallow pan of water. A teaspoon or so of water is then placed in the aluminum box. Within minutes after the module is connected to a 6-V battery, the water in the aluminum box will freeze solid and the box will be coated with a layer of frost. Add more water and the module will produce a cube of ice. The efficiency of this miniature freezer can be increased by making an insulating chamber for the box from foamed plastic panels held together by tape or a rubber band.

Discovery of the Thermoelectric Effect. The discovery of the thermoelectric effect can be traced to 1821 and the German physicist Thomas J. Seebeck. He took two conductors of different materials, connected them to

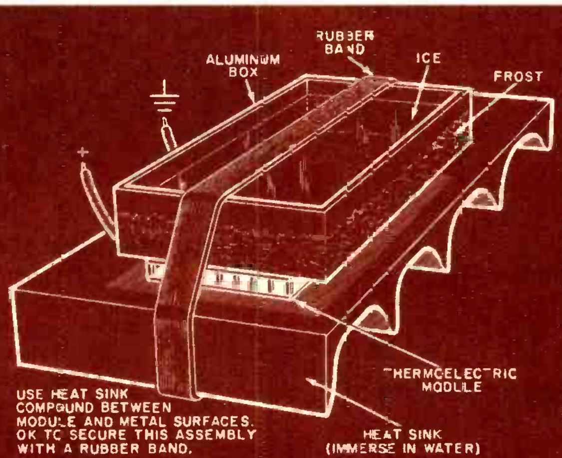

Fig. 2. Simple thermoelectric ice-cube maker.

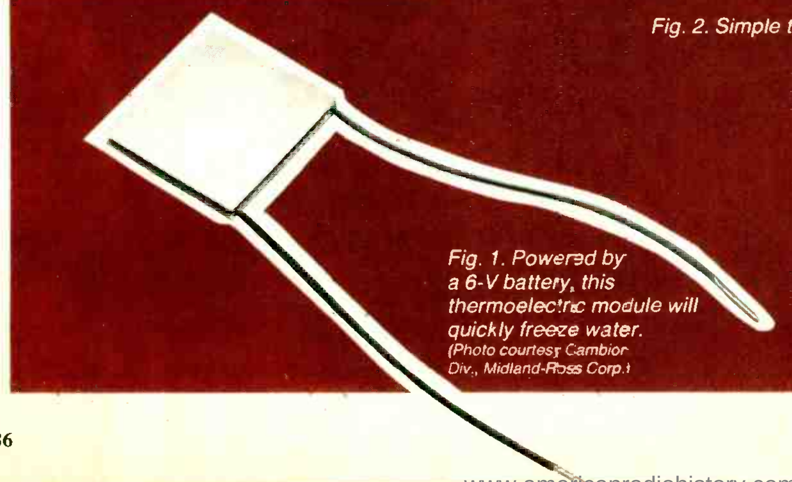

Fig. 1. Powered by a 6-V battery, this thermoelectric module will quickly freeze water. (Photo courtesy Cambion Div., Midland-Ross Corp.)

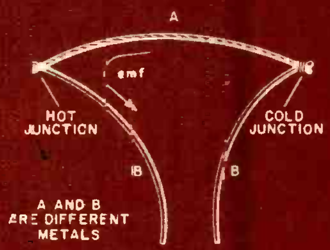

Fig. 3. Construction of a simple Seebeck junction.

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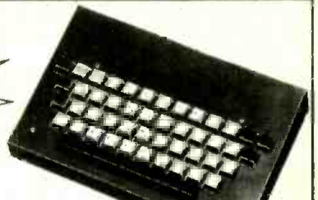

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form two junctions as shown in Fig. 3, and found that if the junctions are maintained at different temperatures, a voltage will appear across the free ends of the conductors. Seebecks's discovery formed the genesis of temperature-sensing thermocouples.

The Seebeck effect can be easily demonstrated using ordinary hardware or even pocket change to make one-half of a Seebeck junction. For example, a homemade thermocouple made by wrapping a few turns of copper wire around one end of a steel nail will generate 6 or 7 μA at a few millivolts when heated by a match. Even more power can be obtained by overlapping the edges of a penny and a nickel and securing the coins together with an alligator clip. After heating the coins with several matches I produced 60 μA at 6 mV.

In 1834, Jean-Charles-Athanase Peltier, a French watchmaker, passed a current through a junction of two dissimilar metals. He found that, depending upon the current's direction, the junction would become warm or cool.

Metal remained the exclusive thermoelectric material for many years. Some of the better thermoelectric junctions are copper-constantan, iron-constantan, and chromel-alumel. Constantan is an alloy of copper and nickel; chromel is an alloy of nickel and chromium; and alumel is an alloy of nickel and aluminum. These and other junctions are widely used today in the manufacture of temperature-sensing thermocouples.

In the Seebeck mode, metal junction thermocouples generate only a few microvolts per degree Celsius. Semiconductor couples may exhibit Seebeck coefficients of hundreds or even thousands of times greater. In the early 1950's, Abram F. Ioffe in the Soviet Union and H.J. Goldsmid in England independently found that semiconductors such as bismuth telluride make excellent thermoelectric materials. Ioffe's group made demonstration power generators and refrigerators. Goldsmid's group made junctions that exhibited a drop of as much as 65° C below room temperature. Scientists in the United States later discovered that lead telluride is also an excellent thermoelectric material.

Semiconductor Thermoelectric Devices. Today most semiconductor thermoelectric devices are based on lead telluride or bismuth telluride. The selection of the alloy depends largely on the preferred operating temperature of the module. For example, one firm employs a quaternary alloy of bismuth, tellurium, selenium and antimony. The alloy is appropriately doped to provide an n-type or p-type semiconductor.

Figure 4 shows the construction of a simple single-junction semiconductor thermoelectric device. The upper ends of the two semiconductor bars are soldered to a common header, and their opposite ends are soldered to separate copper headers to which electrical connections are made. Since practical thermoelectric modules are usually arrays of many such junctions or couples, thin plates of ceramic are attached to both sides of the module to electrically isolate the individual junctions. The ceramic permits reasonably good heat transfer while preventing electrical shorts between adjacent modules.

Referring back to Fig. 4, when a direct current is passed first through the n-type semiconductor bar and then through the p-type bar, heat is pumped from the upper side of the module to the lower side. Conversely, when the polarity of bias is reversed, heat is pumped from the lower side to the upper side.

In either case, the side from which heat is removed rapidly cools while the opposite side becomes very warm. If the heat isn't removed from the warm side, some of it will be radiated and conducted back to the cold side. Eventually the module will reach a point of equilibrium and little or no cooling will occur.

In a practical system, heat can be extracted from the hot side of the module by a forced air blower or a circulating liquid. In both cases, conventional heat sinks and miniature plumbing components can be used.

Commercial thermoelectric modules have more than the single junction shown in Fig. 4. Figure 5, for example, shows an assortment of miniature FRIGICHIP modules made by Melcor (Materials Electronic Products Corp., 990 Spruce St., Trenton, NJ 08648). These modules may have from four to 66 individual couples. They can produce a hot-side/cold-side temperature difference of 67.5° C.

Figure 5 also shows how two module arrays can be stacked or cascaded to achieve a temperature differential of 85° C or more. Three- and four-stage coolers can achieve temperature differentials of 105°C and 125° C or more, respectively. An eight-stage module designed to cool an infrared detector has achieved a temperature drop of 171° C (308°F) below room temperature!

The thermoelectric module in Fig. 1 is a single-stage device having 71 couples. It provides a temperature drop of 60° C or more and has a maximum current rating of 6 A and a maximum forward voltage of 10 V. The unit sells in single quantities for $31.20, but the price drops to $17.80 in quantities of a thousand.

Figure 6 shows a single-stage Cambion module (#801-1029-01) designed to cool dual-in-line ICs. This module

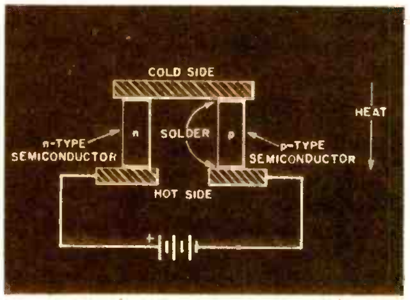

Fig. 4. How a simple single-junction semiconductor thermoelectric device is constructed and energized.

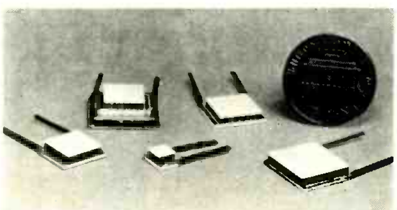

Fig. 5. Miniature single and two-stage Frigichip® thermoelectric modules. *(Photo courtesy Melcor.)*

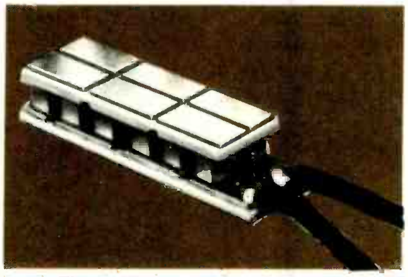

Fig. 6. Thermoelectric cooler to pump heat from dual in-line ICs. *(Photo courtesy Cambion.)*

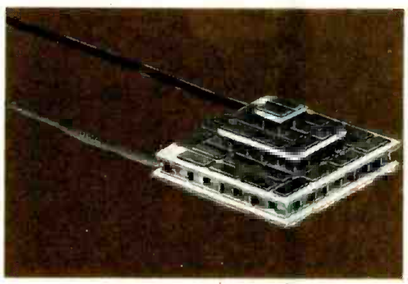

Fig. 7. This 3-stage cooler can give a temperature drop of 115°C or more. *(Cambion photo.)*

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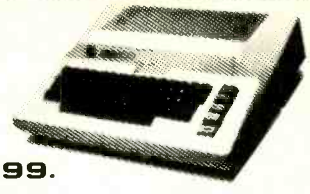

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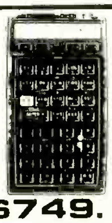

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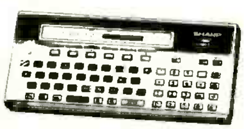

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achieves a temperature difference of up to 60° C or more. It is specified for a maximum current of 7 A at 0.7 V. Individual units are available for $10.40 each. In 1000 lot orders, the cost falls to $5.95.

Figure 7 shows a 3-stage thermoelectric module also made by Cambion (# 801-1006-01). This unit can achieve a temperature drop of 115° C or more. Its maximum operating current is 6 A at 3.2 V. The dark rectangles atop the various stages are copper pads that permit the attachment by direct soldering of additional stages. The copper pads are *not* in electrical contact with the couples beneath them.

Applications. Thermoelectric modules are used in a surprisingly diverse array of applications. Modules such as those shown in Figs. 1, 6 and 7 are used to make solid-state refrigeration and heating systems. One Cambion thermoelectric cooling/heating assembly comes complete with a blower fan and can be used to make a portable refrigerator that can double as a food warmer when the power connections are reversed. Several such systems designed to be powered by the 12-V supply of trucks and cars have been marketed.

Thermoelectric ice makers, baby bottle cooler/warmer units, and even room air conditioners have also been developed. Westinghouse's Advanced Energy Systems Division developed a noise-free 5-ton cooling capacity air-conditioning system for the Navy's *USS Dolphin* submarine. This system consists of ten modules, each measuring 23" × 21" × 4.25" and incorporating 120 couples.

Thermoelectric modules also have many applications in engineering and research. For example, thermoelectric coolers extract excess heat from computer cabinets and microwave waveguides. They also are used to cool laser diodes, far-infrared detectors, CCD imaging arrays, avalanche photodiodes, and photomultiplier tubes. Medical researchers and chemists use thermoelectric coolers to chill and thus immobilize objects and substances being observed with a microscope.

Though still limited to specialized applications, thermoelectric power generators show considerable promise. Several companies in various countries have developed 10-to-100-W thermoelectric generators fueled by propane, gasoline, or kerosene burners. A system designed to power communications systems in remote regions of the Soviet Union delivers 200 W when fueled with 4 to 5 pounds of firewood per hour. Smaller thermoelectric generators installed in the chimneys of kerosene lamps provide power for radio receivers in remote Russian homes.

Many kinds of compact nuclear power generators use thermoelectric modules to convert the heat produced by radioactive decay to electricity. Such generators power remote lighthouse beacons in England, unmanned weather monitoring systems floating at sea and installed at remote sites near the north and south poles, and the electrical systems of various kinds of satellites and space probes. Thermoelectric modules can also convert sunlight into electricity.

Finally, a thermoelectric module can convert alternating current into direct current. The alternating current is passed through a heating element attached to one side of a module. If the opposite side is kept at a cooler temperature, the module will generate a ripple-free direct current.

For More Information. You can find out much more about thermoelectrics by researching the subject at a good library. Specific articles you may find particularly helpful have appeared in *EDN* ("Thermoelectric Coolers Tackle Jobs Heat Sinks Can't," Jim McDermott, May 20. 1980, pp. 111-117) and *Electronics* ("Thermoelectric Heat Pumps Cool Packages Electronically," Dale Zeskind, July 31, 1980, pp. 109-113). The *Encyclopedia Britannica* has a very thorough article on the subject.

Thermoelectric module manufacturers have published helpful literature about their field. By far the most complete reference quide is Cambion's "Thermoelectric Handbook." Specification sheets from Cambion and other manufacturers include helpful design, installation, and application information. Prices for the Cambion modules given above are contingent upon a minimum order of $100. However, Cambion distributors do not necessarily impose an order minimum.

Melcor is another good source of information about thermoelectric modules. Its applications information is very understandable and well illustrated. Best of all are the performance curves for each of the firm's modules. Melcor's modules range in cost from $8.95 to $48 each in small quantities. The company requires a minimum billing of $25.

Before ordering thermoelectric modules, you should first request specification sheets and pricing information from the various manufacturers. In addition to Cambion and Melcor, thermoelectric module manufacturers include Borg-Warner Thermoelectrics (3570 N. Avondale Ave., Chicago, Il 60018) and Marlow Industries, Inc. (1021 S. Jupiter Rd., Garland, TX 75042).

An Easy-to-Use Universal Active Filter

Imagine a single-chip active filter that can be tuned with a single resistor, uses no external capacitors, and simultaneously functions as a lowpass, bandpass and notch filter. Such a filter could save countless hours of design and breadboard evaluation time.

Happily a new generation of such filters is now available. They are collec-

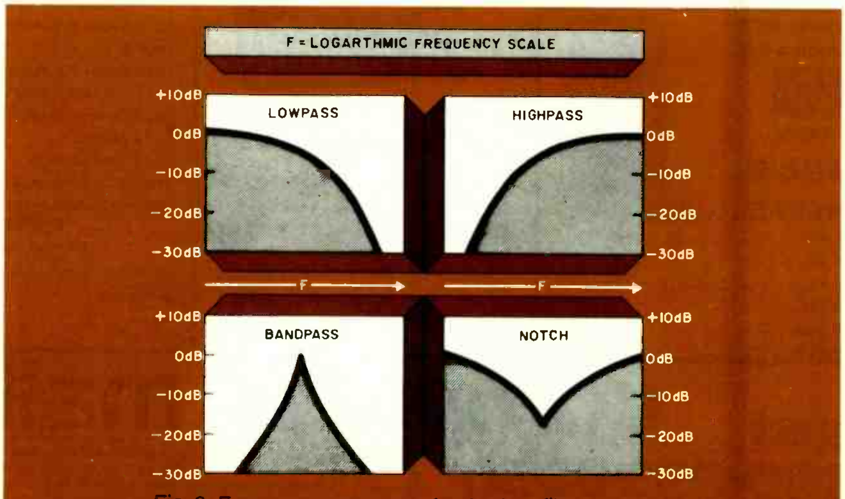

Fig. 8. Frequency responses for the four filter categories.

tively known as *switched capacitor filters*, and their operating paramaters are easily tuned by a few external resistors. *No* external capacitors, the nemesis of conventional active filters, are required.

After I wrote about this topic in the November 1982 installment of "Solid-State Developments," an engineer with National Semiconductor sent some samples of his company's MF-10 universal switched capacitor filter. The MF-10 contains two independent filters in a 20-pin DIP.

