

Typesetting on Personal Computers

Assembling a Moderately-Priced, High-Performance Clone of the IBM PC for Running T_EX

M. Pfeffer and A. Hoenig

This new column is dedicated to bringing to users of all brands of personal computers the latest information on products related directly to T_EX (including: new implementations, printer drivers, and screen previewers), as well as singling out those products from the general computer marketplace that are of special interest to people who set type using personal computers. (Let's hear what you've learned from your experiences, and what you'd like to see in future columns.)

The focus of this issue's column is on building a moderately-priced, high-performance IBM PC clone from sub-assemblies. The information should prove useful not only to users building the complete system, but also those users needing to expand their present systems to handle T_EX. This \$2,000 computer has a 20 megabyte hard disk, 640 k of RAM, and runs T_EX in 30% less time than a PC. Assembly takes just a few hours, needing only a set of screwdrivers (but a set of small nutdrivers helps). Here's the list of the components, followed by the list of suppliers and the assembly instructions. (Footnotes are references to reviews.)

Hard Disk: Although you could work with a 10 Mb drive (T_EX needs 5 Mb), it pays to get a 20 Mb drive: the difference in price is small.

PC's Limited sells 20 Mb drives for \$495, with a one-year warranty. They ship from a variety of manufacturers; the drive I received was a half-height Seagate, with a Western Digital controller. I timed it as having a 75 ms average access time.^{1 2}

If you are adding a hard disk to your present PC, you should replace the PC's 65.5 Watt power supply with a higher-capacity model (see below).

(If you plan to run an operating system other than DOS, you'll probably need to spend an additional \$75 for a Xebec controller.)

Operation Hints: Put 'prompt \$p\$g' in your autoexec.bat file; put 'buffers=16' in your config.sys file; to avoid accidentally formatting the

¹ "Ten by Ten," *PC Tech Journal*, vol. 2, no. 5, pages 53-63, November, 1984.

² "Fixed-Disk Benchmarks," *ibid.*, pages 64-70.

hard disk, rename format.com to formatxx.com and create a file named formatA.bat containing the line 'formatxx A:'—to then format a floppy disk, you use 'formatA'; park the disk's head before moving the computer (and also, preferably, before turning off the computer); review the '/p' and '/w' options to the dir command; routinely backup your files (you can download the backup program bac.com, described in *PC Magazine*, vol. 4, no. 17, pages 197-205, August 20, 1985, by calling [212] 696-0360, where you will also find the diskp.exe program I used to time the drive). Also, look into some of the handy file utilities that make managing a hard disk easy.³

Motherboard: For \$670, ACS sells a tested motherboard⁴ which runs at 8 MHz (a PC runs at 4.77 MHz), with 640 k of RAM, built-in floppy-disk controller, a battery-driven clock/calendar, two serial ports, one parallel port, and six expansion slots (spaced as on an XT). The board comes with a one-year warranty; the current version of its ROM is 2.3, and the current version of the included diskette (containing a RAM-disk program, and the program to set the clock/calendar) has 'version 2.2' on its label.

You'll need to order a floppy-disk cable from ACS (for \$20) to connect the board to the floppy-disk drive, as well as a speaker (\$5, with cable). I also bought a serial cable from ACS (\$15; it comes with a DB-25 connector on its end) to allow the use of an external modem.

(A one-megabyte version of the board is available for \$730; this would allow you to use 192 k of the memory above DOS's 640 k limit as part of a RAM-disk, using the included RAM-disk program (the remaining RAM is preempted by address conflicts). Placing a copy of your editor and manuscript in RAM-disk would allow fast corrections to the manuscript between runs of T_EX.)

Drawbacks: The system lacks power-on diagnostics; the manual is sparse, and no technical manual is available; changing between 8 MHz and 4.77 MHz requires opening the case to move a jumper.

If you plan to write programs in Basic, you'll need to purchase a stand-alone Basic, as no Basic kernel is present in ROM.

³ "The Enhanced AT: A Personal Vision," *PC Magazine*, vol. 4, no. 13, pages 132-133, June 25, 1985.

⁴ "Personal Computers: Kit Computer Turns Out To Be a Sane Idea," *The New York Times*, Section C, May 28, 1985.

Compatibility: In the 8MHz mode, I tested: both implementations of T_EX; PC-Write (my current editor); The Word Plus (a spelling checker); PC-Talk; Turbo Pascal 3.0; Masm; and the Norton Utilities. I was able to bring up (but didn't test extensively): FinalWord's editor; Edix; Microsoft Word; Epsilon; WordStar; and Trace86.

