# THE KIT SOLUTION

BY LAINE STUMP

## *The 8-MHz 16-bit Slicer*

THREE YEARS AGO, my idea of "fast" computing was being able to run my college programming assignments on the resident mainframe without having to trudge across campus at midnight and wait in line for a terminal. To achieve this goal, I searched through ads in the computer magazines and found a terminal to put in my dorm room. It was a Hazeltine 1000, circa 1974, and it cost me $150. I rented a 300-bps (bits per second) modem for $5 a month, set the thing up on my desk, and called it high technology, all 12 display lines. Today, I am using the same old terminal (or what is left of it), and I am still clinging to my penny-pinching ways, but now I have a computer system that rivals machines in the forefront of (affordable) 16-bit computer technology.

The computer at the heart of my system is a Slicer single-board computer, sold in kit form or as a total system by Slicer Computers Inc. of Minneapolis, Minnesota. The board measures only about 6 by 12 inches, but that small space contains an extremely impressive list of features, including an Intel 80186 microprocessor, 256K bytes of RAM (random-access read/write memory), two serial RS-232C communication ports, a disk controller for both 8- and 5¼-inch floppy disks, and an SASI (Shugart Associates' Standard Interface) port for connecting a Winchester disk drive. The computer board, in kit form, sells for $815.

The Slicer kit is not for everyone. It takes slightly more expertise to bring up a Slicer than a standard ready-to-run system, but for those who have the expertise (or a desire to get it) and want a high-performance system for developing CP/M-86 and MS-DOS software, the Slicer and all the add-on boards and operating systems available for it are definitely worth a look.

### WHAT'S IN A KIT?

This kit includes the printed-circuit board and all the integrated circuits (ICs), resistors, connectors, and other parts that are on the circuit board itself—nothing more. To have a complete system you also need a power supply, a serial data terminal, disk drives, a cabinet, cables, and possibly a printer, all of which will raise the price of the total system to anywhere from $1800 if you buy surplus parts to $4000 or more if you get a Winchester disk, a fancy terminal, and the like. This selling/buying/building strategy is similar to that of the legendary Big Board computer, which has had a dedicated following for the last few years (yes, I own a Big Board, too).

### BUILDING THE KIT

The Slicer kit is not intended for the casual user. You must be comfortable with soldering IC sockets and mounting things into cabinets. It is easier to build than most kit computers, though, mainly because the main processor board has just 67 ICs (compared to 118 on the Big Board).

The manual includes step-by-step assembly instructions that can be followed by anyone who knows where to find pin 1 on an IC. The instructions stop at periodic checkpoints to perform tests that tell whether or not you have made a mistake in the assembly so far. For example, a special memory-test monitor allows you to test the machine before you install the RAM

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(random-access read/write memory) chips. You can test it again after installing the first 128K bytes of RAM. By testing in steps, you can more easily discover where you went wrong and get the system running sooner.

I was lucky enough to build my Slicer during a computer convention. Both the hardware and software designers of the system, Dean Klein and Earl Hinrichs, were looking over my shoulder and the shoulders of 12 other builders, but even without their guidance I probably could have assembled the board in two evenings (it took three hours with their help). Of course, after the board was assembled, it still took my brother and me two full days of building brackets and drilling holes to make the thing into a respectable "system" (you know, the kind of computer that doesn't have PC boards and wires strewn across the workbench). For those of you who still balk at wielding a soldering iron, Slicer offers the option of buying the board fully assembled for an extra $200.

The fact that the Slicer is sold in kit form is what turns most prospective buyers away. Because of this, Slicer recently began offering a complete system based on the Slicer board. It sells for $2995 and includes the Slicer, a cabinet, a terminal, two 800K-byte, 5¼-inch disk drives, and the CP/M-86 operating system (MS-DOS is available as an option, and Concurrent CP/M will soon be available). You can also buy the system sans terminal for a reduction in price and without drives for even less.

## History of a Kludge

Most of us just don't have the time to solder sockets, build cabinets, and search through magazine ads for inexpensive disk drives. I didn't have the time, either, but neither did I have the money to buy an integrated system like the IBM PC. That's why I built the Slicer (and the rest of my system) from kits and odds and ends.