To say the MF-10 is easy to use is an understatement. In only a few short hours of bench time, I've used this new chip in as many roles as all the conventional active filter circuits I've built over the past ten years.

Of course conventional active filters have many important applications in both digital and analog circuits. For example, they are used to block undesirable signals and to detect touch-tone and modem signals. In these and many other roles, active filters are far superior to passive filters since they incorporate gain-restoring operational amplifiers.

But, while conventional active filters are exceptionally useful, they can be very tricky to design. If you've never designed one, you might wish to take a quick tour through the pages of any of the many excellent books on the subject. You'll find numerous circuit arrangements, some fairly complex, and enough design equations to wear out your calculator finger.

Even if you successfully wade through the circuits and equations and design you own filter, you will almost certainly find that the first breadboard version you build has a resonant frequency that differs, perhaps substantially, from your design frequency. That's because the resonant frequency of all such filters is only as accurate as the tolerances of the circuit's resistors and capacitors. Precision resistors are relatively cheap and easy to find. But precision capacitors are much more expensive.

All these design drawbacks are overcome by a switched capacitor filter like the MF-10. In this column we'll cover in some detail the operation and use of this device. Then we'll experiment with a tunable MF-10 combination lowpass/notch/bandpass filter. Before finding out how the MF-10 works, however, let's review some active filter basics.

Active Filter Basics. Depending upon their function, most active filters are designated *lowpass, highpass, bandpass* or *notch* filters. The role of the filter is defined by its name. For example, a lowpass filter passes with little or no attenuation all frequencies below a specified cutoff point while blocking all other frequencies. A notch filter attenuates only a very narrow band of frequencies while passing with little or no attenuation those frequencies outside the notch.

Figure 8 illustrates in graphical form the operation of the four basic filter types. Other active filters can also be implemented. For instance, the *allpass filter* shifts the phase of a signal without causing attenuation.

The operation of an active filter is described by a number of terms. Some of the more important ones are:

Passband—band of frequencies passed with little or no attenuation through the filter.

Stopband—band of frequencies attenuated by the filter.

Bandwidth (BW) of a bandpass filter is the difference between the upper and lower frequencies at points 0.707 times the filter's maximum response (−3-dB points).

Center frequency (f_o)—pass and attenuation regions for, respectively, bandpass and notch filters.

Cutoff frequency (f_c)—the point at which the gain in the passband of a filter falls to 0.707 times the attenuated gain (−3 dB point).

Q or *quality factor* of a bandpass or notch filter is f_o/BW. A high Q filter implies a very sharp or narrow frequency response at the center frequency.

Figures 9 and 10 show representative plots of the response of typical lowpass and bandpass active filters made in the conventional fashion with operational amplifiers. Note that the graphs are scaled logarithmically.

Both filters show a 0-dB (gain = 1) response in their passbands. This coincides with a voltage gain of 1. The "ideal" cutoff (Fig. 9) and response (Fig. 10) are included to illustrate that no active filter has a perpendicular cutoff.

The MF-10. The best conventional active filters typically require several op amps, at least two capacitors, and from three to seven resistors. The MF-10 contains *two* completely independent active

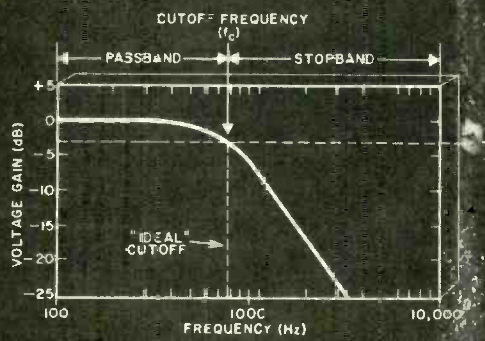

Fig. 9. Lowpass active filter characteristic.

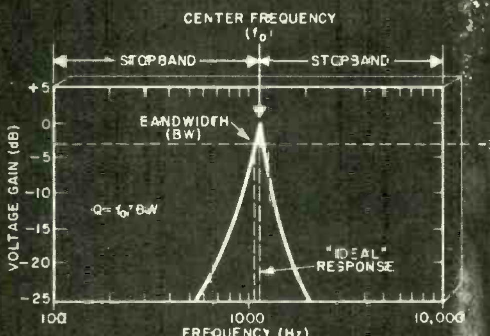

Fig. 10. Bandpass active filter characteristic.

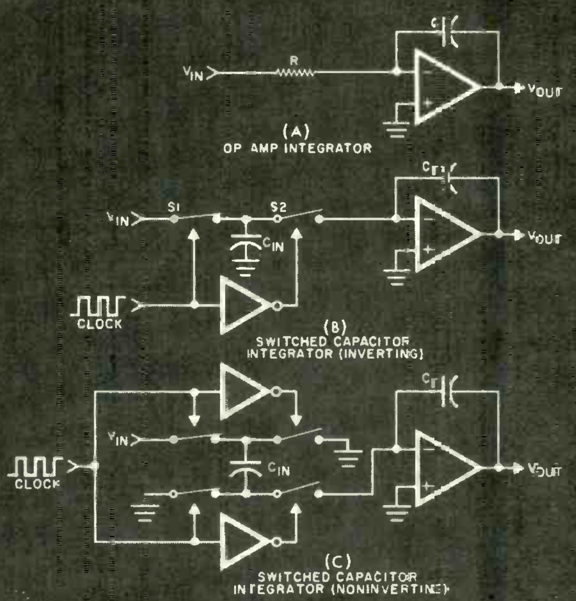

Fig. 11. Three diagrams showing operation of the switched capacitor integrator in the MF-10.

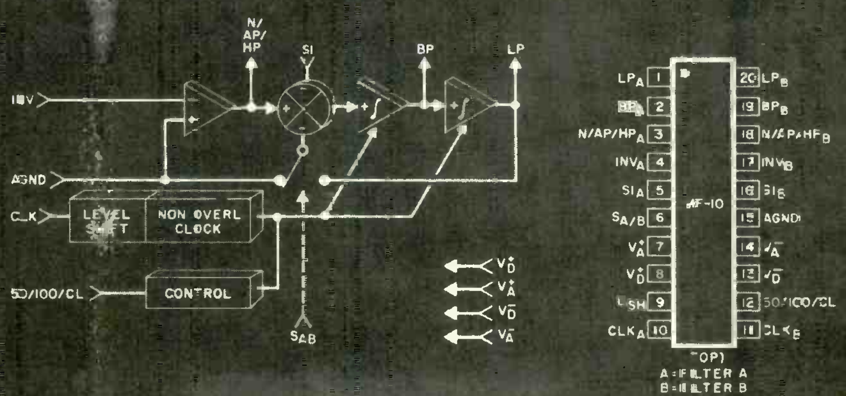

Fig. 12. Block diagram and pin arrangement of the MF-10 active filter.

filters, each of which performs five basic filter functions (lowpass, highpass, bandpass, notch and allpass) with only a few external resistors and no external capacitors—well, almost no capacitors. Unlike conventional active filters, the MF-10 requires an input clock, and clock circuits usually incorporate a capacitor or two. The clock capacitor poses no tolerance problem, however, since the clock's frequency can be easily tuned by changing the value of a single resistor.

The MF-10 is exceedingly easy to use since all five outputs are brought out of the chip. Furthermore, the two second-order filters in a single MF-10 can be cascaded to provide a fourth-order filter. Experienced active-filter designers will be happy to know such classical filter responses as the Butterworth, Chebyshev, Bessel and Cauer are easily implemented with the MF-10.

Another advantage of the MF-10 is its CMOS construction. This is why its typical power-supply current demand is only 8 mA. The supply voltage can range from ±4 to ±7 V when operated from a dual-polarity supply and 0 to +10 V when operated from a single-polarity supply.

Finally, as we'll observe firsthand in the test circuit that follows, the MF-10's response is easily tuned across a wide spectrum by simply varying the clock frequency. In applications requiring a precisely controlled notch or bandpass, the clock can be crystal controlled.

How the MF-10 Works. The key circuits in the MF-10 are a pair of noninverting integrators whose time constants are determined by their respective feedback capacitors and the clock frequency. A conventional integrator like the one in Fig. 11A has a time constant of RC. The precision of the circuit is therefore only as good as the tolerances of the RC components.

The integrators in the MF-10 replace the resistor of the integrator in Fig. 11A with a capacitor. This capacitor is alternately switched by the clock signal, first to the input voltage and then to the feedback capacitor, V_{in} and C_F respectively. As shown in Fig. 11B, the switched capacitor performs the role of the resistor in 11A by transferring the voltage at the input to C_F.

The amount of charge transferred by C_{in} to C_F is determined by the time C_{in} is allowed to charge to V_{in}, and the time C_F is allowed to charge to the voltage C_{in}. In his paper "Introducing the MF-10," Tim Regan, a National Semiconductor applications engineer, shows how the current transferred through C_F to the output of the integrator is V_{in} C_{in} divided by the clock period or V_{in} C_{in} times the clock frequency, F_{clk}. Therefore, the effective resistance of C_{in} is the reciprocal of C_{in} F_{clk}. In other words, the effective resistance of C_{in} can be varied simply by altering the clock frequency. The time constant of the circuit is C_F/C_{in} F_{clk}.

Since the switched capacitor integrator employs on-chip capacitors, you may be wondering why its performance is better than a standard integrator with external RC components. The reason is that the time constant of the switched capacitor integrator is entirely dependent upon the *ratio* of C_{in} and C_F, both of which are fabricated on the same die and thus have precisely controlled dimensions and values.

Incidentally, Tim Regan notes in his paper that the integrators in the MF-10 are noninverting. This requires a somewhat more complex switching arrangement than that shown in Fig. 11B wherein *both* sides of C_{in} are alternately switched. As shown in Fig. 11C, first the upper and lower sides of C_{in} are switched, respectively, to V_{in} and ground. Then the upper and lower sides of C_{in} are switched, respectively, to ground and C_F. This reverses the polarity of the charge on C_{in} that's applied to C_F, thereby preserving the polarity of V_{in} at the integrator's output.

For additional details about how the MF-10 works, see the application note for this chip and Tim Regan's paper. We'll now look at some practical aspects of using the MF-10 and experiment with an MF-10 in a typical circuit.

Using the MF-10. Figure 12 shows a simplified block diagram of one of the filters in an MF-10 and the pin outline for the actual chip. The MF-10 application note describes in detail the function of each pin. What follows is a brief summary.

LP, BP, N/AP/HP are, respectively, the lowpass, bandpass, notch/allpass/highpass outputs of each filter.

INV is the inverting input of each filter.

S1 is used as a signal input pin when the filter is in the allpass mode.

$S_{A/B}$ activates the internal switch that connects the input of the filter's second summer amplifier (see Fig 13) to analog ground AGND ($S_{A/B}$ = low) or the lowpass output ($S_{A/B}$ = high).

V_{+A} and V_{+D} are the analog and digital positive supply pins. They can be interconnected if desired. They should be bypassed with a capacitor (two if separate supplies are used).

V_{-A} and V_{-D} are the analog and digital negative supply pins.

L_{SH} is the level shift pin. It allows the user to use the MF-10 with a variety of power-supply and clock voltages. For example, when powered by a dual ±5V supply and driven by a CMOS clock (±5V), the L_{SH} pin should be tied to ground or V_{-A}, V_{-D}.

CLK is the clock input to each filter. The clock should have a duty cycle of close to 50% for optimum results.

50/100/CL determines the ratio of clock frequency to filter center frequency (50:1 when high and 100:1 when at analog ground).

AGND is the analog ground pin.

Sample:

V_{+A} and V_{+D} are the analog and digital positive supply pins. They can be interconnected if desired. They should be bypassed with a capacitor (two if separate supplies are used).

V_{-A} and V_{-D} are the analog and digital negative supply pins.

Again, be sure to refer to the MF-10 application note for additional information about these pin functions. The explanations given are but brief summaries.

A Tunable Lowpass/Bandpass/Notch Filter. Figure 14 is the circuit for a straightforward LP/BP/N filter made from one-half an MF-10 and an external clock. The clock is made from two inverters in a 4049. Its frequency, and thus the frequency response of the MF-10, can be altered by changing *R5*'s setting. Incidentally, while you may have often seen in this column simple oscillators such as this made from two NAND gates in a 4011, be sure to use the 4049 in this circuit. The 4011 may not oscillate at V_{DD} = +5 V. (If you must use the 4011, try buffering its output with a third gate.)

The MF-10 is connected in what the application note calls the Mode 1 configuration. At least eight other modes are available. Some of the circuit's key parameters are defined in Fig. 13. The circuit is extremely easy to use. The only significant constraints are to observe power supply limits and CMOS handling precautions. Otherwise, operating the circuit is a snap.

For example, with the other values given in Fig. 13, the LP gain is −0.1 (near f_o = 0 Hz), the BP gain is −1 (at

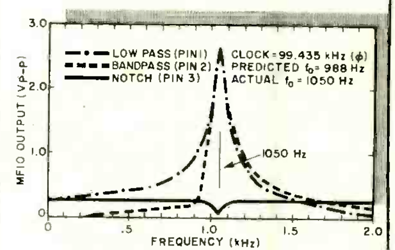

Fig. 14. Response of MF-10 (mode 1— at clock frequency of 99.435 kHz.

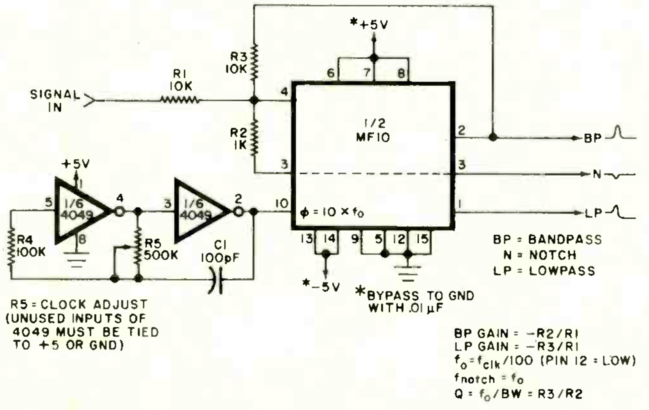

Fig. 13. An MF-10 active filter and clock circuit.

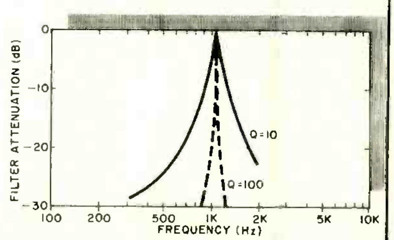

Fig. 15. Logarithmic plot of the same bandpass curve as shown in Fig. 14.

f_0), and the BP/notch Q is 10. The circuit can easily be tuned out to a maximum f_0 of 30 kHz simply by altering the clock frequency (where the ratio of clock frequency-to-f_0 is approximately 100:1). The gain and Q values can easily be altered by changing the resistors.

When the clock frequency of the test circuit was 99.435 kHz, I measured a f_0 for the bandpass and notch outputs of 1050 Hz. This is outside the clock-to-f_0 ratio specified for the MF-10. The *rounded* clock-to-f_0 ratios (pin 12) are 50:1 and 100:1. The *actual* ratios given in the data sheet are 49.94:1 and 99.35:1. In both cases and depending upon the grade of the chip, the actual ratios have a typical and maximum tolerance range of, respectively, ± 0.2 and $\pm 1.5\%$.

My tests, made on successive days with careful attention to detail, gave a ratio of 94.7:1 (pin 12 low). I therefore tried two additional MF-10's and obtained almost exactly the same results. While I cannot account for the apparent discrepancy in clock-to-f_0 ratio, the three MF-10's exhibited virtually identical tolerances.

Figure 14 is a plot superimposing on a linear scale the LP, BP and notch frequency response of the circuit in Fig. 13. The bandpass and notch curves appear quite normal, but the lowpass curve peaks sharply at f_0. This apparent anomaly results from the LP output being programmed by *R3/R1* for a gain of -0.1 at $f = 0$ Hz. This means the LP output should approximate the -0.26 V peak-to-peak at $f = 0$ Hz when V_{in} is 2.6 V peak-to-peak. Figure 14 confirms this is indeed the case.

Recall that frequency response curves for active filters are normally plotted on a logarithmic scale. Figure 15 is a log plot of the bandpass response in Fig. 14. The dashed plot represents the bandpass when the Q was increased from 10 to 100 by reducing *R2* to 100 ohms. Both of these plots as well as the linear scale plots in Fig. 14 are based upon actual measurements.

