VOL. 1 No. 5 Sept. 1984

COMPUTER DIGEST

NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS

BUILD THIS PRINTER DELAY

and connect your Commodore 64 to a wide variety of printers

CIRCUIT-BOARD DESIGN BY COMPUTER

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Everything you always wanted to know and didn't know who to ask!

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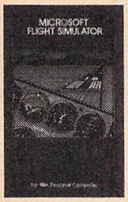

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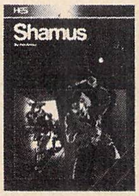

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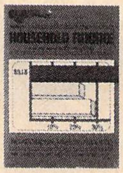

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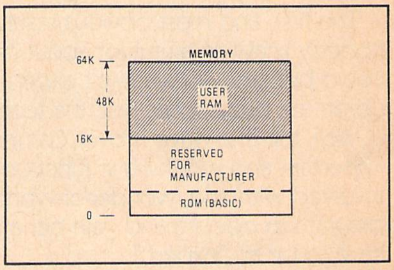
CONTENTS

Page 10

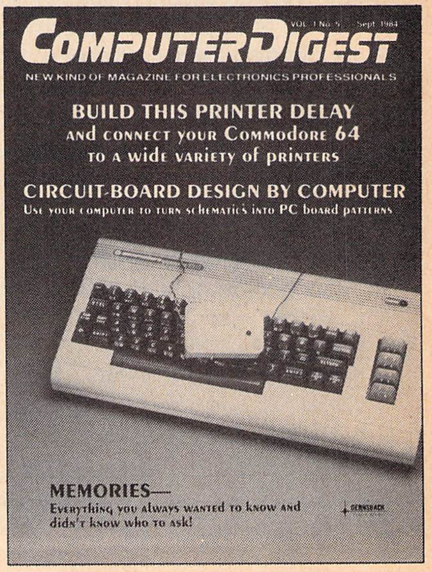
Vol. 1 No. 5 September 1984



Page 14

ON THE COVER

The small device shown connected to the Commodore 64 is one that you build yourself. With it, the Commodore won't lock up, and will operate even though the printer in use is not a Commodore unit! See page 7.



EDITORIAL

Getting friendlier

■In an obvious appeal to those who have little or no experience with computers (and that's *still* practically everybody), many manufacturers have used the words "User Friendly" in their advertising. Well, that may be all well and good, but just *how* user friendly can a computer be without going completely overboard? Let's face it: Computers really burst on the scene with a suddenness that rivals an atomic explosion. The technology came screaming at us out of no place, and actually caught most of us completely unprepared for the veritable onslaught! The point is, that unless you learn *something* about computer technology, *no* computer will seem "user friendly."

The first, and most obvious result of the computer boom was that—since nobody knew an awful lot about the subject—*anybody* with an interest could become an overnight expert. The kids latched onto that, and picked up on the buzzwords first, the technology later.

Well, the first wave is over. Computers are here, they perform an important and worthwhile function in nearly every business you might be involved with and, wonder-of-wonders, you do *not* have to learn to program to operate and gain benefit from the use of a computer. You don't have to be an "expert."

So what happened? Those of us who warily eyed this new phenomenon and decided to dip a toe in the water, quickly learned about the benefits of computers. Our approach to computing became more and more daring. We experimented, met (usually) with success, and went on to bigger and better things. Our expertise—in spite of ourselves—grew. We learned, often by trial and error, what the computer could and could not do. And "user friendly" began to have some good, solid meaning for us.

As the trust between man and machine began to grow, and as the computer proved itself in value, something else became patently obvious. There is a large segment of the community out there that still hesitates to take the big step. They probably recognize the inevitability, yet they procrastinate. That's why I feel that we, as regular computer users, owe it to them and to ourselves to "convert" those people. We all know who they are. Take a positive step. Invite them to see how the computer works. Give them an opportunity to get some hands-on time on your computer. Sell them on the benefits. Remember that as more people buy more computers, not only will the prices drop, but the technology will advance—and that's going to be good for all of us.

Tell your non-computing friends, "C'mon in. The water's fine!"

Byron G. Wels
Editor

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LETTERS

Likes us

Just wanted to tell you that I'm a neophyte when it comes to computers, and the instruction manuals that came with my own unit were so complex that an engineering degree would be needed to make head or tails of 'em. I've been tentatively using a "poke-and-try" system to learn about the computer, but it wasn't until I started reading *ComputerDigest* that I really began to make some headway and understand what was going on.—L. R., Fargo, SD

There's an old saying among us writer-types.. . "Write to express, not to impress." It's our credo here at *ComputerDigest,* and we wish more of the computer magazines would adhere to it.

Here we go again!

I'm concerned that *Radio-Electronics* will go the way of other electronics magazines and orient themselves more towards computer technology exclusively. While *ComputerDigest* is only 16 pages now, I suspect that in a couple of months, you'll be making it 17 pages, then 18 pages, and so on...—D. P., Fresno, CA

No. 'Tain't so! Radio-Electronics *will always remain* Radio-Electronics, *and that's the way it's going to be.* ComputerDigest *is in no way going to ever be more than an offspring. Please don't be the least bit concerned that this supplement will in any way dilute the wonderful content of the magazine you have come to know and love.*

Wants to subscribe!

I've been looking all through both *Radio-Electronics* and *ComputerDigest* to find a card that will let me subscribe to *ComputerDigest* magazine. How can I subscribe to *Computer-Digest?*—P. D., New York, NY

Right now, you can't. The only way to get ComputerDigest *is to subscribe to* Radio-Electronics!

COMPUTER PRODUCTS

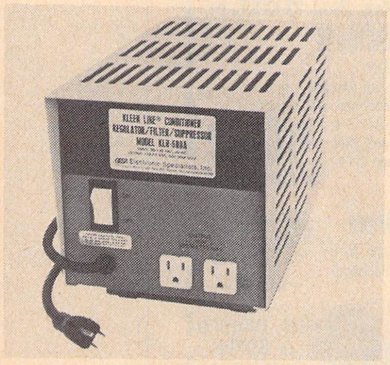
For more details use the free information card inside the back cover

COLOR-GRAPHICS PACKAGE, *Flying Colors,* for the Commodore *64* is the latest in a series of computer-graphics products for microcomputers. A windowed screen menu lets the user pick the desired functions for drawing.

Users can adjust their drawing speed for exacting detail work, and paint with a selection of different colors and brush sizes. Text can be added anywhere on the screen, and a grid feature helps users to align their pictures. The pictures can be saved and retrieved from disk. *Flying Colors* is priced at $39.95—**The Computer Colorworks,** 3030 Bridgeway, Sausalito, CA 94965.

CIRCLE 131 ON FREE INFORMATION CARD

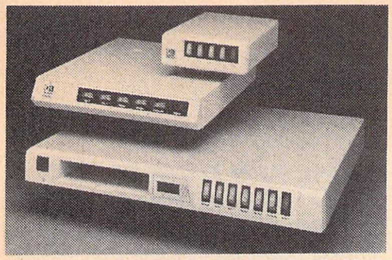
PORTABLE LINE CONDITIONERS, the *KLR* series, are designed to protect sensitive computer equipment. Available for 250-, 500-, 1000-, and 2000-watt loads, the *KLR* line conditioners deliver 120 volts at 3% regulation for 90- to 140-volt variations. With 3% THD sinewave output, the series offers input-spike suppression, transformer-spike suppression, wideband prefiltering, and isolated line-noise elimination.


CIRCLE 132 ON FREE INFORMATION CARD

The 250-watt units are priced at $292.00, and 500-watt units at $391.00 and are enclosed in a 7 × 14 × 8-inch case. A larger case (9 × 17 × 10-inches) houses the 1000-watt model at $562.00 and the 2000-watt unit at $977.00.—**Electronic Specialists, Inc.,** 171 South Main Street, PO Box 398, Natick, MA 01760.