My entire computer system grew out of the old Hazeltine terminal. After I had been using the terminal for about a year, I decided that 12 lines of display was just not enough. I discussed many alternatives with my brother Cecil (the family hardware guru), and we finally decided that the most practical solution to the problem was to purchase a Big Board computer with a built-in 24 by 80 screen and replace the logic board of the terminal. We ordered the Big Board and installed it in the Hazeltine after literally ripping out the terminal's insides and rearranging all the wiring.

I could now display 24 lines of text on my screen at one time, but without a disk drive I could run only on the modem and experiment with small machine-language programs. This, again, was fine for a while, but within two months I broke down and bought a surplus 8-inch disk drive.

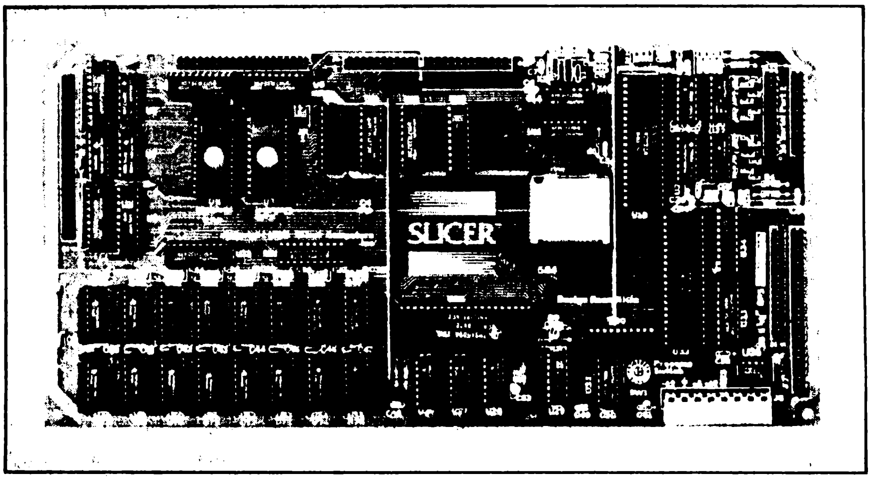

Photo 1: *The Slicer board has an* 80186 *microprocessor, two serial ports, a floppy-disk controller for up to four drives,* 256K *bytes of dynamic* RAM, *and an* SASI *interface. Note that the* RAM *chips (lower left) are piggybacked.*

I spent the following summer in Spokane, Washington, with my brother. We decided to go to a convention of Big Board users put on by *Micro Cornucopia* magazine of Bend, Oregon. That's where I was first introduced to the Slicer. That summer I also acquired, for a very reasonable price, an old Alpha Micro cabinet that had space for two 8-inch drives and a circuit board or two. It was a solid cabinet with a lot of room, and it already had a power supply. Toward the end of the summer, my brother and I started working on a software project. During the winter we had decided that we should move the whole thing over to a 16-bit system, since most of the newer machines are 16-bit. This, and my frustration with the sluggishness of my Big Board, started me thinking seriously about the Slicer.

After another year of school, I spent the summer in Oregon working at *Micro Cornucopia* as an intern. It was there that I finally got a Slicer. I also purchased a Seagate ST-506 5-megabyte Winchester drive from the surplus market for $100.

My system is currently housed in the Alpha Micro cabinet, which holds the Slicer, a single 8-inch Siemens drive on loan from *Micro Cornucopia*, and my wondrous ST-506 Winchester drive. I am still having problems getting the right Winchester controller from Western Digital, though, so the Winchester sits idle for the moment. Due to short finances, I am using some equipment for dual purposes; the Big Board/Hazeltine combination acts as a terminal to the Slicer, and the two floppy-disk drives that are hooked to the Big Board must sometimes be hooked to the Slicer for copying between two floppy disks.