Going Further. While exceptionally versatile and easily tuned, the multipurpose filter in Fig. 13 is only one of several ways you can use the MF-10. Another way it can be operated is in a noninverting mode, or it can be configured for simultaneous highpass, bandpass and lowpass filtering. Indeed, the versatility and operating simplicity of this filter convince me that such filters will soon obsolete shelves of conventional active filter books, design notes, and computer programs. ◇

ENGLISH BROADCASTS Audible in No. AMERICA

By Glenn Hauser

TIME[1] EST	TIME UTC/GMT	STATION	QUAL.[2]	FREQUENCIES, kHz[3]
4:00-4:15 a.m.	0900-0915	BBC	A	15070, 11955, 11750, 9640, 9510, 6195
4:00-4:30 a.m.	0900-0930	R. Japan[4]	B	15195, 9505
4:00-5:30 a.m.	0900-1030	R. Australia	B	15115
4:00-5:00 a.m.	0900-1000	AFRTS, Los Angeles	A	9590, 9530, 6030
4:00-6:00 a.m.	0900-1100	R. Oman	D	11890, 9735
4:15-6:00 a.m.	0915-1100	BBC	C	17790, 15070, (21660 from 1030), 11750, 9740, 6195
4:30-5:20 a.m.	0930-1020	V. of Germany	C	17800, 17780, 15275
4:45-5:15 a.m.	0945-1015	UN Radio	B	13860, 9565 (Sat.)
5:00-5:05 a.m.	1000-1005	R. Netherlands	A	9510, 6020
5:00-5:30 a.m.	1000-1030	V. of Vietnam	C	12036, 10080
5:00-fade (-)	1000-	Falkland Is. Broadcasting Station	C	3958
5:00-6:00 a.m.	1000-1100	R. Korea	C	5975
5:00-6:00 a.m.	1000-1100	All India Radio	C	17875, 17705, 17387, 15350, 15205
5:00-6:00 a.m.	1000-1100	AFRTS, Los Angeles	A	11805, 9700, 9590, 9530, 6030
5:00-fade out	1000-	R. Australia	B	6045, 5995
5:00-8:00 a.m.	1000-1300	WRNO, New Orleans	A	9715 (not all Eng.)(Sun.)
5:00-11:02 a.m.	1000-1602	ABC, Perth	B	9610, 6140
5:00 a.m.-6:00 p.m.	1000-2200	R. Moscow (via Cuba)	B	11840
5:10-12:00 a.m.	1010-1700	V. of Nigeria	C	15120
5:30-6:30 a.m.	1030-1130	Sri Lanka Br. Corp.	C	17850, 15120, 11835 (not all Eng.)
5:58-8:00 a.m. (+)	1058-1300	CBC Northern Service	C	9625, 6065 (not all Eng.)
6:00-6:25 a.m. (+)	1100-1125	R. Finland	C	15400,17800 (exc. Sun.)
6:00-6:30 a.m.	1100-1130	R. Japan	B	9505, 15195
6:00-6:30 a.m.	1100-1130	V. of Vietnam	C	12036, 10080
6:00-6:30 a.m.	1100-1130	Kol Israel	C	17630, 15605, 15585, 13745
6:00-6:56 a.m.	1100-1156	R. RSA	C	25790, 21535, 15220
6:00-7:00 a.m.	1100-1200	R. Korea	B	9750, 15575
6:00-7:00 a.m.	1100-1200	R. Malaysia, Sarawak	C	4950
6:00-7:00 a.m.	1100-1200	V. of Asia, Taiwan	C	5980 (Sun. 1030-1040)
6:00-7:50 a.m.	1100-1250	R. Pyongyang	C	9977, 9745
6:00-8:00 a.m.	1100-1300	AFRTS, Los Angeles	A	6030
6:00-8:00 a.m.	1100-1300	VOA	B	21840, 11715, 9760, 9565, 6110
6:00-8:30 a.m.	1100-1300	TWR-Bonaire	A	11815 (Sat. & Sun. 1100-1330)
6:00-8:00 a.m.	1100-1300	R. Australia	A	9580
6:00-8:30 a.m.	1100-1330	BBC	A-B	25650, 21710, 21660, 21550, 21470, 17790, 15070, 11775, 11750, 9740, 9510, 6195
6:00-9:00 a.m.	1100-1400	4VEH, Haiti	C	11835, 9770
6:00-12:00 a.m.	1100-1700	AFRTS, Los Angeles	A	15430, 15330, 11805, 9700
6:15-6:30 a.m.	1115-1130	Vatican Radio	C	21485, 17840
6:30-6:55 a.m.	1130-1155	RRI, Yogyakarta	C	5047
6:30-6:55 a.m.	1130-1155	R. Nacional, Angola	D	11955, 9535 (Mon.-Fri.)(irreg).
6:30-7:10 a.m.	1130-1210	R. Polonia	D	17865, 11840, 9525
6:30-7:30 a.m.	1130-1230	R. Thailand	C	11905, 9655 or 9650
6:45-7:15 a.m.	1145-1215	R. Malaysia Sabah	C	5980, 4970
7:00-7:15 a.m.	1200-1215	V. Of Kampuchean People	C	11938, 9694 (vary)
7:00-7:20 a.m.	1200-1220	Vatican Radio	B	21485, 17840, 21725, 17865
7:00-7:25 a.m. (+)	1200-1225	R. Canada International	A	17820, 15440, 11955, 11855, 9650 (Mon.-Fri.)
7:00-7:25 a.m.(+)	1200-1225	R. Finland	B	15400, 17800 (not Sun.)
7:00-7:30 a.m.	1200-1230	R. Tashkent	C	15460, 11785, 9715, 9650, 5950
7:00-7:35 a.m.	1200-1235	R. Ulan Bator	C	12070, 6383 (not Sun.)
7:00-7:55 a.m.	1200-1255	R. Beijing	B	15520, 15525, 15180, 11900
7:00-9:30 a.m.	1200-1430	HCJB, Ecuador	A	26020, 17890, 15115, 11740
7:30-7:55 a.m.	1230-1255	R. Tirana	D	11960, 9515
7:30-7:57 a.m.	1230-1257	Austrian R.	C	15165
7:30-8:00 a.m.	1230-1300	R. Bangladesh	D	15282 (variable)
7:30-8:15 a.m.	1230-1315	V. of Germany	C	21600, 17800, 17765
7:30-8:15 a.m. (+)	1230-1315	R. Berlin International	C	21465
7:30-9:30 a.m.	1230-1430	SLBC, Sri Lanka	C	15425, 9720
7:30-9:25 a.m. (+)	1230-1425	R. Finland	C	17800, 15400 (Sun.)
7:35-7:45 a.m.	1235-1245	V. of Greece	C	17910, 15205, 11645 (Mon.-Sat.)
8:00-8:25 a.m. (+)	1300-1325	R. Finland	C	25950, 15400 (Mon-Sat.)
8:00-8:30 a.m.	1300-1330	R. Bucharest	C	17850, 15250, 11940
8:00-8:30 a.m.	1300-1330	R. Norway	C	25730, 25015 (Sun.)
8:00-8:45 a.m.	1300-1345	R. Japan	B	9505
8:00-9:00 a.m.	1300-1400	VOA	A	21840, 15205, 11715, 9760, 9565
8:00-9:00 a.m.	1300-1400	R. Australia	C	9770
8:00-10:00 a.m.	1300-1500	WYFR	A	9535
8:00-10:00 a.m. (+)	1300-1500	WRNO, New Orleans	A	11940 (Sun.) (not all Eng.)
8:00-10:55 a.m.	1300-1555	R. Beijing	C	17700, 15225, 11900, 11600

...ENGLISH BROADCASTS

8:00-10:57 a.m.	1300-1557	R. RSA	C	25790, 15220, 9585
8:00-11:00 a.m. (+)	1300-1600	R. Canada International	A	17820, 15240, 11955 (Sun.)
8:00 a.m.-6:00 p.m.(+)	1300-2300	CBC Northern Service	C	23440, 11720, 9625 (not all Eng.)
8:15-8:45 a.m.	1315-1345	Swiss R. International	B	21570, 21520, 17830, 17785, 15305
8:30-9:00 a.m.	1330-1400	R. Nationale, Laos	C	7020 (varies)
8:30-9:20 a.m.	1330-1420	R. Nederland	C	17605, 11935
8:30-9:30 a.m.	1330-1430	V. of Vietnam	C	15010, 10040
8:30-10:00 a.m.	1330-1500	All India R.	C	15335, 11810
8:30-11:00 a.m.	1330-1600	BBC	B-C	21710, 21660, 21550, 21470, (to 1430), 17790, 15400 (from 1430), 15070, 11750
8:30-11:00 a.m.	1330-1600	R. Malaysia Sabah	C	5980, 4970
8:30 a.m.-fade	1330-	R. Australia	B	6060
8:57-11:55 a.m.	1357-1655	V. of Philippines	D	9578 (Sun.-1556)(not all Eng.)
9:00-9:25 a.m. (+)	1400-1425	R. Finland	C	17800, 15400 (Mon.-Sat.)
9:00-9:30 a.m.	1400-1430	KTWR, Guam	C	9510
9:00-9:30 a.m.	1400-1430	R. Norway	C	17840, 15175 (Sun.)
9:00-9:30 a.m.	1400-1430	R. Sweden	C	17790
9:00-9:30 a.m.	1400-1430	V. Rev. Party, N. Korea	D	4557, 4109
9:00-9:30 a.m.	1400-1430	R. Tashkent	C	15460, 11785, 9715, 9650, 5950
9:00-9:35 a.m.	1400-1435	R. Ulan Bator	C	12070, 7235 (not Sun.)
9:00-9:45 a.m.	1400-1445	BRT, Belgium	C	21815, 17610 (Mon.-Fri.)
9:00-10:00 a.m.	1400-1500	R. Korea	C	9750, 15575
9:00-10:00 a.m.	1400-1500	R. Malaysia Sarawak	C	7160, 4950
9:00-10:00 a.m.	1400-1500	VOA	A	26040, 21840, 15205, 11715, 9760, 9565, 6110
9:00-12:30 a.m.	1400-1730	R. Australia	C	9770, 9710
9:30-9:45 a.m.	1430-1445	Vatican Radio	C	17865 (not Sun.)
9:30-10:00 a.m.(+)	1430-1500	R. Yugoslavia	C	15300, 15240
9:30-10:00 a.m.	1430-1500	R. Veritas Asia	C	15105, 11955
9:30-10:25 a.m.	1430-1525	R. Nederland	B	21480, 17605, 11735
9:30-10:30 a.m.	1430-1530	HCJB, Ecuador	A	26020, 17890, 15115
9:30-11:00 a.m.	1430-1600	Burma Br. Ser.	D	5985, 5040
9:30 a.m.-5:00 p.m.	1430-2200	UN Radio	A	21670, 21625, 15410, 15120 (when in session)
9:35-10:20 a.m.	1435-1520	R. Nepal	D	3230, 7105 or 9589
9:45-10:20 a.m.	1445-1520	R. Ulan Bator	C	17780, 7235 (not Sun.)
10:00-10:30 a.m.	1500-1530	V. of Asia, Taiwan	D	5980 (not Sun.)
10:00-10:45 a.m.	1500-1545	R. Japan	C	9505, 11815
10:00-10:50 a.m.	1500-1550	V. of Germany	C	21600
10:00-11:00 a.m.	1500-1600	V. of Indonesia	C	11790
10:00-11:00 a.m.	1500-1600	VOA	A	26040, 21840, 15205, 9760, 9565, 6110
10:00-11:00 a.m.	1500-1600	V. of Rev. Ethiopia	D	9560
10:00-11:00 a.m.	1500-1600	FEBA, Seychelles	C	11895, 15325
10:00-11:00 a.m.	1500-1600	V. of Nigeria	C	11770 (varies)
10:00-11:00 a.m.	1500-1600	KTWR, Guam	C	9510
10:00-11:00 a.m.	1500-1600	BBC	B	9515, 15260 (Sat., Sun.)
10:00-12:00 a.m. (+)	1500-1700	WRNO, New Orleans	A	15140 (Sun.) (not all Eng.)
10:00-12:30 a.m.	1500-1730	BSHKJ, Jordan	D	9560
10:00 a.m.-6:00 p.m	1500-2300	WYFR, Family Radio	A	11830, 9535, (not all Eng.)
10:30-11:00 a.m.	1530-1600	Swiss R. International	C	21570, 17830, 15125
10:35-10:45 a.m.	1535-1545	V. of Greece	C	17910, 15055, 11645 (Mon.-Sat.)
10:45-11:00 a.m.	1545-1600	Vatican Radio	C	17730
10:45-11:00 a.m.	1545-1600	R. Canada International	A	15325, 17820 (Mon.-Sat.)
-11:00 a.m.	-1600	SBC, Singapore	C	11940, 6120, 5052, 5010 (fade-in time varies)
11:00-11:15 a.m.	1600-1615	R. Pakistan	C	21486, 17660, 17640, 15565, 15530
11:00-11:30 a.m.	1600-1630	R. Norway	C	25730, 21700, 17830 (Sun.)
11:00-11:30 a.m.	1600-1630	R. Portugal	C	21645 (Not Sun.)
11:00-11:30 a.m.	1600-1630	V. of Vietnam	C	15010, 10040
11:00-12:00 a.m.	1600-1700	R. Korea	C	9870, 7550
11:00-12:00 a.m.	1600-1700	VOA	A	26040, 21840, 15430, 15205, 9760
				12030, 11900, 11720
11:00-12:00 a.m.	1600-1700	R. France Int'l	B	21685, 21620, 21580, 17795, 17620, 15315, 15300
11:00 a.m.-12:30 p.m	1600-1730	VOA to Africa	A	26040, 26000, 21485, 19480-LSB, 17870, 15600, 15410
11:00 a.m.-12:45 p.m	1600-1745	BBC	B	21710, 15260, 15070, 9515
11:15-12:00 a.m.	1615-1700	UAE Radio, Dubai	B	21655, 17775, 15300†
11:15 a.m.-12:45 p.m	1615-1745	BBC to Africa	C	17755
11:45-12:00 a.m.	1645-1700	R. Canada International	A	17820, 15325
11:45-12:45 p.m.	1645-1745	R. Pakistan	C	15545†, 11672
12:00-12:30 p.m.	1700-1730	R. Japan	C	9505, 11815
12:00-12:30 p.m.	1700-1730	R. Norway	C	25730, 17715, 15205 (Sun.)
12:00-1:00 p.m.	1700-1800	AFRTS, Los Angeles	A	15430, 15345, 15330, 11805
12:00-3:00 p.m.	1700-2000	4VEH, Haiti	C	11835, 9770 (Sun.)
12:00-3:00 p.m.	1700-2000	WRNO, New Orleans	A	15420 (not all Eng.)
12:00-4:00 p.m.	1700-2100	BSK Saudi Arabia	C	11850 (varies)
12:00-2:00 p.m.	1700-1900	VOA	B	21840, 17785, 15580, 15430, 15205, 11760
12:30-1:00 p.m.	1730-1800	VOA to Africa	A	26040, 26000, 21485, 19840-LSB, 17870, 15877.5-LSB, 15600, 15410
12:45-3:00 p.m.	1745-2000	BBC	C	15400, 15070, 12095, (21710 to 1830)
12:45-5:30 p.m.	1745-2230	All India R.	C	11620
1:00-1:15 p.m.	1800-1815	Kol Israel	C	17585, 13725, 11610
1:00-1:30 p.m.	1800-1830	R. Canada International	A	17820, 15260 (Sat. & Sun. 1800-1900)
1:00-1:30 p.m.	1800-1830	V. of Vietnam	C	15010, 10040
				12050, 11960, 11900, 11700
1:00-2:00 p.m.	1800-1900	V. of Nigeria	C	15120, 17800
1:00-4:00 p.m.	1800-2100	R. Kuwait	C	11675
1:00-4:00 p.m.	1800-2100	AFRTS, Los Angeles	A	17765, 15430, 15345, 15330, 11805
1:00-5:00 p.m.	1800-2200	VOA to Africa	A	26040, 26000, 21660, 21485, 19840-LSB, 17870, 15877.5-LSB, 15600, 15410
1:15-1:45 p.m.	1815-1845	Swiss R. International	C	17850, 17830, 15415, 15125
1:15-2:00 p.m.(+)	1815-1900	BRT, Belgium	C	17595†
1:30-1:40 p.m.	1830-1840	UN Radio	A	21710, 20060-SSB, 18782.5-SSB, 15360, 15120 (Fri.)
1:30-1:57 p.m.	1830-1857	Austrian Radio	C	15560, 17770 (Sun. from 1805)
1:30-2:00 p.m.	1830-1900	V. of Revolution, Guinea	C	15309 (varies) 9650 (Mon., Wed. and Fri.)(irregular)
2:00-2:30 p.m.	1900-1930	R. Norway	C	17840, 17715, 15205 (Sun.)
2:00-2:30 p.m.	1900-1930	V. of Vietnam	C	15010, 10040
2:00-2:30 p.m.	1900-1930	R. Canada International	A	17820, 15260 (Mon.-Fri.)