Most incompatibilities surface in the 8MHz mode. Programs that depend on software timing loops will fail. Some cards can't keep up with the 8MHz speed. One user of the ACS board told me that his Hayes *internal* modem wouldn't work (Hayes told him what needed to be changed to fix the problem), and that he had to patch Crosstalk for the program to run at 8MHz.

(If you purchase the Xebec 1220 hard-disk controller, which incorporates a floppy-disk controller, you'll need to disable the floppy-disk controller built into the ACS board—see the note in the ACS manual, under section 6.12, explaining which chip to replace; the replacement chip costs \$15.)

Operation Hints: With a Hercules card in the system, use `clk1pt1` to set the clock initially, and to transfer the correct time to DOS—the ACS manual incorrectly implies `clk1pt2` should be used.

Some programs can't cope with 640k of RAM, and give an 'out of memory' message, even though they have plenty of room. One solution is to create a RAM-disk, to reduce the amount of memory available to the program.

Floppy-Disk Drive: I chose the CDC half-height drive, based on a review⁵ and my favorable experience with the CDC full-height drives. (But CDC is dropping out of the 5 1/4-inch floppy-disk drive market.)

Power Supply: I purchased a 150 Watt supply from PC's Limited for \$119. I've since noticed an ad for a 200 Watt supply from CC&C.

Case: Purchased from G & L, the case was satisfactory, though some of the screws were improperly machined. The case won't allow the plug from an IBM keyboard to reach the motherboard's jack, because of the grip ring molded onto the plug; if you want to use the IBM keyboard, you'll need to use a keyboard-extension cable (judging from a picture, CC&C's MSC-I case would accommodate the IBM keyboard's plug).

Next time, I'll try a case with a flip-up top, like the one sold by JDR Microdevices for \$59.95.

Display Adapter: I wanted a card that included Hercules monochrome-graphics emulation, for use

⁵ "Double Your Driving Pleasure," *PC Magazine*, vol. 4, no. 10, pages 133–137, May 14, 1985.

with the new T_EX screen previewers. I ordered a card made by Mitsuba from Computer Systems Planning, at \$125. It ran Microsoft's Word in Hercules mode, and Hercules HBasic (on an IBM PC).

Display: Studies indicate better user-performance with yellow displays, with one study revealing the worst performance with an orange display,⁶ yet manufacturers use the term "amber" to cover pumpkin-orange through canary-yellow. Restricting the search to yellow displays still leaves many displays from which to choose,⁷ and other criteria to apply.⁸ (I've always been satisfied with the quality of IBM's green display, but in a side-by-side comparison, a yellow display does seem less harsh.)

The display I tested, the Taxan 122, uses a yellow, long-persistence (PUL) phosphor, to minimize flicker, but the trade-off is a more noticeable afterimage when scrolling.

(Flicker is more discernible when a display is viewed out of the corner of your eye. To check the flicker of a display, as well as imperfections in the phosphor coating, configure a program to work in reverse video; for PC-Write, a freely-copyable editor which can be set to work in reverse video, see Appendix A of its manual.)

Drawbacks: As delivered, the top two scan lines would overlap when the top line was in reverse video, giving the appearance of a single, bright line; adjusting the vertical-line control corrected this. (I also tweaked the other controls to improve the image.)

Operation Hints: For a sharper image, I set the brightness to its near-minimum position, and used the contrast control to adjust the intensity.

Anti-Glare Screen: I purchased a mesh screen, called SuperScreen, from R+R Direct, to reduce glare off the display. The screen imparts a jet-black background to the characters; this makes the characters stand out. I also tested a polarized panel made of plastic, but found it produced a worse glare from the panel than I had off the display.

Drawbacks: The mesh causes a slight degradation of the image, and superimposes its own dot pattern on the characters.

⁶ "Maximize Your Computing Comfort and Efficiency," *Computers & Electronics*, vol. 21, no. 4, pages 35–48, April, 1983.

⁷ "Buyer's Guide to Monitors," *Computers & Electronics*, vol. 22, no. 12, pages 56–59, December, 1984.

⁸ "Video Signals and Monitor Design," *ibid.*, page 53.

Keyboard: The low-cost keyboard I tested differs from the IBM keyboard: it has a soft touch; the keys do not click; it has separate numeric and cursor keypads, horizontally-arranged function keys, and a standard letter-layout (T_EX users may be the only people who prefer IBM's non-standard placement of the backslash and open quote on the PC's keyboard. In the AT, IBM uses the standard office layout).