## The Slicer

The Slicer (see photo 1) seems to have been designed to be fast and com-

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## IN BRIEF

**Name**
Slicer

**Manufacturer**
Slicer Computer Inc.
2543 Marshall St. NE
Minneapolis, MN 55418
(612) 788-9481

**Components**
**Processor:** Intel 80186 (8 MHz)
**Memory:** 256K bytes of RAM; up to 32K bytes of ROM
**Interfaces:** Two RS-232C ports with independently programmable data rates up to 38.4K bps; 1797 controller and an FDC 9229B data separator permit use of 8-inch and 5¼-inch disks, double-density and double-sided; SASI interface allows connection of Winchester controller; 90-line expansion interface provides buffered data, address and control buses

**Operating Systems**
CP/M-86 bundled with kits; MS-DOS ($175) runs with PC expansion board; CCP/M ($85)

**Optional Hardware**
Slicer Expansion Board: up to 256K additional RAM, two additional serial ports, real-time clock with battery backup, and a Centronics-type parallel printer port
Slicer PC Expansion Board: IBM-compatible monochrome monitor, two IBM-type card slots, and an IBM-type keyboard port

**Documentation**
Slicer assembly guide (90 pages) with sections on hardware debugging and testing procedures; Intel data and application sheets

**Prices**

| | |
|---|---|
| Slicer full kit: | $815 |
| easy kit (only hard-to-find-parts): | $470 |
| assembled and tested: | $1015 |
| bareboard (includes documentation and EPROMs): | $150 |
| Expansion Board full kit: | $575 |
| assembled and tested: | $750 |
| memory-board kit: | $395 |
| three-port kit: | $225 |
| bareboard: | $95 |
| PC expansion-board kit: | $550 |
| easy kit: | $400 |
| assembled and tested: X | $600 |
| bareboard: | $200 |
| Enclosure: | $125 |
| with power supply: | $245 |
| with two 5¼-inch 96-tpi (tracks per inch) drives: | $795 |

patible (though not necessarily IBM-compatible). The 80186 microprocessor accomplishes this rather nicely. The clock speed of 8 MHz, along with more efficient microcoding of the instruction set, gives the 80186 an effective execution speed about twice that of the 8088. The 80186 uses the same machine language as the 8088 and 8086, too, so it can run MS-DOS, CP/M-86, and many of the applications programs written to run under these operating systems. The 80186 is also an excellent development environment for new programs for the PC and compatibles market.

A side effect of using highly integrated parts, like the 80186 microprocessor, is that the system can be implemented with relatively few ICs. The 80186 itself eliminates several parts. In addition to the normal functions of a microprocessor, it contains the clock generator, two high-speed DMA (direct memory access) channels, three programmable 16-bit timers, and programmable memory and chip-select logic, eliminating the need for several peripheral chips.

The 80186 is high on performance as well as integration. It has a true 16-bit external data bus, which means that the microprocessor can fetch 2 bytes from memory with each memory access. The 80186 takes advantage of this by putting the extra bytes it retrieves during instruction decoding into an instruction queue along with as many other instruction bytes as it can get when the bus is idle. Since most instructions are executed in the sequence in which they are stored in memory, this can save a lot of time. The 8088 processor, used on the IBM and most compatibles, also has an instruction queue, but it does not hold as many instructions as the queue in the 80186. There are further improvements in execution speed over the 8088. The queuing scheme is also used for other memory accesses, and the microcoding for many of the instructions in the 80186 has been redone to make the instructions execute in fewer clock cycles.

The Signetics 2681 DUART (dual universal asynchronous receiver/transmitter), used for the two RS-232C communication ports on the Slicer, is another example of a highly integrated chip. In addition to two serial ports, it contains the data-rate generators for both channels (programmable 50 to 38,400 bps), a 16-bit counter/timer, and an 8-bit output and a 7-bit input port for system control functions.

The floppy-disk controller is a Western Digital 1797, which has all the features of the popular 1793 controller chip while adding a disk side-select output. This family of chips (the 179x series) has several years of field experience behind it, allowing the developers to spend their time writing the software for it rather than debugging a new chip (this was a problem with the early 80186). The floppy-disk controller section also uses an FDC9229 data separator. This, again, is a standard part that needs no further description here.

The system monitor is contained in two 2732A EPROMs (erasable programmable read-only memories). You can replace these two chips with 2764s or 27128s if you want a more elaborate monitor.

Aside from these six chips, the only other "large" IC on the board is the TMS4500 dynamic RAM controller. This chip takes care of memory refreshing, chip selection, and miscellaneous tasks. It was designed specifically to control up to 256K bytes of 4164 dynamic RAM chips. The rest of the chips on the board are TTL (transistor-transistor logic) and the RS-232C drivers for the two serial ports.