2:00-2:30 p.m.	1900-1930	R. Canada International	A	17875, 15325, 11825 (Sat. & Sun. 1900-2000)
2:00-2:30 p.m.	1900-1930	R. Afghanistan	C	15077 (varies), 11755, 9665
2:00-2:45 p.m.	1900-1945	R. Japan	C	15300, 11815
2:00-3:00 p.m.	1900-2000	HCJB, Ecuador	C	26020, 21477.5, 17790†
2:00-5:00 p.m.	1900-2200	VOA	A	21840, 17785, 15580, 15430, 15205, 11760
2:30-3:00 p.m.	1930-2000	UN Radio	A	21710, 20060-SSB, 18782.5-SSB, 15360, 15120 (Fri.)
2:30-3:20 p.m.	1930-2020	V. of Germany	C	17705, 15150
2:30-3:30 p.m.	1930-2030	V. of Iran	C	9022, 11930 or 9770
2:45-4:15 p.m.	1945-2115	R. Free Grenada	C	15104 (time varies and irregular)
2:50-3:10 p.m. (+)	1950-2010	Vatican Radio	C	9645
3:00-3:30 p.m.	2000-2030	R. Algiers	C	Some of 25700, 21725, 21635, 17745, 15370, 15307, 15215, 15160, 11810, 9760, 9685, 9610, 9510
3:00-3:30 p.m.	2000-2030	R. Canada International	A	17875, 17820, 15325, 11960 (Mon.-Fri.)
3:00-3:30 p.m.	2000-2030	Kol Israel	C	17630, 15585, 13745, 11655
3:00-4:00 p.m. (+)	2000-2100	Spanish Foreign Radio	C	15375, 11760
3:00-4:15 p.m.	2000-2115	BBC	B	15260, 15070, 12095, 11750
3:00-5:00 p.m.	2000-2200	WRNO, New Orleans	A	17775 (not all Eng.)
3:10-4:40 p.m.	2010-2140	R. Habana Cuba	A	11690†
3:30-4:20 p.m.	2030-2120	R. Nederland	B	17605, 15220, 11740, 11730, 9715
3:30-4:30 p.m.	2030-2100	V. of Vietnam	C	15010, 10040
3:45-4:00 p.m.	2045-2100	Vatican Radio	C	15120, 11760, 9625
3:50-4:40 p.m.	2050-2140	R. Habana Cuba	C	17850, 11960
4:00-4:15 p.m.	2100-2115	UN Radio	A	17730, 15120 (Fri.)
4:00-4:30 p.m.	2100-2130	R. Japan	B	15300, 11815
4:00-4:45 p.m.(+)	2100-2145	BRT, Belgium	B	15590 (Mon-Sat.)
4:00-4:57 p.m.	2100-2157	R. RSA	C	11900, 9585
4:00-5:00 p.m.	2100-2200	V. of Nigeria	C	15120, 17800
4:00-5:00 p.m.	2100-2200	AFRTS, Los Angeles	A	21570, 17765, 15430, 15345, 15330 11960, 11750, 11700, 9700
4:00 p.m.-3:15 a.m.(−)	2100-0815	R. New Zealand	C	17705, 15485
4:15-4:30 p.m. (+)	2115-2130	R. Yugoslavia	C	9620
4:15-5:00 p.m.	2115-2200	BBC	A	15260, 15070, 11750
4:15-7:30 p.m.	2115-2430	R. Free Grenada	B	15045 (time varies)(irregular)
4:30-5:00 p.m.	2130-2200	BBC to Falklands	B	15400, 15390, 11820, 9915 9915 (Tue., Fri.)
4:30-5:00 p.m.	2130-2200	R. Canada International	A	17820, 15150, 11945, (17875, 15325 Sat. & Sun.)
4:30-5:00 p.m.	2130-2200	HCJB Ecuador	C	26020, 21477.5, 17790†, 15295†
4:30-5:00 p.m.	2130-2200	UN Radio	A	17730, 15120 (Fri.)
4:30-5:00 p.m.	2130-2200	R. Sofia	B	11920, 11860, 11720
4:30-5:25 p.m.	2130-2225	R. Baghdad	C	9745
4:30-6:00 p.m. (+)	2130-2300	R. Jamahariyah, Libya	B	11815† (time varies)
4:31-5:00 p.m.	2131-2200	KGEI, San Francisco	C	15280
4:40-5:40 p.m.	2140-2240	V. of Free China	C	17890, 15270, 11825
4:45-5:00 p.m.	2145-2200	RTVC, Congo	C	15190 (irregular)
4:45-5:15 p.m.	2145-2215	Swiss R. International	C	21520, 17830, 15305, 11910
5:00-5:30 p.m.	2200-2230	R. Norway	C	15225, 15175, 11870 (Sun.)
5:00-5:30 p.m. (+)	2200-2230	R. Vilnius	B	17900, 17870, 15180, 11790, 9685
5:00-6:00 p.m.	2200-2300	R. Moscow	A	17700, 15425, 12010, 11960, 11860, 11770, 11720, 11700, 9710, 9610
5:00-6:00 p.m.	2200-2300	R. Moscow World Service	B	11980
5:00-6:00 p.m.	2200-2300	R. Canada International	A	17875, 15325 (Mon.-Fri.)
5:00-6:00 p.m.	2200-2300	VOA to Africa	A	26040, 26000, 21660, 21485, 19480-LSB, 17870, 15600, 15415
5:00-6:00 p.m.	2200-2300	V. of Turkey	B	17760, 11740, 9660, 9610
5:00-6:00 p.m.	2200-2300	BBC	A	15420, 15260, 15070, 11750, 9915, 9590, 9410, 6175, 6120, 5975
5:00-7:00 p.m.	2200-2400	AFRTS, Los Angeles	A	25615, 21570, 15430, 15330
5:00-7:00 p.m.	2200-2400	VOA	A	26000, 21460, 17820
5:00-8:00 p.m.	2200-0100	WRNO, New Orleans	A	11855 (not all Eng.)
5:15-5:30 p.m.	2215-2230	R. Japan	C	17755, 15195 (via Portugal 11755†)
5:30-6:00 p.m.	2230-2300	R. Canada International	B	17820, 15190
5:30-6:00 p.m.	2230-2300	Kol Israel	A	13745, 15585, 15200, 11655, 9815
5:30-6:00 p.m.	2230-2300	RAE, Argentina	C	15345 (Mon.-Sat.)
5:30-6:00 p.m.	2230-2300	R. Nacional, Angola	D	11955, 9535 (Mon.-Fri., irregular)
5:30-6:00 p.m.	2230-2300	R. Polonia	C	7125
5:30-6:30 p.m.	2230-2330	R. Sofia	B	15110, 9700
5:30-6:30 p.m.	2230-2330	R. Mediterranean, Malta	C	6110†
6:00-6:30 p.m.	2300-2330	R. Japan	C	17755, 15195
6:00-6:30 p.m.	2300-2330	R. Sweden	C	11705, 15270
6:00-7:00 p.m.	2300-2400	R. Canada International	A	9755, 5960, (Sat. 2300-2330)
6:00-7:00 p.m.	2300-2400	4VEH, Haiti	B	11835, 9770
6:00-7:30 p.m.	2300-2430	BBC	A	15420, 15260, 15070, 11910, 11750, 9915, 9590, 9410, 7325, 6175, 6120, 5975
6:00-7:50 p.m.	2300-2450	R. Pyongyang	C	15231, 9745
6:00-8:30 p.m.	2300-0130	R. Moscow	A	17700, 15425, 12010, 11780, 11770, 9710, 9610
6:00 p.m.-12:07a.(+)	2300-0507	CBC Northern Service	C	9625, 6195 (not all Eng.)
6:15-7:00 p.m. (+)	2315-2400	R. Berlin International	C	11970, 9730
6:30-7:00 p.m.	2330-2400	V. of Vietnam	C	12036, 10080
6:30-7:00 p.m. (+)	2330-2400	R. Kiev	A	17900, 17860, 15180, 11960, 11720 (from Sept. 4, 9685 instead of 11960)
6:35-6:45 p.m.	2335-2345	V. of Greece	C	11645, 9865 (not Sat.)
6:45-7:45 p.m.	2345-2445	R. Japan	C	17825, 15300
7:00-7:25 p.m.	0000-0025	R. Tirana	B	9750, 7065
7:00-7:30 p.m. (+)	0000-0030	R. Canada International	A	9755, 5960
7:00-7:30 p.m.	0000-0030	Kol Israel	A	11655, 9815, 740
7:00-7:30 p.m.	0000-0030	R. Norway	C	15175, 11870, 11850 (Mon.)
7:00-7:45 p.m. (+)	0000-0045	R. Berlin International	C	11970, 9730
7:00-7:55 p.m.	0000-0055	R. Beijing	B	17855, 15120
7:00-8:00 p.m.	0000-0100	VOA	A	21460, 17820, 6873-USB
7:00-8:00 p.m.	0000-0100	R. Sofia	B	15110, 9700
7:00-8:00 p.m.	0000-0100	R. Australia	B	21740, 17795
7:00-8:00 p.m.	0000-0100	FEBC, Philippines	C	17810
7:00-8:00 p.m.	0000-0100	AFRTS, Los Angeles	A	25615, 21570, 15430, 15330, 11790
7:00-8:15 p.m.	0000-0115	All India Radio	C	17805
7:00-9:00 p.m.	0000-0200	VOA to Latin America	A	17730, 17640, (15652.5-LSB to 0100) 15205, 11740, 9650, 6130, 5995, 1580
7:00-9:00 p.m.	0000-0200	R. Luxembourg	C	6090 (Time varies)
7:00-12:00 p.m.	0000-0500	R. Moscow (via Cuba)	A	9600

(To be continued)

OPERATION ASSIST

If you need information on outdated or rare equipment—a schematic, parts list, etc.—another reader might be able to assist. Simply send a postcard to Operation Assist, Computers & Electronics, 1 Park Ave., New York, NY 10016. For those who can help readers, please respond directly to them. They'll appreciate it. (Only those items regarding equipment not available from normal sources are published.)

A. B. Dumont type 350 oscilloscope. Need service and alignment manuals and parts list and schematic. Frederick G. Lewis, 10 Peabody St., Worcester, MA 01604.

Eico Model 460 oscilloscope and Model 324 signal generator. Need operating instructions and schematics. Jerry O. Bonner, 1233 Norris Dr., Bossier City, LA 71111.

Sears Silvertone Model #1482 guitar amplifier. Need schematic and parts list. Mike Warner, 13400 Havana Rd., Garfield Hts., OH 44125.

Symphonic Model TPS 5050 miniature TV. Need 3" picture tube. M. Dudley, 2039 Top Hill Dr., N.W., Roanoke, VA 24017.

Scott Model 342 FM stereo tuner/amplifier. Need schematic and parts list. Donald Cvetko, 4N539 Kingery Highway, Bensenville, IL 60106.

Sonar Radio Corp. Model 30 MF radio telephone. Need schematic, manual and circuit information. James R. Hay, 141 St. John's Blvd., Pointe Claire, P.Q., Canada H9S 4Z2.

KLN Model 41 stereo tape deck. Need schematic. Stephen Greenstein, 2838D Falcon Court East, McGuire AFB, NJ 08641.

Analab Instrument Co. Model 1100, Serial no. 575 oscilloscope. Need operator's and service manuals. Walter J. Fox, Box 526, Christmas Valley, OR 97641.

Precision Model ES-500 oscilloscope. Need manual and schematic. Glenn Tibbett, 22664 Little Beaver, Apple Valley, CA 92307.

Akai Model #M-10 tape recorder. Need instruction manual. Dr. Stuart Vogelmenn, 130 Indian Church Road, Buffalo, NY 14210.

Sansui Model AU-2200 stereo amplifier. Need schematic. Bill Shaffer, 1005 S. Washington Street, Marion, IN 46952.

Superior Test Equipment Co. Model 70 Utility Tester and Model TV-50 genometer. Need any available information. David Ward, 2538 Valley Chapel Rd., Jackson, OH 45640.

KLH Model 41 stereo tape deck. Need schematic. Stephen Greenstein, 2838D Falcon Ct. East, McGuire AFB, NJ 08641.

Akai Model AA 5000, Serial AA-52852 stereo amplifier. Need service manual. Van J. Kaiser, 3131 North 3rd. St., Clinton, IA 52732.

National Model NC 190 receiver. Need parts list, schematic, alignment information and sketch of bottom cover. David Crowell, RFD 2, Box 428, North Scituate, RI 02857.

Northrup-Leeds speedomax recorder 662 X-Y. Need schematic, pens operating manual and repair manual. **Navy** AM-293A/UPX video amplifier. Need schematic and operating manual. Brian Faley, 5225 Palatine Ave. N., Seattle, WA 98103.

Grunow Model 1291AM/SW chassis type 12B Teledial. **Bell Sounds Systems** amplifier Model 2199-B. Need schematics or any available information. Carl Arndt, Box 215, Andale, TK 6000I.

Challenger Model CH30 amplifier. Need schematic and parts list. N. Lombardo, Box 414 St. Michel, Montreal, PQH2A3NI, Canada.

Emerson Model 1232 TV and radio. Need schematic and service manual. Peter J. Cotte, 372 West Scott Ave., Rahway, NJ 07065.

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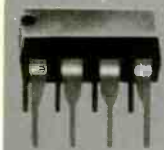

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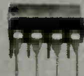

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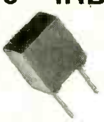

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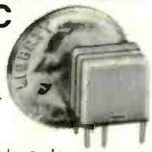

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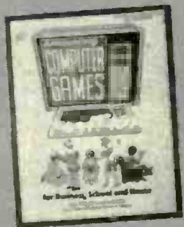

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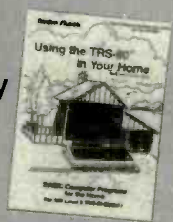

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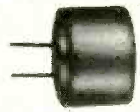

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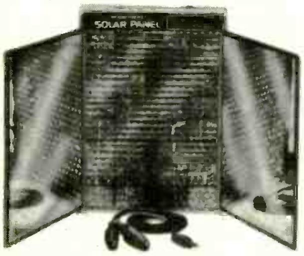

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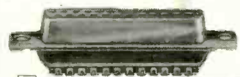
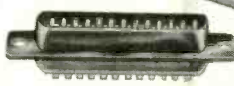


[A]

[B]



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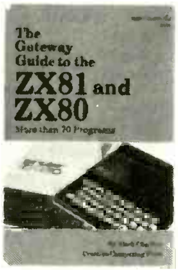

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SET of THREE $99.00

Stock No.	AC Amperes	Price
13730	0-25A	$39.50
13731	0-50A	39.50
13732	0-100A	39.50

ACCESSORY LINE SPLITTER
allows fast readings of AC power consumption of plug in equipment without separation of leads.
Stock No. 13727 **$9.95**

POCKET SIZED BATTERY TESTER
for all types of small batteries from 1.35v to 4.5v
Stock No. 13733 **$13.95**

VOLT-I-CATOR
automotive diagnostic meter plugs into lighter socket and indicates battery condition and charging rates.
Stock No. 13736 **$15.95**

AC VOLTAGE TESTER
plugs into any 110v service receptacle to check line voltage over 50-150 VAC
Stock No. 13735 **$14.95**

VOM-MULTITESTER
versatile Volt-Ohm-Milliammeter in small package
Stock No. 13729 **$13.95**

ELPAC POWER SUPPLIES – SOLV SERIES FULLY REGULATED

SINTEC Stock No.	ELPAC Part No.	Output Voltage	Output Current Rating	Dimensions (HxWxD) in Inches	OVP	Price
13802	SOLV15-5	5	3.0A	4-7/16x4x2	Fixed included	$39.95
13803	SOLV15-12	12	1.5A	4-7/16x4x2	Fixed included	39.95
13804	SOLV15-15	15	1.2A	4-7/16x4x2	Fixed included	39.95
13806	SOLV15-24	24	0.75A	4-7/16x4x2	Fixed included	39.95
13808	SOLV30-5	5	6.0A	5-5/8x4-7/8x3-3/16	OVP-4	59.95
13809	SOLV30-12	12	4.0A	5-5/8x4-7/8x3-3/16	OVP-4	59.95
13810	SOLV30-15	15	3.3A	5-5/8x4-7/8x3-3/16	OVP-4	59.95
13812	SOLV30-24	24	2.0A	5-5/8x4-7/8x3-3/16	OVP-4	59.95
13802-1	Data Sheet for SOLV Series					.25

PIN FORMING TOOL

puts IC's on their true row to row spacing. One side is for .300 centers. Flip tool over for devices on .600 centers. Put device in tool and squeeze.

