By Kirk Kleinschmidt, NTØZ

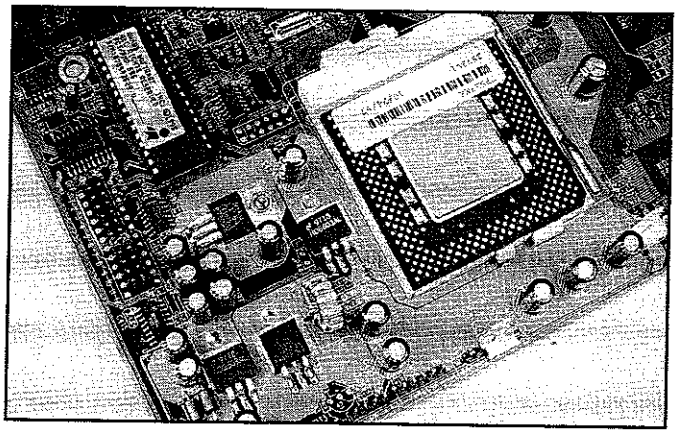
Supercomputers in Your Shack: Build, Don't Buy

Building an IBM-compatible PC is a perfect home-brew project. Whether you want to save money, learn about computer technology or create a fearsome assemblage of customized high-tech hardware, building PCs has never been easier, more accessible or more affordable. Choosing the right components, however, can be challenging in this era of "parts overload." Here's some advice on getting the most bang for your buck—and a computer system that fits your needs, whether ham radio, business, education, gaming—or a little of everything!

If you're at all typical, a computer (or three) shares prime real estate in your shack. Performing dozens of functions for modern hams, personal computers are a fact of life for all but the most retro-tech ops. Although many of us can get by—after a fashion—with clunky, antique PCs, modern Amateur Radio software requires modern hardware and operating systems. And unlike today's top-of-the-line radio gear, which is impossible for home builders to duplicate, we can build, tweak and customize our computers at a level that's on par with the best commercial products. In fact, many home-brew PCs dramatically outperform their "store bought" counterparts!

At thousands of hamfests and computer expos around the country, PC builders sift through a bewildering array of computer parts and related items. These days, when it comes to building PCs, the mechanics of assembling and configuring your system are often easier than choosing the right components—CPUs, motherboards, hard drives and so on. The choices can become overwhelming, even for experienced builders.

This article is not a step-by-step assembly manual—as you'll see later, those details are available in books, magazines and on-line tutorials. What you'll find here, in addition to resources and tips gleaned from personal experience, is help in finding your way through the confusing maze of technology, components and related hardware required to build your own "supercomputer."



Locked firmly in the Socket 7 base of this Shuttle HOT-569 motherboard is a shiny new Pentium 233 MMX CPU (which, although normal, looks "unfinished"—as if someone had pried the smooth plastic top off the chip with a screwdriver). The jumper at the far left is one of only three total. Using the IC and the four regulator chips on the left, the '569 "asks" the CPU about its voltage requirements and sets them accordingly. (All photos by the author.)

Getting Started

A comprehensive treatment of this topic requires *thousands* of pages, so I'm assuming several things:

- That you're building a *new* system. If you want all the latest goodies you'll need modern components.
- That first-timers will make sure they can get help from experienced partners. Building PCs mostly involves assembling and configuring standardized "building block" components, but it's not quite as simple as making a castle out of Lego blocks! After you've built a couple of systems you'll be ready to solo.
- That you're building a Pentium-class machine designed around "Socket 7" motherboard technology, saving Pentium II-class machines (built around the newer "Slot 1" technology), *Unix/Linux* boxes and Apple *Macintosh* systems for a rainy day.
- That you're committed to quality. When it comes to buying computer parts, the highest quality components often cost only 10% to 20% more than the cheap stuff. *Get the good stuff—no exceptions!* You'll be glad you did.