OUTLET EXPANSION, model *P22,* model *P2,* and model *P12* occupies one grounded outlet, providing four to six in its place. Each is individually controlled by a labeled front-panel switch, each switch has a pilot light, and *Power Director* adds a master switch for collective system power-control. Each outlet is protected against surges, spikes, and RF noise. A circuit breaker safeguards against problems caused by equipment overloads. Cord clutter is counteracted by *Power Director's* all-in-a-row outlet organization.

The stand-alone model *P22* (sized to stack with disk drives, modems, or small video monitors) offers four



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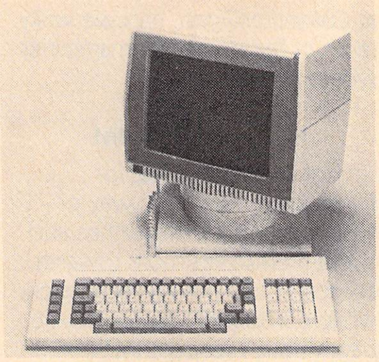
outlets and is priced at $99.00. The monitor-base model *P2* (sized to fit under a CRT or video monitor) offers five outlets and is priced at $139.00. Model *P12* (sized to fit atop an IBM *PC* system) offers six outlets, a digital clock, and a disk-storage bin; it is priced at $199.00.—**CA Computer Accessories,** 7696 Formula Place, San Diego, CA 92121.

TERMINAL, the *Fame-2,* features a 14-inch, green phosphor screen (amber is optional) and 132 columns of data. There are 20 user-programmable function keys, with room in memory for up to 1000 characters. The pre-programmed function keys offer complete editing capabilities, screen-display control, and quick data transmissions from either of two independently configurable ports. Flexible features, such as a print mode, are provided by two ports, which



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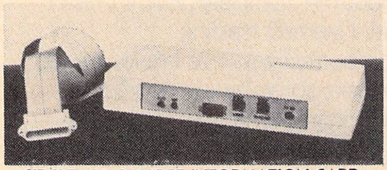
support baud rates to 19.2 kilobaud for communication with the host and other peripheral devices. Standard ports provide RS-232C interfaces and options, including RS-422 or current loop, are available.

The *Fame-2's* split-screen feature offers smooth scrolling and a wide range of video attributes, including underline, reverse video, blinking, and blanking. Screen attributes do not occupy screen space. The *Fame-2* is priced at $795.00.—**Falco Data Products,** 1286 Lawrence Station Road, Sunnyvale, CA 94089.

DIRECT-CONNECT MODEM, the *Mark X,* is a smart, 300-baud auto dial/auto answer modem. The unit operates on most popular software communications packages (such as *ASCII Express*), and can work manually through a keyboard, without computer coding; or automatically, to answer and originate calls at 300 bps for Bell-103 compatibility. The *Mark X* detects dial tone and busy signals and automatically displays dialing status on the CRT.



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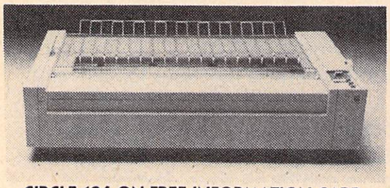
The *Mark X* uses a standard RS-232 serial interface. It comes equipped with a built-in cable and two telephone jacks, and a 12-volt power supply. The *Mark X* directly connects to a modular telephone outlet. It is priced at $169.00.—**Anchor Automation, Inc.,** 6913 Valjean Ave., Van Nuys, CA 94106.

DOT MATRIX PRINTER, the *Imagewriter,* is available in both standard and wide-carriage models. Both print in a 7 × 9 dot-matrix rate of up to 120 characters per second. They also feature eight character-fonts, and



CIRCLE 136 ON FREE INFORMATION CARD

provide variable resolution, pitch, and line spacing. Various fonts, underscoring, and sub- and superscripts can be mixed in the same line. Both printers use either friction-feed or adjustable-width pin-feed tractors. Each also comes with an accessory kit that contains the appropriate connector cables, a user's guide, an applications manual, and software for printing high-resolution graphics.

The standard *Imagewriter* has a retail price of $595.00. The wide-carriage *Imagewriter* is suited for producing documents that require wide paper. It is priced at $749.00.—**Apple Computer, Inc.,** 20525 Mariani Avenue, Cupertino, CA 95014.

CIRCLE 68 ON FREE INFORMATION CARD

PRINTER DELAY FOR THE COMMODORE 64

Here's how to fool your Commodore 64 into thinking it's working with a Commodore printer.

HERB FRIEDMAN

■Just when you begin to think you're ahead of the game something comes along to remind you that "...You can't win... you can't break even... you can't even quit the game!" Well, that's *almost* true, because with our printer delay for the *Commodore 64* computer, you finally get a chance to win one.

The *Commodore 64* is one of the best values in home-and-family and school computers (why it is is a subject for another time), but like most computer manufacturers, Commodore has put in a few *zingers* to keep the customers from using non-Commodore peripherals. One of the *zingers* is an unusual serial printer output that works only with Commodore printers. Unfortunately, the Commodore printers for the 64 aren't all that great, and there is no inexpensive daisy printer that will work with the 64—which precludes low-cost "letter quality" word processing.

The entire printer problem for the *Commodore 64* and the *VIC-20* was resolved with a relatively low-cost interface known as the *CARD?* (from Cardco, Inc., 313 Mathewson, Wichita, Ks 67214), which converts the "Mickey Mouse" serial output of the 64 and VIC-20 computers to a standard Centronics-compatible output. *Centronics-compatible* means you can use the *Commodore 64* and *VIC-20* computers with the most popular high-performance printers from Epson, Okidata, etc. Even the low-cost daisy wheel printers from Smith-Corona, Comrex and Brother.

But good things don't last. Commodore changed the ROM's in the most recent 64's. The result is that the 64 will lock up if you attempt to use the *CARD?* interface and a popular printer instead of a Commodore printer. The way around the lock-up is to disconnect the interface from the computer, power up the system, and then re-connect the interface... a heck of a way to do things.

A more-convenient way to avoid the lock-up without going through the disconnect-connect hassle is to build our printer delay, a device that delays the power to the interface for about 6-10 seconds when the computer is first turned on. When the printer delay's LED glows, you can go ahead and print without fear or worry that the computer is locked up. (Once again, another manufacturer's *zinger* is defeated!)

How it works

The *CARD?* interface has two computer connections. One is a DIN connector that handles the serial output signals; it plugs into any serial connector on the computer or disk drive(s). The other connection is a combination socket/plug adapter for the computer's *Datasette* (cassette recorder) connector; it provides only the 5 volts DC needed by the *CARD?* interface; no signals come through the adapter connection. The adapter slips over the regular Datasette connector and the plug from the Datasette's umbilical cord plug slips over the adapter. A single wire from the adapter to the *CARD?* carries the 5 volts (the ground is provided through the serial DIN connector).

Refer to Figure 1. The printer delay is connected in series with the 5 volt wire from the adapter. When the computer is first turned on, 5 volts is applied to the 555 timer, which does not interfere with the computer. After 6 to 10 seconds, the timer provides a voltage to Q1's base, causing Q1 to conduct. The current through Q1's collector flows through reed relay RY1. The relay's contact closes and applies power to the *CARD?* interface. LED1 indicates that power is applied to the interface.