NEW! Stock No. 10200 $14.95 (ANTI-STATIC MODEL)

ONE TOOL DOES 8 thru 40 PINS! Stock No. 11059 $12.95

OK MACHINE AND TOOL

IC INSERTION/EXTRACTION KIT

Includes DIP IC extractors and inserters to accommodate all ICs from 14 to 40 pins. Tools that engage conductive surfaces are CMOS safe and include grounding lugs. Stock No. 13309 **$37.74**

SOCKET WRAP ID

DIP socket-sized plastic panels with numbered holes in pin locations. Slip onto socket before wire wrapping to identify pins. Also write on them for location, IC part number, function, etc. Simplifies initial wire wrapping, troubleshooting and repair.

13295	14 pin
13296	16 pin
13297	18 pin
13298	20 pin
13299	22 pin
13300	24 pin
13301	28 pin
13302	40 pin
13303	96 pin

$1.82 per pack

IC EXTRACTOR

One-piece, spring steel construction. Will extract all LSI, MSI and SSL devices with 8 to 24 pins. Stock No. 13313 **$2.10**

SINTEC CO. Drawer Q Milford NJ 08848-9990

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CIRCLE NO. 36 ON FREE INFORMATION CARD

4164 64K DYNAMIC 200 NS **$5.95**

TMM2016 2KX8 STATIC 200 NS **$4.15**

STATIC RAMS

2101	256 x 4 (450ns)	1.95
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
2147	4096 x 1 (55ns)	4.95
TMS4044-4	4096 x 1 (450ns)	3.49
TMS4044-3	4096 x 1 (300ns)	3.99
TMS4044-2	4096 x 1 (200ns)	4.49
MK4118	1024 x 8 (250ns)	9.95
TMM2016-200	2048 x 8 (200ns)	4.15
TMM2016-150	2048 x 8 (150ns)	4.95
TMM2016-100	2048 x 8 (100ns)	6.15
HM6116-4	2048 x 8 (200ns) (cmos)	4.75
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
Z-6132	4096 x 8 (300ns) (Qstat)	34.95

LP = Low Power   Qstat = Quasi-Static

DYNAMIC RAMS

TMS4027	4096 x 1 (250ns)	1.99
UPD411	4096 x 1 (300ns)	3.00
MM5280	4096 x 1 (300ns)	3.00
MK4108	8192 x 1 (200ns)	1.95
MM5298	8192 x 1 (250ns)	1.85
4116-300	16384 x 1 (300ns)	8/11.75
4116-250	16384 x 1 (250ns)	8/11.95
4116-200	16384 x 1 (200ns)	8/12.95
4116-150	16384 x 1 (150ns)	8/14.95
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

EPROMS

1702	256 x 8 (1us)	4.50
2708	1024 x 8 (450ns)	3.95
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
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14410	12.95	74C903	.85
14411	11.95	74C905	10.95
14412	12.95	74C906	.95
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14 pin ST	.15	.12
16 pin ST	.17	.08
18 pin ST	.20	.18
20 pin ST	.29	.27
22 pin ST	.30	.27
24 pin ST	.30	.27
28 pin ST	.40	.32
40 pin ST	.49	.39
64 pin ST	4.25	call
ST = SOLDERTAIL		
8 pin WW	.59	.49
14 pin WW	.69	.52
16 pin WW	.49	.49
18 pin WW	.99	.90
20 pin WW	1.09	.98
22 pin WW	1.39	1.28
24 pin WW	1.49	1.35
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WW = WIREWRAP		
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7812K	1.39	7912K	1.49
7815K	1.39	7915K	1.49
7824K	1.39	7924K	1.49
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L = TO-92

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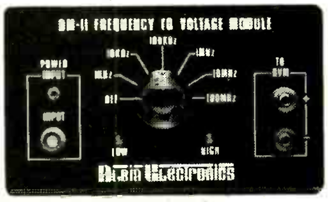

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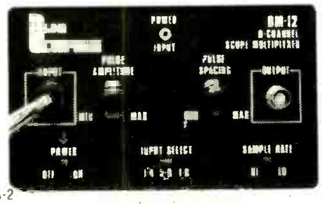

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DISC CAPACITORS

Panasonic Ceramic Disc Capacitors

NEW! KIT — 310 DISC CAPACITORS. Prices include convenient divided plastic box with bin guide for easy storage and quick access. ASSORTMENT OF 18 POPULAR VALUES, PANASONIC QUALITY. CAT. NO. DH-KIT ONLY $24.95

DIGI-KEY now has an expanded line of Panasonic Ceramic Disc Capacitors. Including (listed after NPO banner)

NPO TYPE

For Complete Specs on Physical Size and Electrical Characteristics, consult your *FREE* DIGI-KEY Catalog.

Part No.	Cap.	Volt.	Price 10	100	1,000
P4000	10 pf	500	.75	6.49	48.71
P4002	15 pf	500	.75	6.49	48.71
P4003	18 pf	500	.75	6.49	48.71
P4004	22 pf	500	.75	6.49	48.71
P4005	27 pf	500	.75	6.49	48.71
P4006	33 pf	500	.75	6.49	48.71
P4007	39 pf	500	.75	6.49	48.71
P4008	47 pf	500	.75	6.49	48.71
P4009	56 pf	500	.75	6.49	48.71

See The DIGI-KEY Catalog For Low OEM Prices On Disc Capacitors

PLESSEY "MINI BOX"

Metallized Poly Cap Kit

140 CAPACITORS. Price includes convenient divided plastic box with bin guide for easy storage and quick access. ASSORTMENT OF 14 POPULAR "MINI-BOX" CAPACITORS. CAT. NO. 3050P-Kit ONLY $35.95

PANASONIC RESIN DIPPED TANTALUM CAPACITORS

NEW! KIT — 180 TANTALUM CAPACITORS. Prices include convenient divided plastic box with bin guide for easy storage and quick access. ASSORTMENT OF 18 POPULAR VALUES, PANASONIC QUALITY. CAT. NO. T-KIT ONLY $79.95

Part No.	Cap.	Volt	1	10	100	1000
P2068	0.15	50	.31	2.70	22.50	202.50
P2069	0.22	50	.31	2.70	22.50	202.50
P2070	0.33	50	.31	2.70	22.50	202.50
P2071	0.47	50	.39	3.39	28.32	254.92
P2072	0.68	50	.44	3.78	31.50	283.50
P2073	1.0	50	.54	4.65	38.75	348.75
P2074	1.5	50	.63	5.40	45.00	405.00
P2075	2.2	50	.74	6.38	53.00	477.00
P2076	3.3	50	.81	7.02	58.50	526.50
P2077	4.7	50	1.01	8.73	72.75	654.75
P2078	6.8	50	2.06	17.70	147.50	1327.50

TANTALUM SUBSTITUTES PANASONIC K-SERIES CAPACITORS

New Panasonic K-Series are miniature, low cost aluminum electrolytic capacitors. Their size and performance characteristics make them viable alternatives to tantalums in many applications.

CAPACITANCE TOLERANCE: 20%
D.C. LEAKAGE CURRENT, MAX. 0.01 C V or 3uA
All K-SERIES CAPACITORS We Carry Are Radial

DIGI-KEY Part No.	Cap uF	Working Voltage DC	1	10 Pak	100 Pak	1000 Pak
P800	22		.16	1.42	11.85	106.65
P801	33	6.3	.17	1.49	12.42	111.82
P802	47		.17	1.52	12.72	114.62
P803	100		.20	1.79	14.95	134.55

Panasonic TSW Series

Large Aluminum Electrolytic Capacitors

DIGI-KEY Volume Discount — Compare the Discount when comparing Prices

The Digi-Key volume discount and Service charges are simple to apply. Most items sold by Digi-Key may be combined for a volume discount. Items that are not discountable are identified by the suffix-ND following the part number. After writing your order, total all of the discountable items and apply the appropriate discount. To this subtotal, add the non-discountable items. Then add the handling charge. We pay all shipping and insurance to addresses in the U.S.A., Canada and Mexico when payment accompanies order.

WHEN ORDERING BY PHONE, CALL: 1-800-346-5144 (Mn., Ak., Hi., call 218-681-6674) By mail send your order to: DIGI-KEY, Highway 32 South, Thief River Falls, MN 56701

You may pay by check, money order, Master Charge, VISA or C.O.D. ***DIGI-KEY GUARANTEE:*** Any parts or products purchased from Digi-Key that prove to be defective will be replaced or refunded if returned within 90 days from receipt with a copy of your invoice.

SERVICE	CHARGES	VOLUME DISCOUNT	
$ 0.00-$ 9.99	Add $2.00	$ 0.00-$ 99.99	NET
$ 10.00-$25.00	Add $0.75	$ 100.00-$249.99	Less 10%
$ 25.00-$49.99	Add $0.50	$ 250.00-$499.99	Less 15%
$ 50.00-$99.99	Add $0.25	$ 500.00-$999.99	Less 20%
$100.00 & Up	No Charge	$1000.00 & Up	Less 25%

DIGI-KEY CORPORATION 800-346-5144

In Mn., Ak., Hi. Call 218-681-6674

VISA

NATIONAL SEMICONDUCTOR • PANASONIC • AAVID • CHEMWIK • BISHOP GRAPHICS • N. ARIES • PLESSEY • MOLEX • AAVID • E. F. J. OK MACHINE • UNGAR • GC CHEMICALS • A. NATIONAL SEMICONDUCTOR • PANASONIC •

QUALITY — Name brand products from nationally recognized manufacturers.

SERVICE — Computerized order processing and inventory control.

SAVINGS — Volume Discounts • OEM Quantity Pricing • Toll Free 800 Number

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DIGI-KEY — DIGI-KEY — DIGI-KEY — DIGI-KEY — DIGI-KEY — DIGI-KEY — DIGI-KEY — The Big DIGI-KEY Discount makes a Big Price Difference (SEE BELOW)

ITT SILICON RECTIFIERS ZENER DIODES

3 AMP SILICON RECTIFIER

IF	PIV	Surge	VF
3A	50V	100A	1.1V

Part No.	1	10	100	1000
PR5400	.35	3.00	27.50	250.00

ITT RECTIFIERS

Cat. No.	Description	Pkg.	10	100	1000	10,000
1N4001	1 Amp 50 PIV	DO 41	.80	7.00	60.00	540.00
1N4002	1 Amp 100 PIV	DO 41	.80	7.00	60.00	540.00
1N4003	1 Amp 200 PIV	DO 41	.80	7.50	64.00	576.00
1N4004	1 Amp 400 PIV	DO 41	.80	7.90	68.00	612.00
1N4005	1 Amp 600 PIV	DO 41	1.00	8.00	74.00	666.00
1N4006	1 Amp 800 PIV	DO 41	1.00	9.00	80.00	720.00
1N4007	1 Amp 1000 PIV	DO 41	1.50	12.00	100.00	900.00
1N4148	Ultra Fast Switching Diode (1N914 equiv.)	DO 41	.60	5.00	37.00	276.60

ITT SILICON ZENER DIODES

Catalog Number	Description	Unit Price	10
1N5226B	3.3 V 5% 500mW Zener (1N746A equiv.)	.24	1.80
1N5227B	3.6 V 5% 500mW Zener (1N747A equiv.)	.24	1.80
1N5228B	3.9 V 5% 500mW Zener (1N748A equiv.)	.24	1.80
1N5229B	4.3 V 5% 500mW Zener (1N749A equiv.)	.24	1.80
1N5230B	4.7 V 5% 500mW Zener (1N750A equiv.)	.24	1.80
1N5231B	5.1 V 5% 500mW Zener (1N751A equiv.)	.24	1.80
1N5232B	5.6 V 5% 500mW Zener (1N752A equiv.)	.24	1.80
1N5233B	6.0 V 5% 500mW Zener	.24	1.80
1N5234B	6.2 V 5% 500mW Zener (1N753A equiv.)	.24	1.80
1N5235B	6.8 V 5% 500mW Zener (1N957B equiv.)	.24	1.80
1N5236B	7.5 V 5% 500mW Zener (1N958B equiv.)	.24	1.80
1N5237B	8.2 V 5% 500mW Zener (1N959B equiv.)	.24	1.80
1N5238B	8.7 V 5% 500mW Zener	.24	1.80
1N5239B	9.1 V 5% 500mW Zener (1N960B equiv.)	.24	1.80
1N5240B	10 V 5% 500mW Zener (1N961B equiv.)	.24	1.80
1N5241B	11 V 5% 500mW Zener (1N962B equiv.)	.24	1.80
1N5242B	12 V 5% 500mW Zener (1N963B equiv.)	.24	1.80
1N5243B	13 V 5% 500mW Zener (1N964B equiv.)	.24	1.80
1N5244B	14 V 5% 500mW Zener	.24	1.80
1N5245B	15 V 5% 500mW Zener (1N965B equiv.)	.24	1.80
1N5246B	16 V 5% 500mW Zener (1N966B equiv.)	.24	1.80
1N5247B	17 V 5% 500mW Zener	.24	1.80
1N5248B	18 V 5% 500mW Zener (1N967B equiv.)	.24	1.80
1N5249B	19 V 5% 500mW Zener	.24	1.80
1N5250B	20 V 5% 500mW Zener (1N968B equiv.)	.24	1.80
1N5251B	22 V 5% 500mW Zener (1N969B equiv.)	.24	1.80
1N5252B	24 V 5% 500mW Zener (1N970B equiv.)	.24	1.80
1N5253B	25 V 5% 500mW Zener	.24	1.80
1N5254B	27 V 5% 500mW Zener (1N971B equiv.)	.24	1.80
1N5255B	28 V 5% 500mW Zener	.24	1.80
1N5256B	30 V 5% 500mW Zener (1N972B equiv.)	.24	1.80
1N5257B	33 V 5% 500mW Zener (1N973B equiv.)	.24	1.80

Littlefuse Fuses

3AG "NORMAL-BLO" FUSES

DIGI-KEY Part No.	Amp. Rtg.	5	100	1,000
F100 ND	.010	13.70	208.00	926.00/M
F101 ND	.031	11.00	165.00	741.00/M
F102 ND	.062	4.00	60.00	270.00/M
F103 ND	.100	4.00	60.00	270.00/M
F104 ND	.125	4.00	60.00	270.00/M
F105 ND	.150	4.00	60.00	270.00/M
F106 ND	.175	4.00	60.00	270.00/M
F107 ND	.187	4.00	60.00	270.00/M
F108 ND	.200	4.00	60.00	270.00/M
F109 ND	.250	2.42	36.30	163.00/M
F110 ND	.300	2.42	36.30	163.00/M
F111 ND	.375	2.42	36.30	163.00/M
F112 ND	.500	2.42	36.30	163.00/M
F113 ND	.600	2.42	36.30	163.00/M
F114 ND	.750	2.42	36.30	163.00/M
F115 ND	1	1.24	18.60	84.00/M
F116 ND	1.250	1.24	18.60	84.00/M
F117 ND	1.500	1.24	18.60	84.00/M
F118 ND	1.600	1.24	18.60	84.00/M
F119 ND	2	1.24	18.60	84.00/M
F120 ND	2.500	1.24	18.60	84.00/M
F121 ND	3	1.24	18.60	84.00/M
F122 ND	4	1.98	29.70	134.00/M
F123 ND	5	1.98	29.70	134.00/M
F124 ND	6	1.98	29.70	134.00/M
F125 ND	7	2.42	41.10	321.00/M
F126 ND	8	2.74	41.10	185.00/M
F127 ND	10	2.74	41.10	185.00/M