I purchased the keyboard from ACS for \$125 (JDR sells what appears to be the same keyboard for \$100). Minor variations on this keyboard exist: some, like the one I received, have the caps-lock key next to the 'a' key, while others have the control key next to the 'a' key; some have the PC's placement of the backslash and open quote—be sure to specify your preference when ordering.

Disadvantages: Though some users claim that the soft touch increases their typing speed, I find the cheap feel of the keyboard to be too mushy. The legends on the keys are only surface markings, and will rub off with use.

Surge Suppressors: I know of four instances where computers were fried during lightning storms. Protect your equipment with surge suppressors—one on the power line, and another on the phone line to the modem.

A Curtis Ruby (PC Connection, \$59), protects my power line. A single switch controls its six outlets.

The new Radio Shack catalog lists a phone-line protector (43-102), for \$12.95. Because phone-line protectors often protect only the red and green wires, I disconnected the other two wires (black and yellow) from the jack that feeds into the protector. (The black and yellow pair is unused in most homes with single-line service; the pair is used to activate the line-in-use light in some phone installations, or carries the second line in a two-line system.)

(Incidentally, owners of Compaq and IBM systems can exchange fried motherboards for replacement boards, at less than one-third the cost of a new board.)

Cables: I ordered Curtis printer and modem cables from PC Connection, at \$19 each. The Curtis cables are completely shielded (including the plugs), to prevent stray signals from getting in or out of a cable.

Accessories: Some odds and ends to make your system more comfortable: tilt/swivel base for the display; copy stand (without any magnets); ergonomic chair; flip-top floppy-disk file (such as the one made by MicroComputer Accessories); glare-free lighting; and dust covers.

Software: Aside from T_EX and an editor, you'll need a copy of DOS.

Setup: To minimize strain, the keycaps of the home row of your keyboard should be about 27 inches from the floor: the goal is for your wrists to be level with, or slightly below, your elbows—the standard 29½-inch table height is too high. (My keyboard rests on a small folding coffee-table, in front of the desk that supports the display.)

The display should be leveled horizontally, and propped up to bring its top edge to just below eye level. This also gives you room to place the copy stand directly below the display, minimizing head-turning as you look back and forth.

Suppliers

When placing your orders, ask the expected ship date, and the difference in cost between ground and air shipping.

PC's Limited, in TX: [800] 426-5150 (from Texas: [512] 452-0323). 20 megabyte internal hard disk for a PC (you can specify a Seagate), \$495; 150 Watt power supply, \$119. (Free ground shipping; about \$14 by second-day air.)

ACS, in TX: (Advanced Computer Solutions) [214] 247-5151. Motherboard with 640k, \$670; speaker, with cable, \$5; floppy-disk cable, \$20; serial cable, \$15; keyboard, \$125. Address orders to Tom Langley. (About \$17 for second-day air.)

PC Connection, in NH: [800] 243-8088 (outside continental US: [603] 446-3383). Half-height CDC floppy-disk drive, \$89; Curtis Ruby surge suppressor, \$59; [Curtis printer cable, \$19; Curtis modem cable, \$19]. (Second-day delivery: \$2.)

G & L, in CA: [800] 523-8750 (from CA: [714] 758-8600). XT case, \$49. (Second-day delivery: \$24; ground: up to \$13).

Computer Systems Planning, in NY: [212] 213-9125. Mitsuba display adapter, \$125. This company also sells assembled systems, based on the ACS board; contact Paul Wolotsky.

LogicSoft, in NY: [800] 645-3491 (from NY: [516] 249-8440). Taxan 122 amber display, \$119 (shipping by ground: \$3). LogicSoft will beat advertised prices by \$10; I used this policy, having them beat the \$129 price advertised by Silicon Specialties ([800] 354-7330).

R+R Direct, in OH: [800] 654-PLUS (from OH: [800] 545-PLUS). SuperScreen (A5193 for Taxan 122), \$29.95. (Not a discount house.) Excellent customer service.

Other Companies: Your Personal Computer Store, in TX, [409] 740-3223. Xidex floppy-disks, \$12 for a box of ten, double-sided, double-density disks. Free ground shipping for orders over \$50; \$4 for second-day shipping of three boxes.

JDR Microdevices, [800] 538-5000 (from CA: [800] 662-6279).

CC&C, in CA, [818] 576-1621.

MicroComputer Accessories, in CA, [213] 641-1800.

Quill Corporation, in IL, [312] 634-4800. Computer and office supplies. Good price if item is on sale (a frequent occurrence). Excellent customer service.