Construction

While component values are not really critical, it is suggested that you do not substitute for relay RY1. The

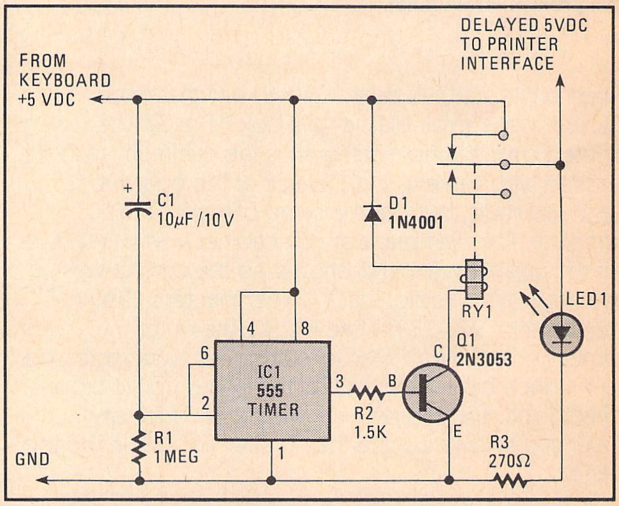


FIG.1—SCHEMATIC DIAGRAM OF THE PRINTER DELAY is simple and straightforward with most parts junk-box available. Do not substitute for relay RY1. Other components are not critical.

CARD? interface taps slightly more than 100 mA from the computer, and the printer delay shown uses about another 25 mA, most of it for RY1. Other relays will probably require much higher current, which might prove to be an excessive current load.

The entire project is assembled on a 1 3/8-inch by 2 7/16

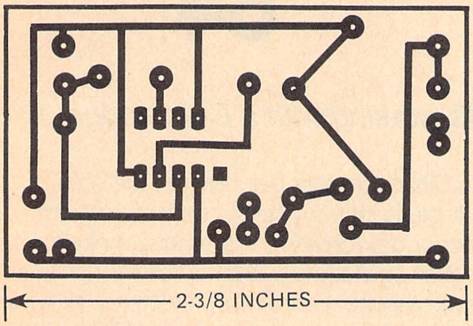


FIG. 2—FULL-SIZE CIRCUIT BOARD DIAGRAM is provided for those who desire to make their own boards. The above pattern can be reproduced photographically, or traced and etched.

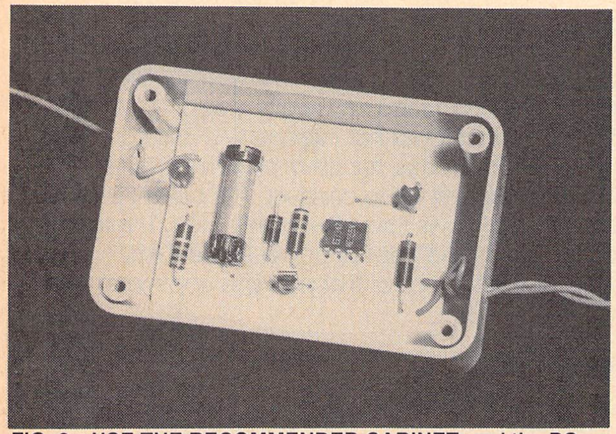


FIG. 3—USE THE RECOMMENDED CABINET, and the PC assembly just drops into place. Giving the wires a twist or two will provide strain relief.

-inch printed circuit board (Fig. 2) which can be tucked into a small plastic "pill box" (Fig. 3). The printed circuit template shown is the minimum size. If desired, you can expand the size of the board to fit larger cabinets, but use the same printed circuit template. For example, a sturdy cabinet was wanted for the unit shown in the photos, so the project was assembled in a Radio Shack "Experimenter's Cabinet," (catalog No. 270-230). (See Fig. 4.) The outer dimensions of the printed circuit board were increased to 1 7/8 inch by 2 7/16-inches so the board could drop directly into the cabinet without the need for any mounting screws. Locate the hole for the LED in the top panel.

All component holes are made with a No. 57 drill. Even RY1's terminals will fit the No. 57 hole. If the relay's terminals don't line up with the holes, just bend the terminals to fit (they normally have substantial play and

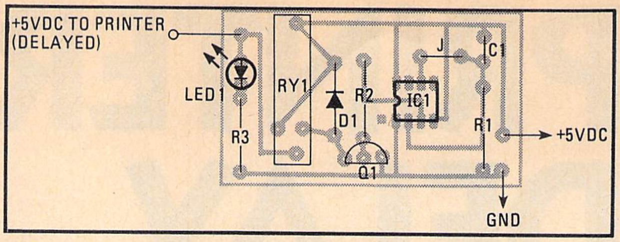


FIG. 4—POSITION THE PARTS on the printed circuit board as shown in this reversed view. The LED mounts atop the board and protrudes through the drilled hole in the cabinet cover.

can be repositioned slightly without bending). (See Fig. 4.)

You will find no assembly problems whatever. Just be sure the right IC and transistor terminals are in the right holes. Note that as shown in the parts placement diagram, the lead arrangement for Q1, from left to right is CBE. Should you substitute with a transistor having a different arrangement, either modify the template, or bend the transistor leads to suit.

LED1 can be any kind of light-emitting diode, though the diffused-lens type is easier to see from any angle. If you use the Radio Shack cabinet, pass the leads of the LED only 1/4-inch through the printed circuit board and solder. The LED will stick up about one inch above the board and will just pass through a hole that you drill in the cabinet's metal cover panel.

Using 12-inch lengths of No. 22 or No. 24 color-coded insulated stranded wire, connect a red wire to the positive (+) DC power-input hole and a red wire to the output hole. Connect a black wire to the input

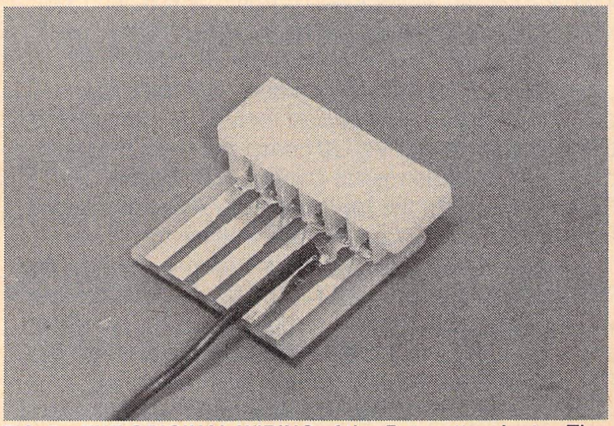


FIG. 5—THE ORIGINAL WIRING of the *Datasette* adapter. The wire connects to the 5-volt terminal. It will be replaced with the wire from the delay cicuit. The terminal to the immediate right of the wire is ground. Tack-solder the ground wire from the delay circuit to this terminal.

ground hole and twist it (not too tightly) with the red input wire.

Drill a 1/4-inch wire-exit hole in each end of the cabinet. Set the printed circuit assembly into the cabinet (just drop it in), pass the wires through the cabinet, and secure the top cover. If you used the suggested Radio Shack cabinet, the LED will just fit through the drilled hole in the panel.

Set the assembly aside for the moment.

Examine the Datasette connector/adapter supplied with the *CARD?*. Take careful notice which side of the adapter has the power wire (there is only one wire). See Figure 5. Using *Solder Wick* and a soldering iron rated at 25 watts or less, unsolder the wire. (Be sure to use the *Solder Wick* or similar desoldering braid. If the solder runs, you'll be creating problems.) The red power-input wire from the printer delay circuit—the one twisted together with the black wire—will be connected in place of this wire (Fig. 6).

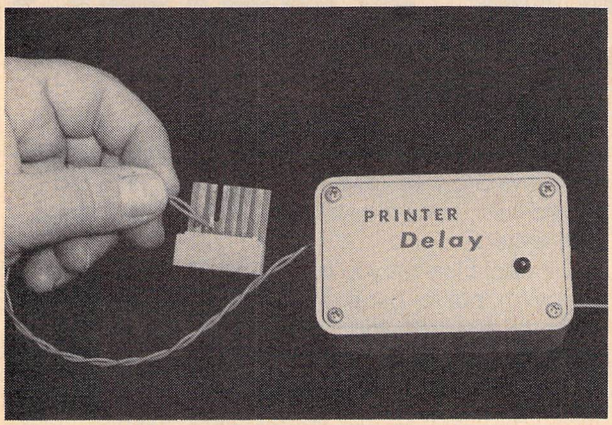


FIG. 6—THE MODIFIED ADAPTER. Note that both connections are to the left of the slot in the adapter. Use #22 or #24 stranded insulated wire for the connections.