3AG SLO-BLO FUSES

DIGI-KEY Part No.	Amp Rtg.	5	100	1,000
F300 ND	.010	6.90	104.00	467.00/M
F301 ND	.031	6.90	104.00	467.00/M
F302 ND	.040	6.90	104.00	467.00/M
F303 ND	.062	4.86	72.90	328.00/M
F304 ND	.100	4.86	72.90	328.00/M
F305 ND	.125	4.86	72.90	328.00/M
F306 ND	.150	4.86	72.90	328.00/M
F307 ND	.175	4.86	72.90	328.00/M
F308 ND	.187	4.86	72.90	328.00/M
F309 ND	.200	4.86	72.90	328.00/M
F310 ND	.250	4.86	72.90	328.00/M
F311 ND	.300	4.86	72.90	328.00/M
F312 ND	.375	4.86	72.90	328.00/M
F313 ND	.400	4.86	72.90	328.00/M
F314 ND	.500	4.86	72.90	328.00/M
F315 ND	.600	4.86	72.90	328.00/M
F316 ND	.700	4.86	72.90	328.00/M
F317 ND	.750	4.86	72.90	328.00/M
F318 ND	.800	4.86	72.90	328.00/M
F319 ND	1	4.86	72.90	328.00/M
F320 ND	1.200	4.42	66.30	298.00/M
F321 ND	1.250	4.42	66.30	298.00/M
F322 ND	1.500	4.42	66.30	298.00/M
F323 ND	1.600	4.42	66.30	298.00/M
F324 ND	1.800	4.42	66.30	298.00/M
F325 ND	2	4.42	66.30	298.00/M
F326 ND	2.250	4.42	66.30	298.00/M
F327 ND	2.500	4.42	66.30	298.00/M
F328 ND	2.800	4.42	66.30	298.00/M
F329 ND	3	4.42	66.30	298.00/M
F330 ND	3.200	4.42	66.30	298.00/M
F331 ND	4	4.42	66.30	298.00/M
F332 ND	5	4.42	66.30	298.00/M
F333 ND	6.250	3.54	7.08	53.10/M
F334 ND	7	3.54	53.10	239.00/M
F335 ND	8	3.54	53.10	239.00/M
F336 ND	10	3.54	53.10	239.00/M
F337 ND	12	3.54	53.10	239.00/M
F338 ND	15	3.54	53.10	239.00/M
F339 ND	20	3.54	53.10	239.00/M
F340 ND	25	3.54	53.10	239.00/M
F341 ND	30	3.54	53.10	239.00/M

3AG PANEL FUSEHOLDER

Black phenolic conforming to MIL M 14, type CFG. Rated at 20 amps for any voltage to 250. Includes neoprene washer, hex nut, and lock washer.

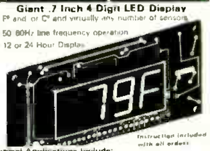
Part No.	1	10	100
F004 ND	1.89	15.00	94.50

National Semiconductor

MA1026 Time-Temp. Clock Module

Giant .7 Inch 4 Digit LED Display

- F° and or C° and virtually any number of sensors
- 50/60Hz line frequency operation
- 12 or 24 Hour Display



Instruction included with all orders

Typical Applications Include: Clock Radio Timers, Alarm Clock, Desk Clock, TV and Stereo Timer, Instrument Panel Clock, Digital Thermometer and much more.

Part No.	Description	Price
MA1026M	MA1026 clock module only	$27.79
MA1026P	Digi-Key switch panel kit (P.C. Board, 12 switches, two LM334Z temp sensors, two KDA32 potentiometers, instructions)	11.95
MA1026T	110 VAC transformer for MA1026M	3.10
MA1026B	Alarm buzzer for MA1026M	3.36
MA1026K	MA1026M, P, T, B	42.95

For additional sensor units, you will need:

LM334Z	Temperature Sensor	1.51
K4A32	300 ohm Potentiometer	.32
502PB	Normally open SPST Switch	.56

"Programmable" Clock Modules

0.7" or 0.84" Red 4-Digit LED Display

User Programmable For:

- 12 or 24 hour display
- 50/60 Hz line frequency
- Fixed or flashing dot (colon indicator)
- Display, hours and minutes, minute and seconds, alarm time, and sleep time
- Battery back up in case of power failure
- Typical applications include: clock radio timer, alarm clock, desk clock, instrument panel clock, and many more

MA1020 — 0.84 INCH HIGH DIGITS

Cat. No.	Description	Price
MA1020M	MA1020 Clock Module only	$17.55
MA1020P	Digi-Key switching panel (includes P.C. board, switches, hardware and instructions)	7.95
MA1020T	110 VAC Transformer for MA1020M	3.10
MA1020B	Buzzer for MA1020M alarm output	3.36
MA1020K	MA1020M, P, B and T	30.95

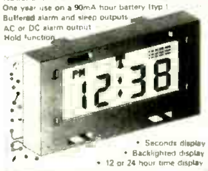
MA1023 — 0.7 INCH HIGH DIGITS

Cat. No.	Description	Price
MA1023M	MA1023 Clock Module only	$11.70
MA1023P	Digi-Key switching panel (includes P.C. board, switches, hardware and instructions)	6.95
MA1023T	110 VAC Transformer for MA1023M	3.10
MA1023B	Buzzer for MA1023 alarm output	3.36
MA1023K	MA1023M, P, B and T	23.95

.5" 4-Digit LCD Clock

National Semiconductor MA1032 Clock Module

- One year use on a 90mA hour battery (typ.)
- Buffered alarm and sleep outputs
- AC or DC alarm output
- Hold function

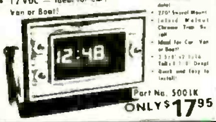


- Seconds display
- Backlighted display
- 12 or 24 hour time display

Cat. No.	Description	Price
MA1032M	MA1032 Clock Module only	$17.95
MA1032C	Switches for MA1032	2.85
MA1032R	MA1032M, C, and AA battery holder	21.20

DIGI-CLOCK KIT

12 VDC — Ideal for Car, Van or Boat!



Part No. 5001K ONLY $17.95

LED's — Red, Green, Amber, Orange

3 mm, 4 mm, 5 mm, Round, Rectangular Arrow

Color	Part No.	10	100	Size MM	Shape
Red Diffused	P300	2.20	19.50	5	Round
Red Clear	P301	2.20	19.50	5	Round
Green Clear	P302	2.20	19.50	5	Round
Green Diffused	P303	2.20	19.50	5	Round
Amber Clear	P304	2.20	19.50	5	Round
Orange Clear	P305	2.20	19.50	5	Round
Amber Diffused	P306	2.20	19.50	5	Round
Orange Diffused	P307	2.20	19.50	5	Round
Red Diffused	P308	2.20	19.50	3	Round
Red Clear	P309	2.20	19.50	3	Round
Green Clear	P310	2.20	19.50	3	Round
Amber Clear	P311	2.20	19.50	3	Round
Red Clear	P312	2.20	19.50	4	Round
Green Clear	P313	2.20	19.50	4	Round
Amber Diffused	P314	2.20	19.50	4	Round
Red Diffused	P315	3.12	26.00	3×5	Rectangle
Green Diffused	P316	3.12	26.00	3×5	Rectangle
Amber Diffused	P317	3.12	26.00	3×5	Rectangle
Red Diffused	P318	2.20	19.50	4×5	Arrow
Green Diffused	P319	3.12	26.00	4×5	Arrow
Amber Diffused	P320	3.12	26.00	4×5	Arrow

Panasonic LED Numeric Displays

Red, Green, Amber and Orange Colors — Direct Drive

Comm. Anode	Comm. Cath.	Digits	Color	Size In.	1	10	100
P322	P343	8	Red	.3	1.25	11.50	105.00
P323	P344	8	Green	.3	1.58	14.50	132.00
P324	P345	8	Amber	.3	1.93	17.70	162.00
P325	P346	8	Orange	.3	1.93	17.70	162.00
P326	P347	8	Red	.43	1.45	13.30	122.00
P327	P348	8	Green	.43	1.78	16.30	149.00
P328	P349	8	Amber	.43	2.10	19.30	176.00
P329	P350	8	Orange	.43	2.10	18.32	176.00
P330	P351	8	Red	.57	1.56	14.50	132.00
P331	P352	8	Green	.57	1.90	17.50	159.00
P332	P353	8	Amber	.57	1.93	17.70	162.00
P333	P354	8	Orange	.57	2.25	20.70	188.00
P334	P355	88	Red	.43	2.10	19.30	175.00
P335	P356	88	Green	.43	2.45	22.50	205.00
P336	P357	88	Amber	.43	3.08	28.30	257.00
P337	P358	88	Red	.57	2.10	19.30	175.00
P338	P359	88	Green	.57	2.45	22.50	205.00
P339	P360	88	Amber	.57	3.58	32.90	299.00
P340*	P361*	8888	Red	.28	5.35	49.20	448.00
P341*	P362*	8888	Green	.28	6.15	56.60	515.00

* Multiplexed Display

Silicon Transistors

DIGI-KEY Part No.	1	10	100	1,000
2N3055	1.44	12.00	108.00	960.00
2N3904	.20	1.79	16.25	146.25
2N3906	.20	1.79	16.25	146.25
2N4124	.21	1.93	17.50	157.50
2N4126	.22	2.01	18.25	164.25
2N4401	.21	1.93	17.50	157.50
2N4403	.21	1.93	17.50	157.50
2N4410	.30	2.70	24.38	219.38
2N5087	.24	2.20	20.00	180.00
2N5089	.24	2.20	20.00	180.00
2N5210	.27	2.48	22.50	202.50
2N5457	.54	4.86	43.88	394.88
92PU01A	.38	3.42	30.88	277.88
92PU10	.38	3.42	30.88	277.88
92PU45A	.41	3.69	33.32	299.82
92PU51A	.38	3.42	30.88	277.88
MJ2955	1.47	13.48	122.50	1102.25
MJE172	.74	6.66	60.13	541.13
MJE182	.65	5.56	46.25	416.25
MJE3439	.56	4.80	40.00	360.00
MJE344	.68	6.12	55.25	497.25
MJE370	.89	8.01	72.32	650.82
MJE371	1.10	9.90	89.38	804.38
MJE520	.86	7.74	69.88	628.88
MJE521	.86	7.74	69.88	628.88
MJE703	1.13	10.17	91.82	826.31
MJE712	.74	6.66	60.13	541.13
MJE722	.74	6.66	60.13	541.13
MJE803	1.01	9.09	82.07	738.57
MPF102	.54	4.95	45.00	405.00
MPS2222A	.21	1.93	17.50	157.50
MPS2369A	.24	2.20	20.00	180.00
MPS2907A	.24	2.20	20.00	180.00
MPS3392	.23	2.07	18.75	169.00
MPS3393	.21	1.93	17.50	157.50
MPS3394	.24	2.20	20.00	180.00
MPS3395	.24	2.20	20.00	180.00
MPS3563	.21	1.93	17.50	157.50
MPS3565	.21	1.93	17.50	157.50
MPS3638A	.21	1.93	17.50	157.50
MPS3641	.21	1.93	17.50	157.50
MPS3643	.21	1.93	17.50	157.50
MPS5918	.22	1.98	17.88	160.88
MPS5930	.21	1.93	17.50	157.50
MPSA13	.27	2.48	22.50	202.50
TIP112	.98	8.40	70.00	630.00
TIP117	1.12	10.08	91.00	819.00
TIP120	1.17	10.73	97.50	877.50
TIP122	1.54	13.20	110.00	990.00
TIP127	1.54	13.20	110.00	990.00
TIP132	2.32	20.88	188.50	1696.50
TIP135	2.32	20.88	188.50	1696.50
TIP29C	.81	6.90	57.50	517.50
TIP30C	.81	6.90	57.50	517.50
TIP31C	.98	8.40	70.00	630.00
TIP32C	1.02	8.70	72.50	652.50
TIP61C	.81	6.90	57.50	517.50
TIP62C	.81	6.90	57.50	517.50

1% Metal Film Resistors

¼ Watt • TW • Temperature Coefficient: 100 ppm/°C

Max. RC WV: 250V. Max. Voltage: 500V. Dielectric Withstanding Voltage: 500V

Standard Resistor Values from 10 to 1.00M ohms

STANDARD RESISTOR VALUE TABLE

[illegible]

How To Order: Take any standard resistor value (2.32K) and add an "X" (2.32KX); this is the DIGI-KEY part number. Order by quantity and price listed below.

	5 for	100 for	1000 for
¼ Watt 1% Metal Film	.50	$3.90	$30.00

For large quantities and prices as low as $9.25 M contact DIGI-KEY

5% Carbon Film Resistors

Specifications

[illegible]

5% Carbon Film Resistor Values in Ohms

[illegible]

When ordering individual resistors, place a "Q" after the ohms value for ¼W and an "H" for ½W resistors.

¼ WATT 5% CARBON FILM RESISTOR ASSORTMENT

RS125	5 each of 73 values in the series 1.0, 1.2, 1.5, 1.8, 2.2, etc. to 1M ohm of the ¼W 5% resistor for a total of 365 pieces	$9.90
RS225	5 each of 72 values in the series 1, 1.3, 1.6, 2.0, 2.4 etc. to 910K ohm of the ¼W 5% resistor for a total of 360 pieces	$9.90

½ WATT 5% CARBON FILM RESISTOR ASSORTMENT

RS150	5 each of 73 values in the series 1.0, 1.2, 1.5, 1.8, 2.2 etc. to 1M ohm of the ½W 5% resistor for a total of 365 pieces	$9.90
RS250	5 each of 72 values in the series 1, 1.3, 1.6, 2.0, 2.4 etc. to 910K ohm of the ½W 5% resistor for a total of 360 pieces	$9.90

Remember: a "Q" after the resistance value indicates a ¼ watt, an "H" indicates a ½ watt (i.e., 10KQ or 10KH). Prices are for single values.

¼ Watt	5 for 25¢, 200 for $3.40, 1000 for $13.00
½ Watt	5 for 25¢, 200 for $3.60, 1000 for $16.00

In order to receive the pricing below, the resistor part number must be followed by a "ND" (i.e. 10KQ ND) and ordered in multiples of 1,000 only.

Price /1000	1M	10M	50M	100M	500M	1000M
¼W	8.10 M	7.20 M	5.80 M	5.40 M	4.50 M	4.00 M
½W	12.25 M	10.25 M	9.50 M	8.90 M	7.40 M	6.85 M

ROBINSON NUGENT, INC.

TERMINATION JUMPERS

S = SOCKET CONNECTOR TERMINATION

P = PCB CONNECTOR TERMINATION

X = CARD EDGE CONNECTOR TERMINATION

Number After Dash Is Cable Length In Inches

[Termination jumper price tables (styles 1A, 1B, 1H, 2A, 2B, 2H, 3A, 3B, 3H, C, D, E; Robinson Nugent part numbers R300–R422 with 6, 12, 18, 24, 36 inch lengths, priced at 1, 10, 100, 1000) — illegible at this resolution]

DIP Jumper Cable Assembly

Standard Assembly Styles

Style 2, Style 4, Style 6, Style 8, Style 0

Dot Indicates Pin 1

Number After Dash Is Cable Length In Inches

[DIP jumper cable price table (R102–R140, 14–40 contacts, styles 0–8, priced at 1, 10, 100, 1000) — illegible at this resolution]

alpha wire cable tubing

Hookup Wire, Stranded, PVC Insulated

[illegible]

Hookup Wire, Solid, PVC Insulated

[illegible]

Multiconductor Solid PVC Insulated Cable

[illegible]

Multipair Individually Foil Shielded Cable

[illegible]

Multiconductor Stranded PVC Insulated Cable

[illegible]

See Your FREE DIGI-KEY Catalog For Color Codes

Twisted Pair, Solid, Comm. and Control Cable

[illegible]

See Your FREE DIGI-KEY Catalog For Color Codes

Shrinkable Tubing, Polyolefin, Black

UL and CSA Accepted. Flame Retarded. Self Extinguishing.