There are several connectors on the board. The floppy-disk section has two: a 34-pin connector for 5¼-inch drives and a 50-pin connector for 8-inch drives. The SASI port uses another 50-pin connector, and each serial port uses a 26-pin connector. Two more connectors on the board are used as an expansion bus. These two connectors are basically an extension of all the data, address, and control lines from the microprocessor. This expansion bus is used for the Slicer Expansion Board (see photo 2) and the PC board (described below). You can also use the expansion interface to connect any hardware add-on projects that you might want to build yourself.

The Slicer's power needs are +5 volts (V) 3 amps, +12 V 60 milliamps, and −12 V 50 milliamps. The power supplies hook to the board through a little plug-in connector, so the board is easy to remove. The only chips that need +12 and −12 V are the four RS-232C driver chips for the serial ports; the rest just need +5 V.

You must buy separately any other hardware that you want or need for the system, so things like disk drives, printers, and terminals will vary greatly in performance, specifications, and price from machine to machine. Due to the system software of the Slicer, however, you can use nearly any disk drive, printer, or terminal on the market.

For instance, the Slicer recognizes 8-inch single- and double-sided drives (1.3 megabytes maximum on double-sided double-density 8-inch disks), and it recognizes 5¼-inch single- and double-sided, double- and quad-density (800K bytes maximum on double-sided quad-density 5¼-inch disks). It will also automatically recognize most brands of the new 3½-inch disk drives (because most of these drives have been designed to look like either an 8-inch or a 5¼-inch drive).

When you decide that you want to add a Winchester disk, the Slicer already has the software to handle it; you just need to buy the drive, the Winchester controller, and a beefier power supply, and plug them all in. The controller is necessary because the Slicer implements only the "host adapter" portion of the Winchester interface, as do all other computers. The software on the Slicer is set up for the industry-standard Xebec 1410 controller or the Western Digital 1002-SHD. The Western Digital board has been available lately for about $245 and seems to be a solid unit. Make sure to specify the "SHD" portion of the part number if you happen to order the 1002; there are several models, and this is the only one that works with the Slicer.

## SOFTWARE

The only software included in the $815 price of the Slicer is a disk containing utility programs written to run under CP/M-86, a BIOS (basic input/output system) for CP/M-86, source code to all these, and the assembly-language source code to the debug monitor and system software contained in the monitor EPROMs. The disk is available in either 8-inch single-sided single-density or 5¼-inch single-sided IBM format.

The debug monitor is another of the Slicer's strong points. It is contained in the monitor EPROMs, so even if you cannot boot up a disk, you can still look around at memory, read and write to the disk, output values to I/O ports, enter small machine-language programs, and so on. The value of this becomes apparent when you're debugging a new program that crashes; if you were running under CP/M's DDT debugger, you would have to reboot the machine and, in the process, write over the very program you were trying to examine. With the ROM-based debugger, you merely hit the reset button and you are immediately at the debugger prompt. You can now look at the contents of memory to discover what went wrong, modify parts of memory, and even restart execution of the program if you like.

One other interesting use of the Slicer debugger is to trace the operation of CP/M-86. By booting up CP/M, hitting the reset button, and telling the debugger to set breakpoints at appropriate locations and restart execution at the BIOS warm-boot location, you can trace every time a certain section of CP/M or the BIOS is executed. This is not possible with a disk-based debugger like DDT, since the debugger would be overwritten as soon as you returned to CP/M.

The utilities on the disk include SETUP, a program to change various system parameters like the amount of memory allocated to RAM disk and the printer data rate; SLIFORM, a disk formatter program for several 8-inch and 5¼-inch formats; and HFORM, a Winchester disk formatter.