The power supply ground for the printer delay is the #1 adapter terminal, which is located at the edge of the adapter, *immediately adjacent* to the terminal with the red wire. Tack-solder the black wire from the printer delay to this terminal *in the same relative location as the red wire.*. Use just a touch of solder so it doesn't flow down the terminal.

Cut the original wire from the adapter to the *CARD?*'s DIN connector about three inches behind the connector. Cut the remaining red wire from the printer delay to size and solder it to the wire stub from the *CARD?* connector. Wrap the connection with a few turns of tape.

The installation is now complete.

Checkout and use

Connect the *CARD?*'s DIN connector to the matching socket on the computer or disk drive and install the CARD?'s *Datasette* adapter on the computer's Datasette connector (see Fig. 7). Notice that the adapter has a polarizing slot that engages a "key" on the computer connector. You cannot reverse the adapter unless you force it and break the "key" or the adapter. If you use a *Datasette* cassette recorder, slip its umbilical cord connector over the adapter.

Now turn on only the computer.—No peripherals. The computer should "come up" with its usual READY screen display and the LED on the printer delay should be off. In 6 to 10 seconds, the LED should light. If it doesn't, something is wrong with the printer delay circuit or the red and black connections to the *Datasette* adapter.

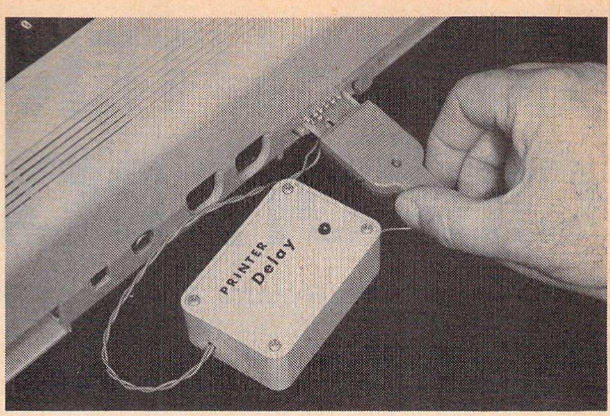


FIG. 7--THE ADAPTER WIRE SLIPS ONTO the computer's Datasette then onto the adapter.

If the LED lights, all is okay. Turn the computer off. Now turn on the computer, the printer and the disk drives, if used, in any order you want. After 6-10 seconds, the printer delay's LED will light and the system is ready for use.

To check the system, simply enter the program:

```
10 OPEN 4,4
20 PRINT#4, "I DID IT"
30 CLOSE 4
40 END
```

and then run the program.

If everything is working properly, the printer will print "I DID IT."

Next, check your disk drive. Place a disk with a known file in the drive and LOAD it. If it loads, everything is working properly.

By using the printer delay it should make no difference in what sequence the peripherals are turned on. There will be no lock-up of the computer regardless of the power-up sequence, and it won't be necessary to fuss or fiddle with any of the peripheral connections.

PARTS LIST (All resistors ¼ watt, ± 10%)
R1—1 megohm
R2—1500 ohms
R3—270 ohms
Capacitors
C1—10 μF, 10 volts, tantalum
Semiconductors
IC1—555 Timer
Q1—2N3053
D1—1N4001 Silicon rectifier, 50 PIV or higher
LED1—Diffused lens LED
Other Components
RY1—5-volt reed relay, Radio Shack 275-232
See text
Miscellaneous—Cabinet, printed circuit board, wire, etc.

COMPUTER-AIDED CIRCUIT BOARD DESIGN

Design printed-circuit board layouts using your Apple II.

GLENN CALDERONE

■CAD—*C*omputer-*A*ided *D*esign. In the manufacturing of anything from automobiles to spacecraft, a design can make its debut and be tested long before a physical device that uses the design is actually built. Tests, modifications and improvements can all be implemented at the touch of a keyboard or the sweep of a light pen.

Circuit-board design systems, like most industrial CAD systems, are usually reserved for big spenders—the necessary hardware and software cost a bundle. Until recently, it wasn't practical for the small scale (or part time) designer to even consider using a computer for circuit-board layouts. However, using an *Apple II* and a dot-matrix printer, just about anyone can create even complex printed-circuit artwork without drawing on paper or pasting lines and dots on acetate. The end result will be a professional-looking, highly accurate circuit board which you can expose, etch, and drill yourself. Of course, you can also send the computer-generated artwork to a PC-board specialist for the actual board making.

After drawing the circuit trace pattern on the *Apple II* computer screen, you can store it as binary data on a diskette, and then "dump it" to a dot-matrix printer. The image printed on paper can then be converted into a film positive (or negative) by the camera person at your local graphic arts or offset print shop.

The Apple high-resolution graphics screen consists of 53,760 square dots or *pixels* (picture elements) arranged in a pattern of 280 across by 192 down. On the computer screen, each pixel may or may not appear as a square—it depends on the quality of your CRT and how it's adjusted. For example, a pixel may look more like an oblong dot on your screen. But when the hi-res image is transferred to paper, each pixel will appear as a nice square.

Drawing on the *Apple II*

Although drawing on the *Apple II* hi-res screen can be done with simple *Applesoft* commands such as HPLOT and XDRAW, it is far easier to use one of the popular graphics software packages. (All samples shown in this article were done with *E.Z. Draw 3.3* from Sirius Software). Those let you use either the keyboard, joystick, drawing tablet, or light-pen to put lines on the screen. Master the art of drawing straight lines—starting and stopping on the same X or Y axis coordinate, before you start your first circuit design. Most programs offer a continuous on-screen readout of your drawing cursor location, so you can make sure you are lined up before you draw. Your best PC-board design will have all lines and rectangles drawn either perfectly horizontal or vertical. Avoid diagonal and curved lines, since they take up too much space and look ragged.

The apple II gives you four colors (plus black) to work with, but for our project, you should always use white to draw with and black to erase. If you try to use colors, some lines will not show up, and those that do will print as dotted lines. When viewed on a color screen, vertical lines may appear either green or violet even when you've selected the color white. That's normal for the *Apple II*, but distracting when you are designing circuits. In fact, the resolution and sharpness of most color sets when used with the *Apple II* is unsatisfactory for high-resolution artwork, since you need to clearly see each pixel as a separate dot. So use a monchrome display screen (green, amber or white) if possible. Or if you do use a color screen, turn the chroma intensity all the way down.

Scale

We have chosen 1 pixel to represent the smallest line, dot, or hole on our circuit board. A distance of 60 pixels represents 1 inch on the finished board. That scale means that our minimum foil trace size must be 0.0167 inches (1/60 of an inch), and we can locate parts to plus or minus half that (.00834 inches). On a 12-inch CRT you will have a working area of about 5 by 7 inches. It really doesn't matter what size screen you design your circuit on—the finished circuit board pattern will be a rectangle 3.2 inches high and 4.67 inches wide.

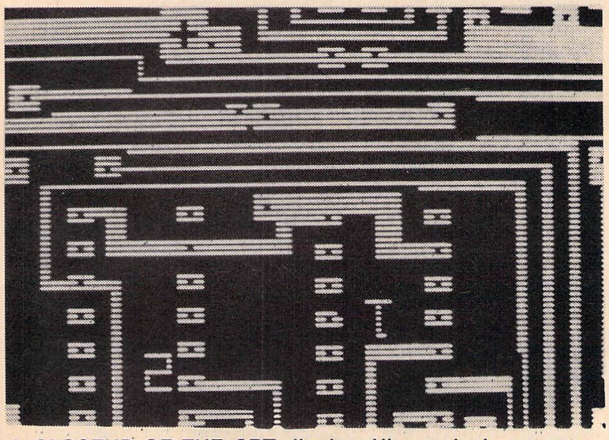
But is it large enough for your project? It depends on how complicated your circuit is and how densely you package the components on the board. You should be able to easily lay out eight socketed 16-pin ICs plus the necessary resistors, capacitors and diodes on a board, including input/output connectors. With mounting hardware and connectors, the little circuit board will fit nicely on readily available, pre-sensitized PC blanks (4 or 4½ by 6 inches).