[illegible]

Adhesive Wall Shrinkable Tubing, Black

MIL-I-23053/4B Class 2. Flame Retarded. Self Extinguishing. Waterproof.

[illegible]

Self-Encapsulating Caps, Black

Inexpensive Method of Encapsulating Electrical Connections or Sensors

[illegible]

D-Subminiature Connectors

9, 15, 25, 37, and 50 contact solder pot contacts. Accommodates up to 20 AWG standard wire. Current Rating of 5 Amps. Contacts: Pin, copper alloy, gold over nickel plate. Socket, phosphor bronze, gold over nickel plate. Temperature Range: -55° to 120°C

DIGI-KEY Part No.	Style	1	10	100	1,000
1S9P ND	9 Pin Male	1.66	13.50	120.00	900.00
1S9S ND	9 Pin Female	2.18	17.78	158.00	1185.00
1S15P ND	15 Pin Male	2.20	18.00	160.00	1200.00
1S15S ND	15 Pin Female	3.03	24.75	220.00	1650.00
1S25P ND	25 Pin Male	3.00	24.53	218.00	1635.00
1S25S ND	25 Pin Female	4.42	36.23	322.00	2415.00
1S37P ND	37 Pin Male	4.13	33.75	300.00	2250.00
1S37S ND	37 Pin Female	6.19	50.63	450.00	3375.00
1S50P ND	50 Pin Male	5.25	42.98	382.00	2865.00
1S50S ND	50 Pin Female	8.20	67.05	596.00	4470.00
HD9 ND	9 Pin Hood	1.62	13.50	108.00	810.00
HD15 ND	15 Pin Hood	1.62	13.50	108.00	810.00
HD25 ND	25 Pin Hood	1.62	13.50	108.00	810.00
HD37 ND	37 Pin Hood	1.80	15.00	120.00	900.00
HD50 ND	50 Pin Hood	2.01	16.75	134.00	1005.00

The Digi-Key volume discount and handling charges are simple to apply. Most items sold by Digi-Key may be combined for a volume discount. Items that are not discountable are identified by the suffix-ND following the part number. After writing your order, total all of the discountable items and apply the appropriate discount. To this subtotal, add the non-discountable items. Then add the handling charge. We pay all shipping and insurance to addresses in the U.S.A., Canada and Mexico when check or money order accompanies order.

WHEN ORDERING BY PHONE, CALL: 1-800-346-5144 (Mn., Ak., Hi., call 218-681-6674) By mail send your order to: DIGI-KEY, Highway 32 South, Thief River Falls, MN 56701

You may pay by check, money order, Master Charge, VISA or C.O.D. ***DIGI-KEY GUARANTEE:*** Any parts or products purchased from Digi-Key that prove to be defective will be replaced or refunded if returned within 90 days from receipt with a copy of your invoice. Prices subject to change without notice.

HANDLING CHARGES		VOLUME DISCOUNT	
$0.00-$9.99	Add $2.00	$0.00-$99.99	NET
$10.00-$25.00	Add $0.75	$100.00-$249.99	Less 10%
$25.00-$49.99	Add $0.50	$250.00-$499.99	Less 15%
$50.00-$99.99	Add $0.25	$500.00-$999.99	Less 20%
$100.00 & Up	No Charge	$1000.00 & Up	Less 25%

CIRCLE NO. 14 ON FREE INFORMATION CARD

7400

**Number of Pins of each I.C. for easy Socket purchase

Part No.	**Pins	Price
SN7400N	14	.19
SN7401N	14	.19
SN7402N	14	.25
SN7403N	14	.25
SN7404N	14	.25
SN7405N	14	.25
SN7406N	14	.29
SN7407N	14	.29
SN7408N	14	.25
SN7409N	14	.25
SN7410N	14	.25
SN7411N	14	.25
SN7412N	14	.35
SN7413N	14	.35
SN7414N	14	.49
SN7416N	14	.25
SN7417N	14	.25
SN7420N	14	.19
SN7421N	14	.35
SN7422N	14	.45
SN7423N	16	.59
SN7425N	14	.29
SN7426N	14	.29
SN7427N	14	.25
SN7428N	14	.49
SN7430N	14	.25
SN7432N	14	.29
SN7437N	14	.25
SN7438N	14	.29
SN7439N	14	.59
SN7440N	14	.19
SN7441N	16	.89
SN7442N	16	.45
SN7443N	16	.99
SN7444N	16	.99
SN7445N	16	.69
SN7446N	16	.69
SN7447N	16	.69
SN7448N	16	.69
SN7450N	14	.19
SN7451N	14	.19
SN7453N	14	.19
SN7454N	14	.19
SN7459A	14	.25
SN7460N	14	.19
SN7470N	14	.29
SN7472N	14	.29
SN7473N	14	.35
SN7474N	14	.35
SN7475N	16	.45
SN7476N	16	.35
SN7479N	14	4.95
SN7480N	14	.69
SN7482N	14	1.19
SN7483N	16	.59
SN7485N	16	.59
SN7486N	14	.35
SN7489N	16	2.25
SN7490N	14	.39
SN7491N	14	.59
SN7492N	14	.39
SN7493N	14	.39
SN7494N	14	.69
SN7495N	14	.49
SN7496N	16	.49
SN7497N	16	2.75
SN74100N	24	1.49
SN74104N	14	.89
SN74105N	14	.89
SN74107N	14	.29
SN74109N	16	.39
SN74116N	24	1.49
SN74121N	14	.39
SN74122N	14	.55
SN74123N	16	.49
SN74125N	14	.45
SN74126N	14	.45
SN74132N	14	.49
SN74136N	14	.69
SN74141N	16	.69
SN74142N	16	2.95
SN74143N	24	2.95
SN74144N	24	2.95
SN74145N	16	.59
SN74147N	16	1.49
SN74148N	16	1.19
SN74150N	24	1.19
SN74151N	16	.59
SN74152N	14	.59
SN74153N	16	.59
SN74154N	24	1.25
SN74155N	16	.59
SN74156N	16	.59
SN74157N	16	.59
SN74160N	16	.69
SN74161N	16	.69
SN74162N	16	.69
SN74163N	16	.69
SN74164N	14	.69
SN74165N	16	.69
SN74166N	16	.89
SN74167N	16	2.79
SN74170N	16	1.29
SN74172N	24	4.95
SN74173N	16	.69
SN74174N	16	.69
SN74175N	16	.69
SN74176N	14	.69
SN74177N	14	.69
SN74179N	16	1.49
SN74180N	14	.69
SN74181N	24	1.95
SN74182N	16	.89
SN74184N	16	1.95
SN74185N	16	1.95
SN74190N	16	.69
SN74191N	16	.69
SN74192N	16	.69
SN74193N	16	.69
SN74194N	16	.69
SN74195N	16	.69
SN74196N	14	.89
SN74197N	14	.89
SN74198N	24	1.19
SN74199N	24	1.19
SN74221N	16	1.19
SN74251N	16	.79
SN74276N	20	1.95
SN74279N	16	.79
SN74283N	16	1.49
SN74284N	16	2.95
SN74285N	16	2.95
SN74365N	16	.55
SN74366N	16	.55
SN74367N	16	.55
SN74368N	16	.55
SN74390N	16	1.49
SN74393N	14	1.49

74LS

Part No.	**Pins	Price
74LS00	14	.25
74LS01	14	.25
74LS02	14	.25
74LS03	14	.25
74LS04	14	.29
74LS05	14	.29
74LS08	14	.29
74LS09	14	.29
74LS10	14	.29
74LS11	14	.35
74LS12	14	.35
74LS13	14	.39
74LS14	14	.59
74LS15	14	.35
74LS20	14	.29
74LS21	14	.29
74LS22	14	.29
74LS26	14	.29
74LS27	14	.29
74LS28	14	.35
74LS30	14	.29
74LS32	14	.35
74LS33	14	.55
74LS37	14	.35
74LS38	14	.35
74LS40	14	.29
74LS42	16	.55
74LS47	16	.75
74LS48	16	.75
74LS49	14	.75
74LS51	14	.25
74LS54	14	.29
74LS55	14	.29
74LS73	14	.39
74LS74	14	.39
74LS75	16	.39
74LS76	16	.39
74LS78	14	.39
74LS83	16	.65
74LS85	16	.69
74LS86	14	.39
74LS90	14	.55
74LS92	14	.55
74LS93	14	.55
74LS95	14	.79
74LS96	16	.89
74LS107	14	.39
74LS109	16	.39
74LS112	16	.39
74LS113	14	.39
74LS114	14	.39
74LS122	14	.49
74LS123	16	.79
74LS125	14	.49
74LS126	14	.49
74LS132	14	.59
74LS133	16	.59
74LS136	14	.39
74LS138	16	.59
74LS139	16	.59
74LS151	16	.59
74LS153	16	.59
74LS154	24	.99
74LS155	16	.69
74LS156	16	.69
74LS157	16	.69
74LS158	16	.59
74LS160	16	.69
74LS161	16	.69
74LS162	16	.69
74LS163	16	.69
74LS164	14	.69
74LS165	16	1.19
74LS166	16	1.19
74LS168	16	1.19
74LS169	16	1.19
74LS170	16	1.49
74LS173	16	.69
74LS174	16	.59
74LS175	16	.59
74LS181	24	2.49
74LS190	16	.89
74LS191	16	.89
74LS192	16	.79
74LS193	16	.79
74LS194	16	.69
74LS195	16	.69
74LS197	14	.79
74LS221	16	.89
74LS240	20	1.09
74LS241	20	1.09
74LS242	14	1.09
74LS243	14	1.09
74LS244	20	1.09
74LS245	20	1.49
74LS247	16	1.09
74LS248	16	1.09
74LS249	16	1.09
74LS251	16	.59
74LS253	16	.59
74LS257	16	.59
74LS258	16	.59
74LS260	14	.59
74LS266	14	.59
74LS273	20	1.49
74LS279	16	.49
74LS283	16	.69
74LS290	14	.89
74LS293	14	.79
74LS298	16	.89
74LS352	16	1.29
74LS353	16	1.29
74LS365	16	.49
74LS366	16	.49
74LS367	16	.49
74LS368	16	.49
74LS373	20	1.29
74LS374	20	1.29
74LS375	16	.69
74LS386	14	.45
74LS393	14	1.19
74LS399	16	1.49
74LS670	16	1.49
81LS95	20	1.49
81LS97	20	1.49

74S/PROMS*

Part No.	**Pins	Price
74S00	14	.35
74S02	14	.35
74S03	14	.35
74S04	14	.35
74S05	14	.45
74S08	14	.39
74S09	14	.39
74S10	14	.35
74S11	14	.35
74S15	14	.35
74S20	14	.35
74S22	14	.35
74S30	14	.35
74S32	14	.45
74S38	14	.89
74S40	14	.39
74S51	14	.35
74S64	14	.39
74S65	14	.39
74S74	14	.55
74S86	14	.55
74S112	16	.55
74S113	14	.55
74S114	14	.55
74S124	16	2.95
74S133	16	.45
74S134	16	.50
74S135	16	.89
74S136	14	1.39
74S138	16	.89
74S139	16	.89
74S140	14	.55
74S151	16	.99
74S153	16	.99
74S157	16	.99
74S158	16	.99
74S160	16	2.49
74S174	16	.99
74S175	16	.99
74S188*	16	1.49
74S194	16	1.49
74S195	16	1.49
74S196	14	1.49
74S240	20	2.25
74S241	20	2.25
74S242	14	2.49
74S243	14	2.49
74S244	20	2.49
74S251	16	1.19
74S253	16	1.19
74S257	16	1.19
74S258	16	1.19
74S260	14	.79
74S280	14	1.95
74S287*	16	1.95
74S288*	16	1.95
74S373	20	2.49
74S374	20	2.49
74S387*	16	1.95
74S471*	20	5.95
74S472*	20	4.95
74S473*	20	4.95
74S474*	24	4.95
74S475*	24	4.95
74S570*	16	2.95
74S571*	16	2.95
74S572*	18	4.95
74S573*	18	4.95
74S940	20	2.49
74S941	20	2.49

CA—LINEAR

Part No.	**Pins	Price
CA3010H		.99
CA3013H		2.15
CA3023H		3.25
CA3035H		5.95
CA3039H		1.35
CA3046N	14	.89
CA3059N	14	3.25
CA3060N	16	3.25
CA3080E	8	.89
CA3081N	16	1.49
CA3082N	16	1.49
CA3083N	16	1.49
CA3086N	14	.69
CA3089N	16	1.69
CA3096N	16	1.19
CA3130E	8	1.49
CA3140E	8	.99
CA3160H		1.95
CA3401N	14	.59
CA3600N	14	3.95

CD—CMOS

Part No.	**Pins	Price
CD4000	14	.29
CD4001	14	.29
CD4002	14	.29
CD4006	14	.89
CD4007	14	.29
CD4009	16	.39
CD4010	16	.39
CD4011	14	.29
CD4012	14	.15
CD4013	14	.39
CD4014	16	.79
CD4015	16	.39
CD4016	14	.39
CD4017	16	.75
CD4018	16	.79
CD4019	16	.39
CD4020	16	.75
CD4021	16	.79
CD4022	16	.79
CD4023	14	.29
CD4024	14	.69
CD4025	14	.23
CD4026	16	2.49
CD4027	16	.45
CD4028	16	.69
CD4029	16	.79
CD4030	14	.39
CD4034	24	1.95
CD4035	16	.89
CD4040	16	.79
CD4041	14	.79
CD4042	16	.69
CD4043	16	.79
CD4044	16	.79
CD4046	16	.89
CD4047	14	.89
CD4048	16	.39
CD4049	16	.39
CD4050	16	.39
CD4051	16	.79
CD4052	16	.79
CD4053	16	.79
CD4056	16	2.95
CD4059	24	7.95
CD4060	16	.89
CD4066	14	.39
CD4068	14	.39
CD4069	14	.29
CD4070	14	.39
CD4071	14	.29
CD4072	14	.29
CD4073	14	.29
CD4075	14	.29
CD4076	16	.79
CD4078	14	.49
CD4081	14	.29
CD4082	14	.29
CD4093	14	.49
CD4098	16	1.95
CD4506	16	1.19
CD4507	14	.39
CD4508	24	3.95
CD4510	16	.89
CD4511	16	.89
CD4512	16	.89
CD4514	24	1.79
CD4515	24	1.79
CD4516	16	.99
CD4518	16	.99
CD4519	16	.39
CD4520	16	.79
CD4526	16	1.19
CD4528	16	1.19
CD4529	16	1.19
CD4543	16	1.19
CD4562	14	6.95
CD4566	16	1.39
CD4583	16	2.49
CD4584	14	.59
CD4723	16	1.19
CD4724	16	1.19
MC14409	16	13.95
MC14410	16	13.95
MC14411	24	11.95
MC14412	16	13.95
MC14419	16	7.95
MC14433	24	13.95
MC14538	16	1.19
MC14541	14	1.19

(More in Catalog)

MICROPROCESSOR COMPONENTS

MICROPROCESSOR CHIPS

Part No.	**Pins	Function	Price
CDP1802	40	CPU	$9.95
2650	40	MPU	14.95
IDM2901ADC	40	CPU—4-bit slice (Com. Temp. Gr.)	19.95
MCS6502	40	MPU w/Clock (65K bytes mem.)	9.95
MC6802CP	40	MPU w/Clock and RAM	7.95
INS8035N-6	40	MPU—8-bit (6MHz)	5.95
INS8039N-6	40	CPU-Sgl. chip 8-bit (128 bts. Ram)	5.95
INS8040N-6	40	CPU (256 bytes RAM)	5.95
INS8070N	40	CPU (64 bytes RAM)	11.95
INS8073N	40	CPU w/Basic Micro Interpreter	14.95
P8085A	40	CPU	5.95