Assembly

In the directions that follow, my use of "left" and "back" assumes that the case is oriented as if in operation on a desk in front of you, and that the motherboard is oriented as it would be when inside the box: component-side up, card-slots in the back-left corner.

Prepare the Case: Put aside six of the chrome screws (the ones with hex/Phillips heads)—they'll be used later to attach the top cover to the black base, and to secure the two cards. Remove the back card-support cage (the one with eight cutouts). Attach a chrome blanking plate over each cutout, except over the first cutout (the left-most cutout when held as if already mounted inside the case—screw-holes up), and except over the sixth cutout (I used the remaining chrome hex-head screws for this, and when I ran out, finished with the black screws with the built-in washers). Loosely attach the cage inside the box (allowing it to slide), using four black screws (the ones with the built-in washers); the cage will be tightened later.

Attach a black plastic edge-guide (which stabilizes the front edge of a card) to the left-most position inside the front of the base; insert one of the tiny black screws from the inside of the case, through the top hole in the guide, and secure with a hex-nut on the outside of the case. (The edge-guides that came with my case overlap more of a card than the snap-in guides that normally come with cards, but this didn't create a problem with the Mitsuba card.)

Drop the speaker into its position at the front of the base. Bring its cable around the lower-left edge of the base's front panel, into the inside of the base; if the cable isn't long enough to reach the near left drive shelf (close to the point where the speaker's connector is plugged onto the motherboard), you'll have to route the cable through one of the grill

cutouts behind the speaker, and force the speaker down into place. I used a dab of epoxy to secure the speaker.

Attach the small, black, oval blanking plate inside the rear of the box, to cover the left of the two D-connector cutouts. Install the D-connector from the serial cable in the right cutout, and route the other end of the cable out the large circular hole, to keep it out of the way for the moment.

Prepare for the Motherboard: The board is held in place by nine brass stand-offs, hex-nuts, and black screws. To eliminate improperly-machined hardware at this point, thread the hex-nuts onto the stand-offs, and insert the tiny black screws into the other end (if you don't have enough tiny black screws, use the black screws with built-in washers).

Turn to Fig. 1 of the ACS manual, and make the following annotations (it's easier to find the proper connection points by working from this drawing, rather than the legends printed on the circuit board, as it's sometimes difficult to decide if a legend on the board refers to the connector to the left of the legend or the connector to the right of the legend): E1 is the speed jumper; P1 is the connector for the two power leads from the power supply; S1 is the set of DIP switches; P3 is the connector for the floppy-disk drive's cable; P6 is the connector for the serial port's cable (COM1:); and P2 is the connector for the speaker.

Configuring the Motherboard: To discharge any static you may be carrying, touch a large metal object; then remove the motherboard from its anti-static bag, and rest the board on top of the bag.

To set the board to its 8 MHz speed, move the jumper on the E1 block so it connects pin 2 to pin 3.

Refer to section 7 of the manual to set the DIP switches; on my board, I set 5 and 6 'off' (for monochrome display), and I set 7 and 8 'on' (for a single floppy-disk drive). Verify that switches 3, 4, and 9 are properly set for the amount of memory on your board (see section 7.03).

Installing the Motherboard: The threaded ends of the brass stand-offs are inserted from the bottom of the board, and secured with hex-nuts on the top (component side) of the board, but to prevent the mounting hardware from short-circuiting the metallic traces that run near some of the board's mounting holes, you must use the insulating red washers. Ideally, insulating washers would be placed above and below every hole, but if your case doesn't come with enough washers to do this, use what washers you have in these ten essential locations (orient the board component-side up, with

the card slots in the back-left corner; a row runs left-to-right, a column runs back-to-front): back row, middle column: top side; middle row, all three columns: top and bottom; front row, left corner: top and bottom; front row, middle column: top. You can use a nut driver to hold the hex-nuts as you tighten the stand-offs, but don't try to hold the nuts with a pliers—pliers are too likely to slip off the nut, and damage a trace.

After installing the stand-offs, hold the board above the case's back-left corner, with the middle column of stand-offs just inside the left lip of the case, and the back of the board just touching the back of the case; lower the board into the case (the left-most column of stand-offs will be resting outside the case). Slide the board to the right, until the left-most column of stand-offs touch the outside of the left lip of the case. Pull up on left drive shelf; while pulling it up, lift the left edge of the motherboard up, until the left-most column of stand-offs are above the left lip of the case; slide the motherboard right, until the stand-offs are to the right of the case's lip, then lower the board onto to bottom of the case. While maintaining your pull on the drive shelf, slide the motherboard into position. Release the drive shelf.