Since we have chosen a scale of 60 pixels-per-inch, we need to translate our component-lead spacing and mounting sizes into pixel units. Common DIP sockets all use 0.1-inch pin spacing, so we use six pixels. The width of a 16-pin DIP is about .325 inches—or 20 pixels. Suggested spacing for other IC's and discrete devices is shown in Fig. 1.

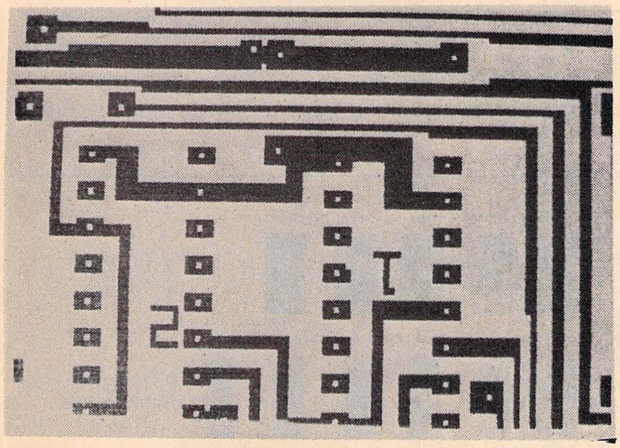
With care, you can safely make PC board patterns one pixel wide with only one pixel space separating them. If you have the room make all foil patterns as wide as possible. This keeps resistance to a minimum and makes it easier to expose the board and reduces the chance of etching away a trace.

How to begin

Outline the on-screen working area by marking the four corners (or tracing the entire rectangle). Lay out your power-supply rails, inputs and outputs first. If your software permits it, draw and store images of the patterns you use most often, such as DIP sockets, small transistors, and edge connectors. Recalling them from disk and moving them about as necessary is much faster than drawing identical patterns over and over.



A CLOSEUP OF THE CRT display. Hi-res pixels appear as oblong, rounded points of light.



CLOSEUP OF PRINTOUT FROM a dot-matrix printer. Pixels now appear as squares.

Remember you are designing the foil side of the board, which is a mirror-image of the component side. For DIP sockets, "pin 1" will be on the upper right hand corner. Use normal PC board layout practices:

- Keep inputs and outputs separate.
- Allow enough room for components on the other side of the board.
- Double check every trace against your schematic.

As a beginner you may want to sketch a rough layout on paper before going to the computer, but after awhile it should be easy to design and draw right on the screen. The ease of design at this point depends somewhat on the available features of your drawing software. Some programs allow you to mark an area and duplicate it several times at different locations on the screen. That is useful when your circuit uses identical stages, such as a decoder-driver/LED assembly. Draw it once, and create two or three side-by-side duplicates. Use your program's "fill", "color," or "paint," feature to fill-in large areas, especially parts of the board where no components will be mounted and no traces will go. The less copper you have to remove form the board, the longer your etchant will last and the less time you'll have to wait to see the results.

Since IC's, resistors, and capacitors all require different size holes, you can code your pattern to the proper size drills. For example, all dip sockets could use a 3×5 pad with a 1-pixel hole in it; resistors, a 4×5 pad with a 1×2 hole; capacitors, a 4×6 pad with a 2×2 hole. (See Fig. 2.) Adjust the pad and hole sizes to match the lead diameter of the components you are using. Hint: Make all pads at least 3 by 4 pixels. If they are any smaller you risk lifting the copper foil off the board when soldering.

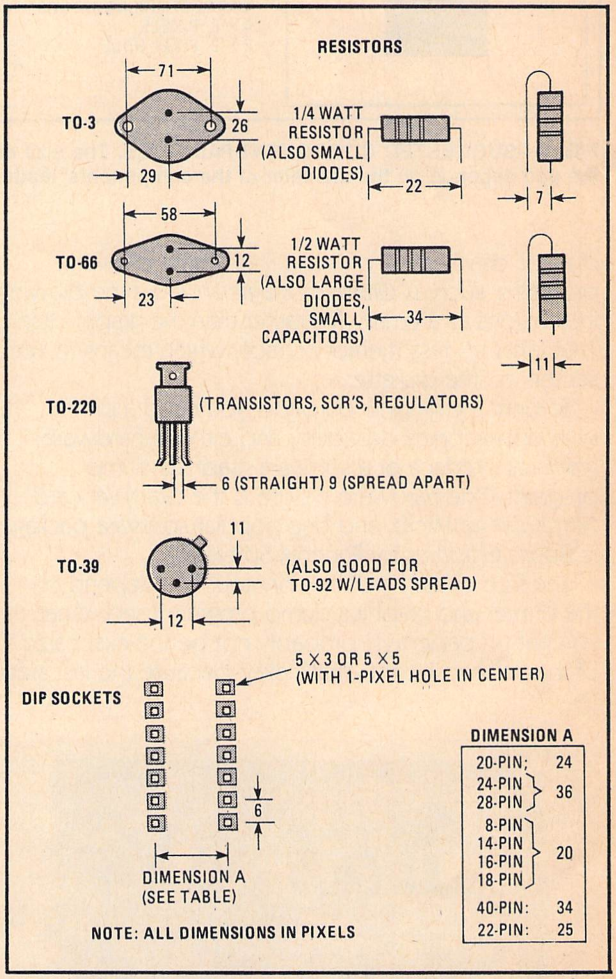


FIG. 1—SUGGESTED SPACINGS REQUIRED for some of the common components you may find yourself dealing with.

Storing and printing

The *Apple II* stores its hi-res graphics page (8192 bytes) on disk as a 34 sector binary file, and one 5.25

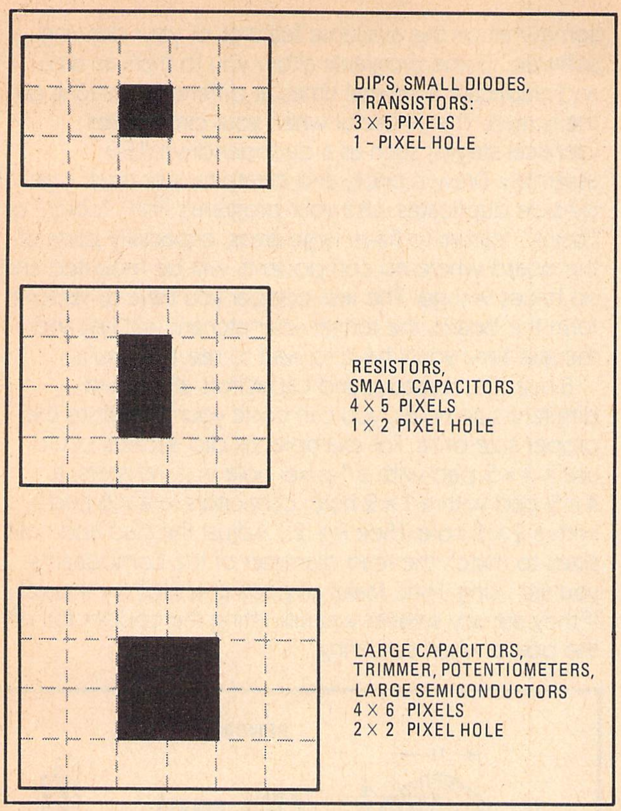
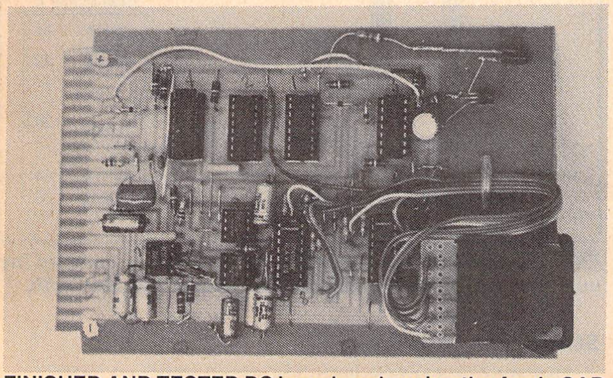


FIG. 2—SUGGESTED COMPONENT-PAD SIZES. The size of the pad depends on the diameter of the components' leads.

diskette can hold 14 of those files. Some drawing programs, such as *Graphics Magician*, store the drawing instructions as a binary file rather than the graphic itself. That takes up less memory space, which means fewer sectors on the diskette.