The CP/M BIOS is one of the Slicer's more amazing parts. It is set up to recognize automatically not only the density but also the size of each drive. This means that you can hook up two 5¼-inch drives as A and B and two 8-inch drives as C and D today, then reverse the drives tomorrow, and the system will still understand. It will boot from the 5¼- or 8-inch floppy or the Winchester disk. About the only things that the system doesn't auto-

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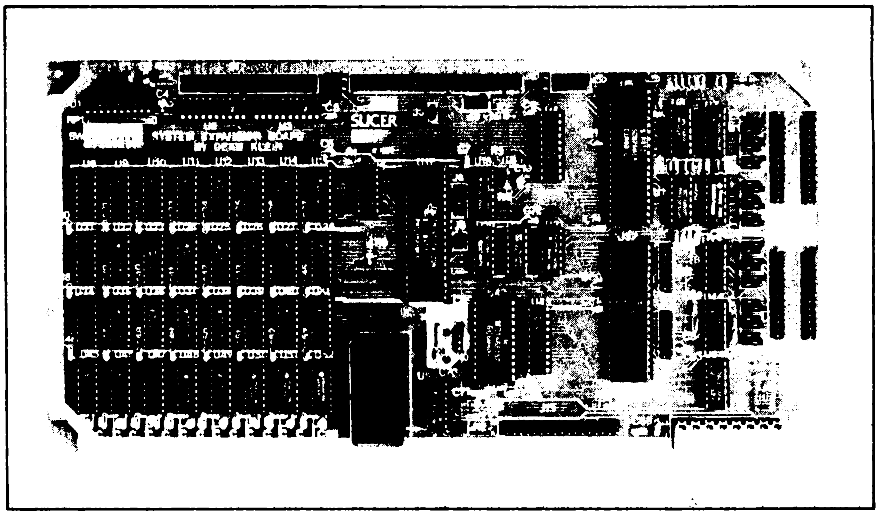

Photo 2: *The Slicer expansion board has an additional* 256K *dynamic* RAM, *a real-time clock/calender with battery backup, a parallel port, and four serial ports.*

matically recognize are the printer data rate and the size of the Winchester'drive; you can set these up in a few seconds with the SETUP program. All this means that you will very infrequently, if ever, have to reassemble the BIOS; almost any hardware configuration of the Slicer will run just fine with the BIOS the way it is.

Another great thing about the BIOS on the Slicer is that it reads the disk a full track at a time, rather than on a sector-by-sector basis. All requests for a sector from the same track of the disk can then be processed without going back to the disk. This speeds up disk activity quite a bit, as evidenced by the disk read/write benchmarks (see table 1).

## CP/M-86

Slicer Computers Inc. sells CP/M-86 already configured for the Slicer. You can also buy CP/M-86 for the IBM PC and install it yourself if you like. This will save you $15 to $30 and takes about 15 minutes if you have another system already running CP/M (-80 or -86); complete instructions are included in the Slicer documentation.

CP/M-86 is very similar to good old CP/M-80 (nearly identical, actually). This makes it the preferred (or, shall I say, more comfortable) operating system for many people who, like myself, are coming to the Slicer from a strong 8080 and Z80 background. This was the first operating system made available for the Slicer, and until recently it was the only one.

## MS-DOS

Slicer now also sells MS-DOS version 2.11, which opens up another large market of programs to Slicer owners. The performance figures of the Slicer under MS-DOS should be very similar, if not identical, to those of a Slicer running CP/M-86.

## Concurrent CP/M-86

The programmers at Slicer are just finishing up an implementation of CCP/M, a descendant of the IBM version, but with massive changes to get rid of the dependence of the software on a specific configuration. In the process, much of the system has been enhanced. One nice feature of the version for the Slicer is that, unlike the IBM PC version, it allows you to change the number of physical consoles, so you can actually make the Slicer into a multiuser system.

The most incredible thing about CCP/M is that it does windowing on a serial terminal; all other implementations that I have heard of,require memory mapping to work (the Slicer version will do memory mapping as well). It was not trivial to make windowing work over a serial line, either. The copy of CCP/M that I received was, of course, a preliminary version (XIOS version 0.4), and there was a note from Earl Hinrichs, who wrote most of the Slicer software: "The window programs supplied by DRI [Digital Research] are very IBM dependent. I did not use any DRI stuff. Ignore DRI window documentation."

I was originally skeptical about the practicality of windows on a serial terminal—waiting for the screen to paint at 9600 bps with just one job is bad enough; four would surely make it unbearable. I was mildly surprised when I tried it; it is passable at 9600 bps and very nice at 19,200 bps. It would probably be bordering on the speed of memory-mapped windows with a 38,400-bps terminal, if I could just find an affordable terminal that could keep up at that speed.