To temporarily counterweight the base, place a heavy book in the right drive shelf (volume 2 of *The Art of Computer Programming* does nicely). To install the screws into the left column of stand-offs, slide the base so that the left side of the case extends over the edge of the table. Install the screw in the middle row first. Don't tighten any of the nine screws until all are in position. After installing the three screws in the left-most column, move the base further off the table, until the middle column of holes is accessible (take care that the case doesn't fall off the table) and install the screws in this column, again starting with the middle screw. Move the base back on the table. Remove the book. Connect the free end of the serial cable to P6 (as always, the side of the cable with the red stripe goes near pin 1 of the motherboard's connector—be sure to position connectors squarely on their double row of pins). To insert the screws in the right-most column, turn the base over, or stand it up on its back panel. Tighten the nine screws.

Clean those areas where you intend to place the self-adhesive feet, and then attach the feet.

Connect the plug from the speaker to P2; route the cable down and out of the way. Connect the floppy-disk drive cable to P3 (red stripe on cable to pin-1 side of connector), and allow the cable to run off to the side.

Installing the Power Supply: Of the six plugs coming out of the power supply, four are identically shaped. Of these four identically-shaped plugs, two will be used to power the two drives; the other two remain unused. The remaining two (larger) plugs will be connected to the motherboard at P1.

Remove the four round-head screws from the back of the power supply—these will secure the supply in place. Slide the power supply in from the right. When it's half way in, connect the two larger plugs to P1 (these plugs are keyed with small nibs, to prevent you from incorrectly switching them around). Slide the supply in the rest of way, then slide it forward toward the drive shelves, and then back against the rear of the case (this causes the lips in the bottom of the supply to engage the lips in the case). Use the four screws to secure the power supply.

Installing the Hard Disk: (Read the directions that come with the drive.) Partially slide the drive into the right drive shelf. Attach the two ribbon cables from the controller, which is still outside the case, to the drive (the side of a cable with the red stripe goes closest to the notched side of an edge-card connector on the drive). Attach the power lead from the power supply (this D-shaped plug will fit only one way). Slide the drive in the rest of the way. Insert the screws loosely (I used some spare screws to secure the drive on both sides). While pushing the drive back against the front of the case, tighten the screws.

Installing the Floppy-Disk Drive: (Read the directions that come with the drive; the drive comes configured as an 'A' drive, which is what we want.) Partially slide the drive into the left drive shelf. Attach the connector from the power supply. Attach the connector that's at the end of the cable coming from P6 to the drive (the side of the cable with the red stripe, and twisted segment, goes to the notched side of the drive's edge-card connector). While gently holding the cable from P6 down against the motherboard, slide the drive in the rest of the way (the drive sits atop P6's connector and ribbon cable). Loosely insert the two screws (by hand) into the left side of the drive (if you drop a screw, take care not damage the board when retrieving the screw). You're now about to tighten the screws—but to avoid the danger of dropping your screwdriver onto the motherboard (and damaging the delicate metallic traces), tie a loop of string loosely around your wrist, and tie the other end around the screwdriver; this way, if you accidentally let go of the screwdriver, it won't fall onto the

board. While pushing the drive back against the front of the case, tighten the screws.

Inserting the Display Card: Slide the Mitsuba display adapter into slot 1 (the left-most slot). Adjust the card cage so the connectors on the card are centered in the cutout. Use a hex-head chrome screw and the screwdriver with the wrist strap to attach the mounting bracket of the card to the cage. Tighten the cage to the base.

Insert the Hard-Disk Controller: Slide the controller into slot 6. Using the screwdriver with the wrist strap, secure the card's mounting bracket to the cage, with a hex-head screw.

Completing the Assembly: Insert a black plastic blanking plate above each drive.

Neatly fold the cables together, and slide them into the space between the drives and the power supply. (I used 8-inch nylon wire ties, Radio

Shack 278-1642, to keep the wires together.) Push the cables from the hard-disk controller down and against the controller, so they won't snag on the lip that's beneath the center of the top cover, as you slide on the cover.

Slide on and secure the top cover; check that the cover's lip has engaged the lip on the top of the base. Connect the display and keyboard.

To attach the anti-glare mesh, place the Velcro pads on the top and bottom (horizontal) parts of the frame—the vertical sides of the frame don't sufficiently overlap the display's case to give a firm grip.

Follow the directions that came with the hard disk on partitioning and formatting the drive (my disk had already been partitioned).

© 1985 M. Pfeffer.

Date submitted: October 4, 1985.