To print the graphic on paper you need a printer with dot-graphics capability, and either a hardware graphics interface or a software graphics dump program. One hardware device is the *Grappler* card from Orange Micro, and one popular software package is *Zoom Graphics* by Phoenix Software.

The size of the hardcopy printout will depend on the printer and graphics dump program used. What you get on paper will probably not be the exact size of the finished board. That's okay, because the last step is making a film positive for contact-printing onto a light-sensitive PC board—and there the size can be adjusted. At this point you may wish to send your artwork out to a PC board fabricator. If you're going to etch the boards yourself, have your artwork photographed by a commercial offset printer. Rates vary, but expect to spend about $5.00 for a finished piece of film up to 8 × 10 inches, including the necessary image size reduction. Need a negative instead of a positive film? Your computer graphics dump program can reverse the image before it gets to the printer. Or the print shop can make a negative. Of course, if you're handy with a large-format (press, view or process) camera and have access to a darkroom, you can keep the entire project in-house.



FINISHED AND TESTED PC board made using the Apple CAD method.

Doing more than one board design? Put them all together and shoot them all on one piece of film and cut them apart later. When choosing the size to make your hard copy, it's best to go larger than life and have it reduced when it's photographed. That way you can more easily touch up any defects in the printout (or errors in your design that you didn't previously catch). The circuit boards in the pictures here were printed on a dot-matrix printer with the graphics-dump software set for 2 × enlargement, so that each pixel printed as a 2 × 2 dot pattern. The resulting paper printout was larger than the finished board, so we made a reduction to 60% with the film camera.

Here's how to determine the amount of reduction: measure exactly the distance between 60 pixels on your hard copy, in inches. Take the reciprocal (divide into 1) to arrive at the necessary percentage. Hint: Make two marks on your PC board layout that are exactly 60 pixels apart. They needn't be larger than one dot each.

For edge connectors using .1-inch (on centers) spacing, make your lines 3 pixels wide, centered every

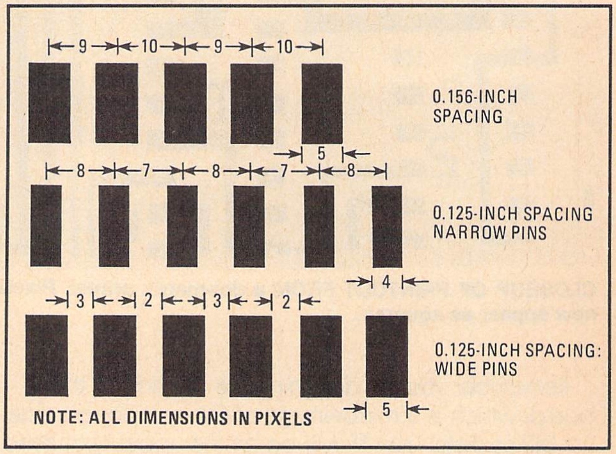


FIG. 3—SPACING REQUIREMENTS for typical edge connectors are shown here. You could use edge-connector decals on your film positive, if you prefer.

6 pixels. Spacings such as .125 and .156 are shown in Fig. 3. If you wish, you can apply edge-connector decals to your actual-size film positive, and draw connecting lines with an opaque-ink pen.

With some practice you will find it faster and easier

Software listing

This is a partial listing of currently available graphics programs for the *Apple II+* and IIe:

Apple Graphics Tablet from Apple
Applegraphics II from Apple
The Complete Graphics System from Penguin Software for joystick or tablet
E.Z. Draw 3.3 from Sirius Software
Graphic Solution from Accent Software
Graphics Magician from Penguin
The Artist from Sierra On-Line Software
Versa-Writer from Versa Computing

Commercial circuit-board CAD systems

Commercial circuit board designers use elaborate computer-aided design systems to create the artwork (or even actual boards) for large, complicated double-sided circuit boards without ever lifting a pencil. Combine CAD with CAM (*Computer Aided Manufacturing*) and even the film and etching processes can be eliminated.

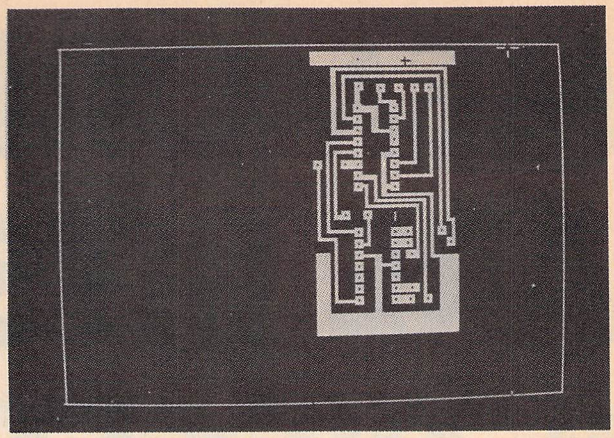
Commercial systems are a dream-come-true for design engineers, considering some of the things the computer can do. For example, the engineer can digitize a hand-drawn schematic, or draw the circuit on the computer screen directly. Next, the computer routes the traces as desired, and checks the schematic to make sure all connections are made. It also lists all unconnected pins and wiring errors. Using advanced rule-checking, the CAD system looks for traces, pads or components that are too close together. The ultimate design aid is a feature that automatically moves parts around to make room for design changes.

Commercial CAD systems offer very high-resolution displays using RGB color-monitors, so that parts outlines and traces on each side of the board appear in different colors. The circuit-board design is not stored as pixel data, but as vectors. What you see on the screen is independent of the actual design data, so resolution is not limited by the computer hardware. That lets you pick an area on the circuit board, magnify or "zoom-in" to draw the traces, and drop down to a lower magnification to see the entire board.

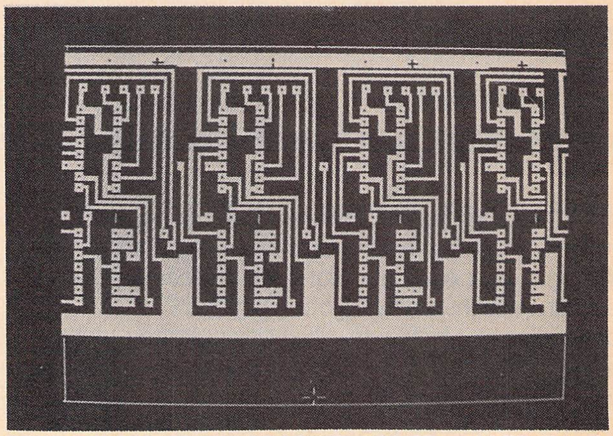
Printing the finished circuit-board pattern is done on either a pen plotter or laser imaging-system. Plotted images are usually very large, and reduced by photographic means to an actual size negative or positive film. Direct imaging by laser can be done on film or directly onto the resist coating of a copper-clad circuit board.

Some CAD/CAM systems actually machine the circuit board traces, using a computer-controlled router to grind away the thin layer of copper on a blank circuit board.