You can access the window functions from the keyboard by typing the Window Command key followed by the function you want to execute. You can modify the size and position of the windows on the screen in real time, without exiting from any of the jobs that are currently running. You can switch to another window, change the windowing mode, display a status line for the current window, or enter the window manager, where you can alter the windows.

There are several different modes of operating in a virtual-terminal environment. The Slicer implementation allows you to change three main parameters affecting the operation of the virtual consoles. The first choice is between dynamic and disk-buffered mode. In dynamic mode, all the consoles are updated as new output is sent to them from their respective programs; in disk-buffered mode, the output of each job is saved on disk until you switch to that job with the windowing commands, then all of the saved output is sent past the screen at once.

You also have a choice between line- and screen-buffered modes. In line-buffered mode, the last 2000 characters output to a job are saved in its buffer in memory; in screen-buffered mode, the CCP/M XIOS (ex-

*(continued)*

Table 1: *The Benchmark programs were written and compiled with* Turbo Pascal *version* 2.0. *The listings for these programs are available for downloading on* BYTE*net* Listings, (603) 924-9820, *as* STUMP1 *through* 4. *The times for disk access show how long it takes to write and read a* 64K*-byte sequential text file to a blank floppy disk. The Sieve times record how long it takes to run one iteration of the Sieve of* Eratosthenes *prime-number benchmark. The Calculations times show how long it takes to do* 10,000 *multiplication and division operations using single-precision numbers. The tests were run on a* Big Board (Z80A *at* 4 MHz, 64K *bytes of* RAM, *two* 8*-inch single-sided single-density drives, and* CP/M-80) *and the* Slicer (80186 *at* 8 MHz, 256K, *two* 8*-inch single-sided single- or double-density drives, and* CP/M-86). *All times are in seconds.*

| | Big Board | Slicer<br>Single-density | Slicer<br>Double-density |
|---|---|---|---|
| Disk write | 29.2 | 19.9 | 15.4 |
| Disk read | 25.4 | 17.8 | 13.6 |
| Calculations | 49.8 | 33.1 | —— |
| Sieve | 2.5 | 0.6 | —— |

tended input/output system) keeps an exact copy of the contents of the screen for each job. A lot of overhead is involved in screen-buffered mode, since the XIOS must interpret all cursor-control and clearing commands sent to the screen. Line-buffered mode will not work properly with windowing, however, so both modes are necessary.

In line-buffered mode, application programs can use the special escape commands of the terminal hooked to the Slicer; in screen-buffered mode, they must use standard IBM PC escape commands. Any of the commands not implemented on your terminal are simulated in software. In order for this to work, you must use the SU program described below to tell CCP/M your terminal's commands for positioning the cursor and clearing the screen.

The third choice of modes is, of course, between using windowing and simply having the currently active job fill the entire screen. You may think that you will always want to use windows, but many times you will want to see the full screen of a job, and it's nice to be able to just type a key and have it that way. Also, since the nonwindowing method can use line-buffered mode, output to the screen can be more efficient.

Besides the operating system itself, the CCP/M disk contains all the standard CCP/M utilities (PIP, SUBMIT, GENCCPM, etc.). It also includes W, a program that can save the current window parameters and restore them at a later time, and SU, a setup program that virtually eliminates the need for GENCCPM.

SU lets you define the location, data rate, terminal type, and windowing parameters of up to 10 physical consoles, as well as the location, type, and capacity of on-line disk drives (which disk is the system disk, what I/O ports the printers are on, etc). This can all be done interactively or from a file that contains all the information in a readable form. Just as you will probably never have to reassemble the CP/M-86 BIOS, you probably will never have to reassemble the CCP/M-86 XIOS; any changes in hardware that are not automatically detected can be changed with SU.

*One strange thing about CCP/M is that you have to go back to normal CP/M to format a new disk.*

One strange thing about CCP/M is that, since the Slicer disk formatter uses direct disk access, you have to go back to normal CP/M to format a new disk; the same applies to making a new system disk. I am not sure if this is due to the way the Slicer formatter program is written or if it is a restriction of the operating system itself, but it would be nice to be able to operate entirely under CCP/M. As it stands, you must have regular CP/M to install Concurrent on your system. Also, the PC-DOS emulation module hasn't been included in this version. When I asked the people at Slicer about this, they gave a noncommittal reply about possibly putting this feature in sometime in the future; for now you will have to boot up MS-DOS to run MS-DOS programs. A year ago this was normal; now it is a slight annoyance.