Z80, Z80A, Z80B, Z8000 SERIES

Part No.	**Pins	Function	Price
Z80	40	CPU (MK3880N)(780C) 2MHz	$4.95
Z80-CTC	28	Counter Timer Circuit	5.95
Z80-DART	40	Dual Asynchronous Rec./Trans.	11.95
Z80-DMA	40	Direct Memory Access Circuit	15.95
Z80-P10	40	Parallel I/O Interface Controller	5.95
Z80-S10/0	40	Serial I/O (TxCB and RxCB Bonded)	15.95
Z80-S10/1	40	Serial I/O (Lacks DTRB)	15.95
Z80-S10/2	40	Serial I/O (Lacks SYNCB)	15.95
Z80-S10/9	40	Serial I/O	15.95
Z80A	40	CPU (MK3880N-4)(780C-1) 4MHz	5.95
Z80A-CTC	28	Counter Timer Circuit	5.95
Z80A-DART	40	Dual Asynchronous Rec./Trans.	11.95
Z80A-DMA	40	Direct Memory Access Circuit	17.95
Z80A-P10	40	Parallel I/O Interface Controller	5.95
Z80A-S10/0	40	Serial I/O (TxCB and RxCB bonded)	16.95
Z80A-S10/1	40	Serial I/O (Lacks DTRB)	16.95
Z80A-S10/2	40	Serial I/O (Lacks SYNCB)	16.95
Z80A-S10/9	40	Serial I/O	16.95
Z80B	40	CPU (MK3880N-6) 6MHz	11.95
Z80B-CTC	28	Counter Timer Circuit	13.95
Z80B-P10	40	Parallel I/O Interface Controller	13.95
Z8001	48	CPU Segmented	51.95
Z8002	40	CPU Non-Segmented	55.95
Z8030	40	Serial Comm. Controller	44.95
Z8036	40	Counter/Timer & Parallel I/O Unit	29.95

6800/68000 SERIES

Part No.	**Pins	Function	Price
MC6800	40	MPU	4.95
MC6802CP	40	MPU with clock and RAM	7.95
MC6810APl	24	128x8 Static RAM	3.95
MC6821	40	Peripheral Inter. Adapt (MC6820)	4.95
MC6828	24	Priority Interrupt Controller	15.95
MC6830L8	24	1024x8-bit ROM (MC68A30-8)	10.95
MC6850	24	Asynchronous Comm. Adapter	4.95
MC6852	24	Synchronous Serial Data Adapter	5.75
MC6860	24	0-600bps Digital MODEM	9.95
MC6862	24	2400bps Modulator	12.95
MC6880A	16	Quad 3-state bus. trans. (MC8T26)	2.25
MC68000L8	64	MPU 16-Bit (8MHz)	69.95
MC68488P	40	General Purpose Int. Adapter	8.95
MC68652P2	40	Multi. Protocol Comm. Controller	24.95
MC68661PB	28	Enhanced Prog. Comm. Int.	8.95
SY6522	40	Peripheral Inter. Adapter	7.95

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Part No.	**Pins	Function	Price
INS8080A	40	CPU	3.95
TMS5501	40	Synchronous Data Interface (SIRC)	14.95
INS8154	40	128 Byte RAM 16-Bit I/O	13.95
INS82C06	20	Octal D Flip Flop Tri State (74C374)	2.49
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DP8214	24	Priority Interrupt Control	3.95
DP8216	16	Bi-Directional Bus Driver	2.25
DP8224	16	Clock Generator/Driver	2.25
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INS8248	28	Display Controller (74C912)	8.95
INS8250N	40	Asyn. Comm. Element	10.95
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DP8255	40	Prog. Peripheral I/O (PPI)	4.49
DP8257	40	Prog. DMA Control	7.95
DP8259	28	Prog. Interrupt Control	6.95
DP8275	40	Prog. CRT Controller	29.95
DP8279	40	Prog. Keyboard/Display Interface	8.95
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DP8304	20	8-bit Bi-Directional Receiver	2.49
DP8307	20	8-bit Bi-Directional Receiver	2.49
DP8308	20	8-bit Bi-Directional Receiver	2.49
DP8310	20	Octal Latched Peripheral Driver	4.95
DP8311	20	Octal Latched Peripheral Driver	4.95

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M-Z80	User Manual	7.50
M-CDP1802	User Manual	7.50
M-2650	User Manual	5.00
30001	1982 Nat. Linear Data Book (1952 pg.)	11.95
30008	1980 Nat. Memory Data Book (464 pg.)	6.95
30011	1980 Nat. Linear Applications (736 pg.)	15.95
30013	1983 Zilog Data Book (641 pg.)	7.95

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Part No.	**Pins	Function	Price
DS0025CN	8	Dual MOS Clock Driver (5MZ)	2.49
DS0026CN	8	Dual MOS Clock Driver (5MZ)	1.95
INS1771N-1	40	Floppy Disk Controller	16.95
INS2651N	28	Communication Chip	8.95
MM58167N	24	Microprocessor Real Time Clock	8.95
MM58174N	16	Micro. Compatible Time Clock	7.95
COP402N	40	Microcontroller w/64-digit RAM and Direct LED Drive	5.95
COP402MN	40	Microprocessor w/64-digit RAM & Direct LED Drive w/N Buss Int.	5.95
COP470N	20	32-seg. VAC Fluor. Drvr. (20 pin pkg.)	3.25
MM5369EST	8	Prog. Oscillator/Divider (100Hz)	1.19

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Part No.	**Pins			Price
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4027	16	4096x1	(250ns)	2.49
4116N-2	16	16,384x1	(150ns)	1.89 - 8/14.95
4116N-3	16	16,384x1	(200ns)	1.69 - 8/12.95
4116N-4	16	16,384x1	(250ns)	1.49 - 8/10.95
4164N-150	16	65,536x1	(150ns)	7.95 - 8/59.95
4164N-200	16	65,536x1	(200ns)	7.49 - 8/54.95
MM5261	18	1024x1	(300ns)	.49 - 8/1.95
MM5262	22	2048x1	(365ns)	.49 — 8/1.95
MM5270	18	4096x1	(250ns) MK4096	4.95
MM5280	22	4096x1	(200ns) 2107	3.95
MM5290-2	16	16,384x1	(150ns)	1.89 - 8/14.95
MM5290-3	16	16,384x1	(200ns)	1.69 - 8/12.95
MM5290-4	16	16,384x1	(250ns)	1.49 - 8/10.95
MM5298-3	16	8192x1	(200ns)	1.69

STATIC RAMS

Part No.	**Pins			Price
1101	16	256x1	(650ns)	1.49
2101	22	256x4	(450ns) 8101	2.49
2102	16	1024x1	(350ns)	.89
21L02	16	1024x1	(450ns) L.P.	1.49
2111	18	256x4	(450ns) 8111	2.95
2112	16	256x4	(450ns) MOS	2.95
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2147	18	4096x1	(70ns)	4.95
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TMS4044	18	4096x1	(450ns)	3.95
TMS4045	18	1024x4	(450ns)	3.95
5101	22	256x4	(450ns) CMOS	4.95
MM5257	18	4096x1	(450ns) 4044	4.95
HM6116P-3	24	2048x8	(150ns) CMOS	7.95
HM6116-4	24	2048x8	(200ns) CMOS	6.95
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74C920	22	256x4	(250ns) CMOS (6551)	3.95
74C921	18	256x4	(250ns) CMOS	3.95
74C929	16	1024x1	(250ns) CMOS (6501)	3.95
74C930	18	1024x1	(250ns) CMOS (6518)	3.95
74S189	16	16x4	(35ns) 93405	1.95
74S200	16	256x1	(80ns) 93410	3.95
74S206	16	256x1	(60ns) 93411	3.95
74S289	16	16x4	(35ns) 3101	2.25
82S10	16	1024x1	(50ns) O.C. (93415)	3.95
82S25	16	16x4	(50ns) O.C. (74S289)	2.25

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Part No.	**Pins			Price
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2708	24	1024x8	(450ns)	3.95
2708-5	24	1024x8	(550ns) SM00246	2.95
TMS2516	24	2048x8	(450ns) 2716	6.95
TMS2532	24	4096x8	(450ns) NMC2532	9.95
TMS2564	28	8192x8	(450ns)	19.95
TMS2716	24	2048x8	(450ns) 3 voltage	7.95
2716	24	2048x8	(450ns)	4.95
2716-1	24	2048x8	(350ns)	6.95
2732	24	4096x8	(450ns)	9.95
2758Q	24	1024x8	(450ns) single +5V	2.95
MM2764	28	8192x8	(450ns)	16.95
MM2764-3	28	8192x8	(300ns)	19.95
MCM68764	24	8192x8	(450ns)	39.95
74S188	16	32x8	PROM O.C. (6330-1)	1.49
74S287	16	256x4	PROM T.S. (6301-1)	1.95
74S288	16	32x8	PROM T.S. (6331-1)	1.95
74S387	16	256x4	PROM O.C. (6300-1)	1.95
74S471	20	256x8	PROM T.S. (6309-1)	5.95
74S472	20	512x8	PROM T.S. (6349-1)	4.95
74S473	20	512x8	PROM O.C. (6348)	4.95
74S474	24	512x8	PROM T.S. (DM87S296N)	4.95
74S475	24	512x8	PROM O.C. (6340)	4.95
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74S571	16	512x4	PROM T.S. (6306)	2.95
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74S573	18	1024x4	PROM T.S. (82S137)	4.95
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82S123	16	32x8	PROM T.S. (27S19)	2.95
82S126	16	256x4	PROM O.C. (27S20)	3.95
82S129	16	256x4	PROM T.S. (27S21)	3.95
82S130	16	512x4	PROM O.C. (27S12)	5.95
82S185	18	2048x4	PROM T.S. (TBP24S81)	9.95
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DM87S181N	24	1024x8	PROM T.S. (82S181)	9.95
DM87S184N	18	2048x4	PROM O.C. (82S184)	9.95
DM87S185N	18	2048x4	PROM T.S. (82S185)	9.95
DM87S190N	24	2048x8	PROM O.C. (82S190)	19.95
DM87S191N	24	2048x8	PROM T.S. (82S191)	19.95

DATA ACQUISITION

Part No.	**Pins	Function	Price
DC10		Mostek DC/DC Convert. +5V to -9V	2.95
MC3470P	18	Floppy Disk Read AMP System	4.95
MC1408L7	16	7-bit D/A Converter (DAC0807LCN)	2.49
MC1408L8	16	8-bit D/A Converter (DAC0808LCN)	2.95
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DAC0806	16	8-bit D/A Converter (0.78% Lin.)	1.95
ADC0809	28	8-bit A/D Converter (8-Ch. Multi.)	4.49
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DAC1000	24	10-bit D/A Conv. Micro. Comp. (0.05%)	13.95
DAC1008	20	10-bit D/A Conv. Micro. Comp. (0.20%)	7.95
DAC1020	16	10-bit D/A Conv. (0.05% Lin.)	8.49
DAC1022	16	10-bit D/A Conv. (0.20% Lin.)	5.95
DAC1222	18	12-bit D/A Conv. (0.20% Lin.)	6.95
AF100-1CN	16	Universal Active Filter 2.5%	5.95
AF121-1CJ	24	Touch Tone Low Band Filter	19.95
AF122-1CJ	24	Touch Tone High Band Filter	19.95
LM334Z		Constant Current Source	1.19
LM335Z		Temperature Transducer	1.40
LM399H		Temp. Comp. Prec. Ref. (5ppm/C°)	5.00
AY-5-1013A	40	30K Baud Uart (TR1602)	4.95

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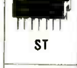
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74HC11	14	.69
74HC14	14	.85
74HC20	14	.75
74HC27	14	.75
74HC32	14	.75
74HC42	16	1.39
74HC73	14	.75
74HC74	14	.99
74HC75	16	.99
74HC76	16	.75
74HC85	16	2.19
74HC86	14	.99
74HC107	14	.75
74HC109	16	1.39
74HC112	16	.75
74HC113	14	.75
74HC132	14	.89
74HC138	16	1.49
74HC139	16	1.49
74HC147	16	1.19
74HC151	16	1.19
74HC153	16	.99
74HC157	16	1.19
74HC158	16	1.59
74HC160	16	1.79
74HC161	16	1.79
74HC164	14	1.79
74HC165	16	2.39
74HC173	16	1.59
74HC174	16	1.39
74HC175	16	1.39
74HC192	16	1.39
74HC193	16	1.39
74HC194	16	1.59
74HC195	16	1.49
74HC242	14	2.79
74HC243	14	2.79
74HC251	16	1.19
74HC253	16	.99
74HC257	16	1.19
74HC259	16	1.49
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74HC390	16	1.49
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74HC533	20	3.95
74HC534	20	3.95
74HC595		3.75
74HC688		3.19
74HC4002	14	.79
74HC4020	16	2.19
74HC4024	14	1.59
74HC4040	16	2.19
74HC4060	16	2.19
74HC4075	14	.75
74HC4078	14	.69
74HC4511	16	3.29
74HC4514	24	4.79
74HC4538	16	2.95
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74C08	14	.35
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74C14	14	.59
74C20	14	.35
74C30	14	.35
74C32	14	.39
74C42	16	1.39
74C48	16	1.95
74C73	14	.79
74C74	14	.69
74C85	16	1.95
74C86	14	.39
74C89	16	5.95
74C90	14	1.19
74C93	14	1.19
74C95	14	1.39
74C107	14	.89
74C151	16	2.49
74C154	24	3.49
74C157	16	2.25
74C160	16	1.19
74C161	16	1.19
74C162	16	1.19
74C163	16	1.19
74C164	14	1.49
74C173	16	.79
74C174	16	1.19
74C175	16	1.19
74C192	16	1.49
74C193	16	1.69
74C195	16	1.39
74C221	16	1.95
74C240	20	1.95
74C244	20	1.95
74C373	20	2.49
74C374	20	2.49
74C901	14	.59
74C903	14	.59
74C906	14	.59
74C911	28	8.95
74C912	28	8.95
74C915	18	1.19
74C917	28	8.95
74C922	18	4.49
74C923	20	4.95
74C925	16	5.95
74C926	18	5.95
80C95	16	.39
80C97	16	.39

LINEAR

Part No.	**Pins	Price
TL071CP	8	.79
TL072CP	8	1.39
TL074CN	14	1.95
TL081CP	8	.59
TL082CP	8	1.19
TL084CN	14	1.95
LM301CN	8	.35
LM302H		1.95
LM304H		1.95
LM305H		.99
LM307CN	8	.45
LM308CN	8	.69
LM309K		1.25
LM310CN	8	1.75
LM311CN	8	.69
LM312H		2.49
LM317T		1.19
LM317K		3.95
LM318CN	8	1.95
LM319N	14	1.95
LM320K-5		1.35
LM320K-12		1.35
LM320K-15		1.35
LM320T-5		.89
LM320T-12		.89
LM320T-15		.89
LM323K		5.95
LM324N	14	.59
LM337T		1.95
LM338K		6.95
LM339N	14	.69
LM340K-5		1.35
LM340K-12		1.35
LM340K-15		1.35
LM340T-5		.79
LM340T-12		.79
LM340T-15		.79
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LM350K		4.95
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LF356N	8	1.10
LM370N	14	4.49
LM373N	14	3.95
LM377N	14	1.95
LM380N	14	.89
LM381N	14	1.79
LM382N	14	1.39
LM384N	14	1.79
LM386N-3	8	.89
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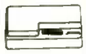

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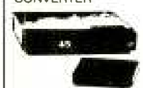

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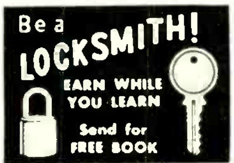

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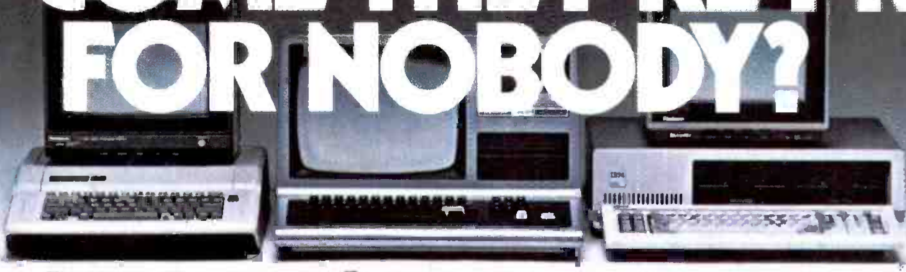

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