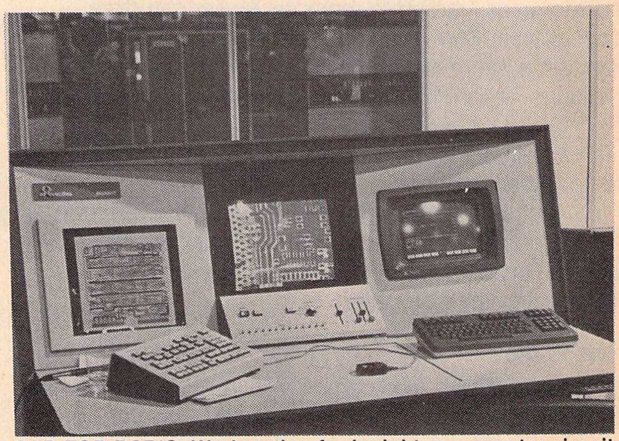
If you have an IBM PC (or compatible computer) with 512K memory, two disk drives and color-graphics board, you can get into the "big time" for as little as $4500. Personal CAD SYSTEMS, Inc. markets a software package called *PC-CARDS* for designing boards up to 60 by 60 inches, with 500 components or 10,000 pins, whichever comes first. Ready to spend more? For about $37,000 there's *ICON* by Summagraphics Corporation. Other contenders in the large system category include *Insight* by Scitex; Excellon Automation; and *EAS Series 700* by Engineering Automation Systems, Inc.



TYPICAL USEFUL DESIGN. CMOS 4511 (seven-segment decoder/driver) and MAN-7 LED display. This one-stage display circuit (stored on diskette) becomes a building block for more complicated designs.



FOUR STAGES OF THE DECODER/DRIVER and LED. It took only 30 seconds to assemble from the one shown in the previous photo.



CAD FOR PCB'S: Workstation for Insight, a computer circuit board design system by Scitex Corporation (Israel). Drawn, photographed or digitized artwork can be entered, along with drilling information. The computer enhances the design, checks for errors and draws the finished pattern on its laser scanner.

to design and draw PC boards on your *Apple II* than any other way. For larger, more complicated designs, you can draw them in sections and paste the printed images together.

MEMORIES ARE BITS & PIECES

HERB FRIEDMAN

Computers are often purchased based on the answer to the question "How much memory is there, rather than "Can this computer do the job I need done?"

■If you're an old hand at personal computing, you probably know the ins and outs of every memory location in your computer. But if you're new to personal computing (or haven't yet gotten beyond contemplating which entry-level computer to purchase for the family), then you may still be confused by the terms RAM and ROM.

RAM and ROM are two kinds of computer memory: There is actually a third kind, WOM—*W*rite *O*nly *M*emory (no joke)—but we will not get into that at this time. RAM is an acronym for *R*andom *A*ccess *M*emory, also known as read/write memory. A user can store information in RAM, read the data stored there, and change the information stored as well. The data in RAM is volatile—it vanishes when its power supply is turned off.

ROM is an acronym for *R*ead *O*nly *M*emory, ROM is memory that has been preprogrammed with *permanent* data that cannot be changed; the user can only read the data stored in the cell. The data cannot be modified or erased: it is always there when power is applied to the computer.

What is 64K

RAM and ROM can be employed in any combination up to the maximum number of memory cells that can be addressed by the microprocessor that runs the computer. Without going into the mathematics of how it's done, an 8-bit computer can address (or work with) a maximum of 65,536 individual memory cells—what we call 64K. (We'll explain why 65,536 is called 64K—for 64,000—in a moment). A 16-bit computer can theoretically address tens of thousands of memory locations, but because of design considerations for personal computers, the present limit is about 786K. To keep the numbers simple and easy to comprehend, we will limit our discussion to 8-bit computers.

First, the "missing" memory. What happened to the missing 1536 memory cells in the 64K computers, such as Radio Shack's 64K *Color Computer* and the *Commodore 64*? There is no missing memory: 64K is *electronic shorthand* for 65,536. We use that "shorthand" as a convenient way to describe partial blocks, such as 1K, 2K, 4K, 16K, etc.

Anyway, back to ROM and RAM. The computer doesn't care whether the theory it works with is ROM or RAM: there can be one single cell of ROM and 65,535 cells of RAM, or one cell of RAM and the remainder ROM. The total of RAM and ROM can be less than the maximum. But without *bank switching* it can't be more.

Memory configurations

In the typical home computer, part of the available memory is used for the ROM having built-in BASIC, the video-screen memory, and assorted utilities needed to run the computer. In the early models of the Radio Shack and Apple computers, the first 16K of memory was reserved for the manufacturer: the user-available memory started at 16K. Since the first 16K was reserved, it meant that a maximum of 48K was available for user RAM. There could be as little as 4K of user RAM, but the maximum was 48K.

Bear in mind that contrary to the implications in the advertising by their competitors, the Radio Shack and Apple computers weren't inferior to a 64K computer; they were, in fact, 64K machines that allowed only 48K for the user. Depending on the software, the 48K machines could be—and usually were—superior to the so-called 64K computers.

Figure 1 shows how it was done. Depending on the particular computer, the resident BASIC, the video

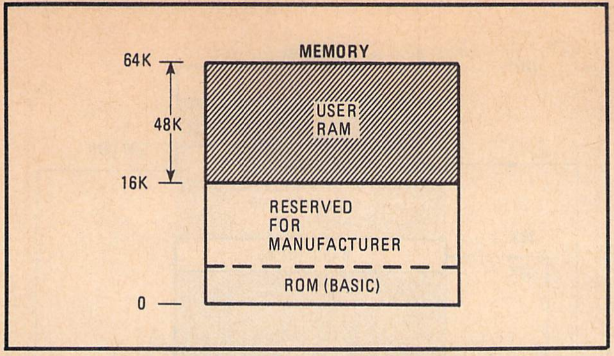


FIG. 1.—THE EARLY, SUCCESFUL, PERSONAL COMPUTERS handled future expansion by reserving all memory addresses below 16K for the manufacturer's use. Enhancements were tucked into the unused memory below 16K and did not interfere with the user RAM located above 16K.

memory, and the I/O took up between 4K and 12K, leaving at least 4K available for future expansion. When, for example, Radio Shack upgraded their version of BASIC, they tucked the improvements into the "free" memory below 16K. In that way, Radio Shack and Apple upgrades did not usually interfere with existing software, or the user-written programs that used the free RAM above 16K. When Radio Shack introduced a disk system for their computer they were able to tuck the disk controller's address into the reserved area below 16K, and again, did not cause unnecessary problems for users upgrading their basic computer.

Computers that don't have memory-mapped video or BASIC in ROM have almost the entire 64K of RAM available for user use, as shown in Figure 3. (If the video screen is memory-mapped, the RAM used for the video is not available to the user.) Note that the CPU (the microprocessor) "sees" both the 64K of RAM and a small start-up program in a ROM separate from the main memory. The start-up ROM program causes the CPU to read a small *loader* program from the associated disk drive to RAM; the loader in turn reads the disk operating system in from the disk to RAM. (If the computer uses CP/M, the operating system loads into both the top and bottom of memory—the user area is between the two.)

If the user decides to then program or run a BASIC program, he would use the operating system to load BASIC into another part of memory—above the RAM containing the disk operating system. Depending on the particular version of BASIC, the total RAM required for both the operating system and the BASIC interpreter could easily total 24K. Add in a few required utilities here and there, and the original 64K of RAM shrinks to about 32K of user-available memory; which is about what we had from the so-called "48K" Radio Shack and Apple computers when they were running disk BASIC. (There is no such thing as a "free lunch" or "free memory.")