The last complaint that I have about CCP/M is that the characters used to separate the different windows on the screen are normal text characters; they sometimes get lost in the text. It would be nice if the SU program could redefine these characters to allow the use of the graphics characters available on some terminals. The display might then appear less confusing.

### ADDING MEMORY

Another sad note about CCP/M is that it is ineffective when you have only 256K bytes of RAM. With four virtual consoles, I did not even have enough memory left over to compile a 30K-byte Turbo Pascal program, even

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when the other three jobs were sitting idle. This is not really the fault of the Slicer people; complex operating systems take a lot of memory, and the only solution is to buy more memory. Unfortunately, the 256K bytes on the Slicer is the maximum that can be put on the main board, one of the reasons why Slicer designed the Slicer Expansion Board.

The Slicer Expansion Board and CCP/M go together nicely. The Expansion Board has the extra memory you need for the larger operating system and the extra terminal ports you need to connect multiple physical consoles. The Expansion Board has the same dimensions as the Slicer, 256K bytes of RAM, four more serial ports, a real-time clock, and a Centronics-type parallel printer port. It is sold in kit form or assembled, just as the Slicer is, and plugs into the expansion bus on the Slicer. It sells for $575 as a complete kit or $395 as just a memory board. You can install multiple expansion boards on the same Slicer, to a limit of 896K bytes.

## COMPATIBILITY

The inability of the Slicer to run many 16-bit application programs for the IBM was a major stumbling block in the past; the designers have produced a solution. A soon-to-be-released "PC board" will allow the Slicer to run programs specifically on and for the PC. The first questions asked about the Slicer, "Is it compatible with the PC?" and "Will it run Lotus?" will now have the answers "Kind of" and "Yes, with extra hardware."

Several things are necessary to run programs written for the PC; video, for example, must be memory-mapped, and video memory must be at a certain location in the 1-megabyte address space. The PC board (see photo 3) has a built-in monochrome video controller that has the memory in the right place. If you prefer, you can also install an IBM monochrome or color video card. You can plug many of the other IBM expansion cards into the PC board, too. The only cards that can't be used are IBM memory-expansion cards and cards that use IBM's DMA (e.g., disk controllers).

The most impressive thing about the PC board is that it has the proper firmware (ROM chips) to support IBM ROM (read-only memory) calls. This means that with the PC board, you will be able to run Lotus on the Slicer (or so I've been told). The real test will be Microsoft's Flight Simulator program, but for most people the ability to run 1-2-3 is the compatibility they require.

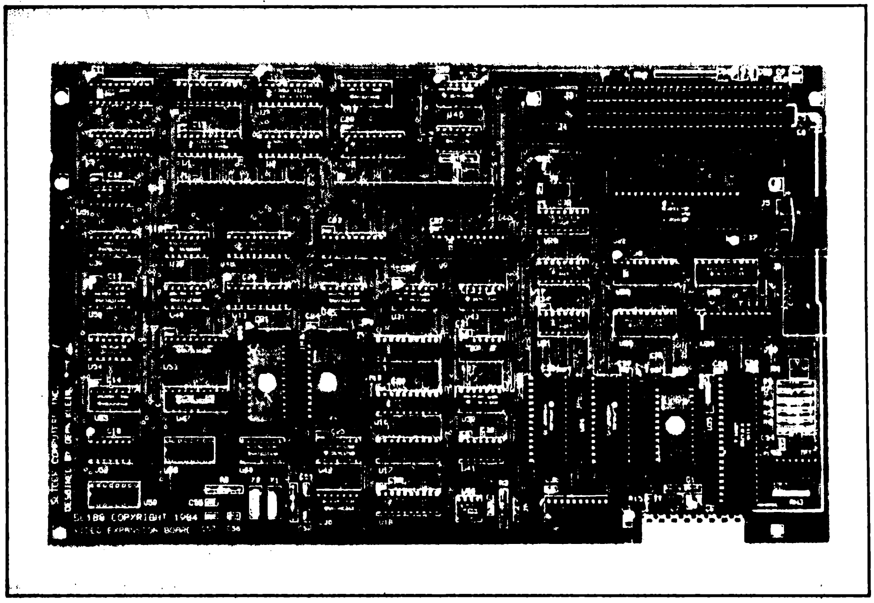

Photo 3: *The video expansion board supports an* IBM-*compatible* 80 *by* 24 *monochrome display,* 640 *by* 200 *bit-mapped graphics, and has two* IBM PC *slots and a connector for an* IBM *replacement keyboard.*

Even without the PC board, you can still run a lot of stock programs. On the software development side, CompuView sells versions of VEDIT that will run on any CP/M-86 or MS-DOS system, and nearly any compiler for MS-DOS or CP/M-86 will run on the unadulterated Slicer. I use CP/M-86 Turbo Pascal daily and will soon have Turbo for MS-DOS (a generic MS-DOS version is available as well as the version that works only on compatibles). Quite a few C compilers are available for both MS-DOS and CP/M-86 (Manx C, for instance), and there are several FORTRAN compilers, too (although, strangely, only for MS-DOS; could the fact that Microsoft wrote the most popular FORTRAN compiler have something to do with this?).

Lotus will not run on the Slicer without the PC board, but dBASE II runs with no problems. Versions of WordStar that do not use the PC memory-mapped video are also available, so they should run as well. Probably the best way to find out if a program runs on the Slicer is to borrow a copy from a friend and try it.

If you get 5¼-inch drives for the Slicer, you can directly read and write IBM PC single-sided and double-sided disks. You won't have to worry about getting your software purchases transferred to a special format.

Another good source of programs for the Slicer is the public domain. The SIG/M Users Group has several disks of CP/M-86 software, and *Micro Cornucopia* has disks of public-domain software specifically configured for the Slicer. Turbo Pascal and the CP/M utilities are the only programs I use on my Slicer that are not in the public domain.

## DOCUMENTATION

Whether you buy the Slicer as a bare board or as part of an integrated system, you will receive a 90-page manual that contains hardware and software documentation. The hardware documentation includes a step-by-step assembly guide with sections on hardware debugging and testing procedures. There is also a theory of operation and schematics for all sections of the board with diagrams showing pinouts of all the connectors. Most of this is detailed enough to make it easy to install peripherals and find hardware problems. A data book on the Signetics 2681 DUART is included, as well as a data book and application notes on the 80186. Unfortunately, there is no data sheet on the TMS4500 RAM controller or the 1797 disk controller chip; apparently, it was decided that most people would never need to do anything with these two chips anyway, but some of us do like to know.

The software documentation has instructions for installing the Slicer BIOS into standard IBM CP/M-86, for running the utilities included on the Slicer disk, and a very detailed description of the contents of the monitor EPROMs. You are not only told about the commands available in the debugger, you are also told how to write software that accesses the monitor routines for doing such things as printing messages, reading and writing on the disk, and so on.

The manual seems to contain enough information for a person who has some experience to find his way around. Some of the information is sketchy, though. I was not overly impressed with the amount of information included on hooking up a Winchester drive. Also, the manual seems not to be organized in any special order. The first section deals with CP/M-86 and the utility programs, then it hops right into kit assembly, followed by the theory of operation, then hardware debugging, then the monitor, and finally back to the connector pinouts and schematics. Hardware and software are not separated; they seem to be shoved together in whatever order they happened to be in when the manual was stapled together.

In addition, you also receive the

firms prepared on the operating systems.

## CONCLUSION

Overall, the Slicer is an inexpensive (for the performance), solid machine that can be the base of an efficient software-development system. It can also be used as a multiuser system in a small business environment.

I bought the system with the idea of using it for software development, and it seems perfectly suited to the task. I wanted a system that was reliable, fast, and mildly compatible with the IBM. The Slicer has remained totally solid since it was first assembled; it is the most reliable piece of hardware I have ever owned. The benchmarks comparing the Slicer to my Big Board speak for themselves; it is fast. The unmodified Slicer has problems running some software written for the IBM, but all software written on the Slicer will run on the IBM. If you must have a true IBM-compatible, then you should probably wait for the PC board to be released or look elsewhere.

*The Slicer is a solid machine; it is the most reliable piece of hardware I have ever owned.*

The support from Slicer is refreshing, too. There is always someone available to help solve problems when I call. The Slicer had some problems at first, but most of them have been solved because the company actually responds to user requests. ■