The advantage to having the full 64K of memory available comes when you are running a non-BASIC applications program. If an applications program is written in BASIC, BASIC must be resident in the computer for the program to run. But if the program is in pure binary code there is no need for a resident

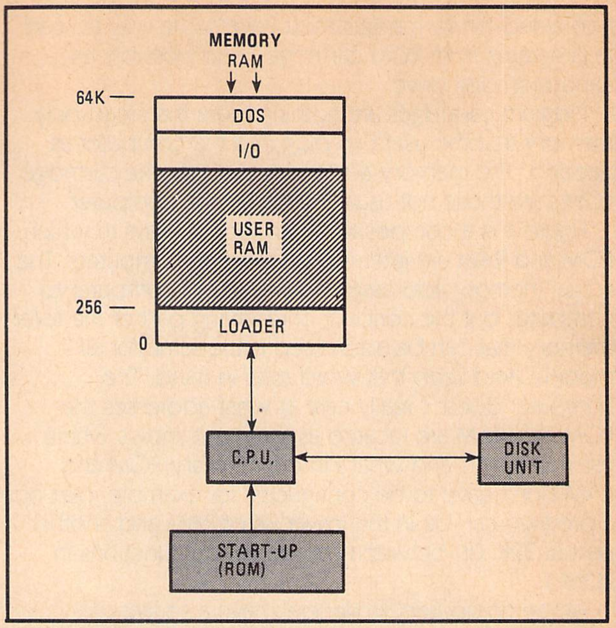


FIG. 2.—WHEN THE ENTIRE MEMORY IS FREE (empty), an operating system must be loaded in from a disk. (Early non-disk personal computers loaded BASIC and its utilities from cassette tape.) The loading process is usually started by a small start-up program of less than 256 bytes located in ROM outside the main memory. In the case of CP/M, the operating system loads into both the top and bottom of RAM; the user RAM is between the two.

BASIC. Referring back to Figure 2, instead of the monitor loading BASIC in from disk to RAM, it can load an applications program into the RAM above the operating system, with the remaining RAM being available to the user.

But consider what would happen if we tried the same thing with the arrangement shown in Figure 1, where only the RAM available above 16K is free. The applications program would have to go in above 16K. Without going into the arithmetic, the same applications program would leave from 4K to 12K less RAM available for the user in the ROM-BASIC computer than in the computer with a full 64K of memory available.

In their latest computers Radio Shack and Apple make an extra 16K of RAM available by switching the ROM's containing the BASIC in and out of the circuit. In the simplest terms, Radio Shack does it this way: The computer starts and attempts to load an operating system from the disk drive. If the CPU senses that the disk contains the CP/M operating system the ROM's are switched out and replaced with RAM, thereby making a full 64K of RAM available to the user, and the CP/M system loads into memory. If the computer senses the disk is loading a TRSDOS-like operating system such as NEWDOS or DOSPLUS, the ROM's are left in-circuit and user-memory starts at 16K.

When the ROM is a cartridge

That kind of juggling of memory works out well when done smoothly, but it doesn't adapt well to the home-and-family computers such as Radio Shack's *Color Computer* and the IBM *PCjr*. The reason is that the home-and-family models must have some way to load in programs from ROM cartridges, and possibly an expansion disk drive.

Program cartridges are nothing more than read-only memory that the user can plug into the computer as needed. The memory addresses used for the cartridge ROM's are those not usually used by the computer.

Figure 3 is a composite of the various ways in which ROM and RAM are intermixed by home computers. The actual memory addresses will vary from computer to computer, but the concept of reserving part of the *total* memory that can be addressed is the same for all models. And keep that word *total* in mind. The computer doesn't really care at what addresses the ROM and RAM are located as long as it knows where the memory is and what's in the memory. ROM and RAM don't have to be contiguous; for example, part of a program can be in the lower 8K of RAM and another part at 32K. (In-between can be several functions in ROM.)

Home computers, in general, have a socket (connector) into which a program cartridge can be inserted. When the socket is empty the computer's CPU "sees" only the first 32K of memory, which contains the start-up sequence, video memory, BASIC, etc. When you turn on the power, the computer "comes up" in BASIC, with the screen displaying a prompt such as OK or READY.

The program cartridge that plugs into the socket has its ROM(s) installed on a printed-circuit board. The circuit board's connector—called an edge-connector—consists of foil "fingers" that match the socket's terminals. Two (or more) of the fingers serve as a "switch" for the computer's CPU.

When the cartridge is inserted into the socket the "switch" finger contacts force the CPU to "see" the ROM in the cartridge. The CPU carries out the instructions (program) stored in the ROM, which is usually a complete program: a game, a word processor, a spreadsheet, etc. As a general rule, cartridge software is completely resident in the memory locations above 32K (except for the common computer functions that are normally resident in ROM below 32K, such as the printer and cassette-tape I/O, color control, etc.). Also, though the program is located above 32K, it uses the free RAM located below 32K for transient data.

In the IBM *PCjr*, the cartridge called *Cartridge BASIC* is actually overlay enhancements to the BASIC already in ROM. The cartridge starts the computer, applies the enhancements, and then uses the original ROM functions.

While we generally speak of cartridges containing software in ROM, there is nothing to prevent the cartridge from also having RAM. There are several cartridge programs that require more RAM than is normally supplied with the computer. In those instances, the program cartridge also contains the extra RAM required by the program; but the "extra" RAM is lost when the cartridge is removed.

While we tend to associate plug-in cartridges with software, they also can be used for disk systems; the controller and the operating system. In that instance,

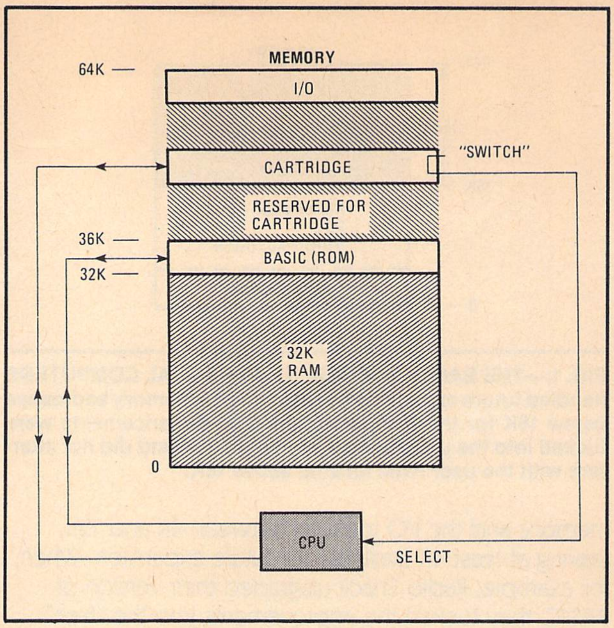


FIG. 3.—THE HOME/FAMILY COMPUTERS generally use specific areas of memory for user RAM, BASIC, and I/O. They can be positioned anywhere within the *memory map*. A cartridge, with ROM preprogrammed for a game, applications program or a disk operating-system, makes use of the unoccupied addresses of the memory map. Special switching contacts within the cartridge force the CPU to look at the cartridge for its start-up instructions.

the cartridge contains a disk controller, the complete disk operating system in ROM and, in some instances, extra RAM for the disk operating system's transient functions. One side of the cartridge connects to the computer, the other side has connections for the disk-drive mechanism. (Or, the disk-operating ROM's are built directly into the disk drive's cabinet, and a connecting cord connects the ROM's to the computer.) Once again, "switch" fingers on the cartridge's edge-connector forces the CPU to "see" the cartridge. There's no need to load an operating system in from the disk because it's already in memory, ready to go the instant the computer is turned on.

Bank switching

Though we have been speaking in terms of 64K of memory for 8-bit computers, many 8-bitters now address 128K of RAM. Bank switching is exactly what the term implies: The memory is arranged in two (or more) banks of 64K. Special hardware and software automatically switches in the correct bank as needed. Generally, the software for a computer with bank-switched memory will provide some means whereby the total memory can be partitioned. For example, the total memory of a Radio Shack *Model 4* computer can be partitioned so that some of the RAM functions as a *RAM-disk*. As far as the computer is concerned, the partitioned memory is actually a disk, only the data can flow into and out of the "electronic disk" a lot faster than it can from a real disk. Unlike a real disk however, when the computer is turned off, all the data in the RAM-disk is lost unless previously saved in a physical disk.◀CD▶