Pieces and Parts

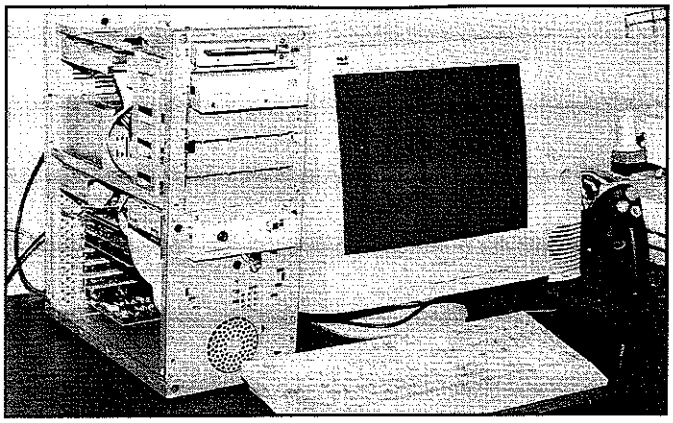
Simply speaking, building a computer is a straightforward process of acquiring all of the parts (case, power supply, motherboard, CPU, RAM, drives, plug-in cards, keyboard, mouse, etc) and putting them together in the correct sequence. Once everything is assembled it's time to format the hard drive, tweak the system settings and install the operating system/software. BINGO! You have a new computer!

That's a bit simplified, of course, but essentially complete. The difficult part for newcomers is choosing the right components. The choices depend on how the computer will be used, available financial resources, which operating systems and software are required, and so on. So, without further ado, let's examine the parts required to build a modern Pentium-class PC.

Cases and Power Supplies

Most computer cases are sold with built-in power supplies. Earlier designs tended to be horizontal "desktop" units that doubled as convenient pedestals for small monitors. Tower (vertical) cases are prevalent today, and they come in three sizes: mini, mid, and full. Mini and mid tower systems are fine for most users, while full size towers are used for network servers and other high-end machines.

In addition to a variety of sizes, cases are designed to accommodate several motherboard "form factors" (board size and layout of



The Pentium machine shares the test bench with my Viewsonic 17GS monitor (pay no attention to the sewing machine in the background!). The Enlight mid-tower case has three nifty "slide out" internal hard drive mounts. The rear mount above the power supply holds the system's hard drive, which leaves *plenty* of room for expansion.

mounting holes, etc). Early PCs used motherboards with "AT" form factors (quite large). Today, most motherboards are built to "baby AT" (smaller and more compact) and the newer "ATX" form factors. ATX systems, which offer better cooling, standardized port connectors, foolproof power supply connectors and more, will eventually replace AT systems. Many ATX cases accept ATX and baby AT motherboards to assure a smooth transition between technologies.

Make sure you get a case that fits your motherboard's form factor and has a suitable power supply (a UL-listed supply that puts out 200 to 250 W is best). Remember: With computer cases, you get what you pay for. Inexpensive cases often have misaligned parts and the panels and innards fit together sloppily. If the mechanics of the case are lacking, it's likely that the quality of the power supply is commensurate. Power supply faults frequently kill computers...so consider case quality carefully!

At press time, quality cases cost $60 to $80, while "bargain" cases run $35 to $50. The $20 to $30 difference pays off with excellent benefits! On a good case the body panels and parts fit together like a Lexus, not a Yugo. And the power supply is clean and stable, with an oversize fan. Good cases also have extra front-mounted fans that blow across the CPU area. Nice!

Motherboards

As the heart of your new system, choosing the right motherboard is critical and, unfortunately, somewhat difficult. Hundreds of manufacturers make thousands of different motherboards in a variety of shapes, sizes and prices. This is no place to skimp on quality, so unless you're specifically familiar with a certain model of motherboard or manufacturer, stick to a name-brand AT or ATX motherboard of known quality. Here are some other considerations:

- Can the motherboard physically accommodate your CPU and provide the correct voltage(s)? Newer CPUs run at lower voltages to reduce power consumption and heat production. Many use a "split plane" design that powers the chip's external areas at a slightly higher voltage than the chip's "logic core."
- Which chipset does the motherboard use and how is it implemented? A motherboard's chipset is the specific set of ICs that lets the CPU talk to the various buses, memory and peripherals. All other factors aside, faster is better!
- Does the board use a complicated swarm of jumpers to control its various settings, or does it have enough "intelligence" to "autoconfigure" many of its own systems? Some advanced motherboards "query" the CPU and RAM chips to automatically provide correct voltages and settings.
- Does the motherboard allow users to manually set bus speeds, clock multipliers and CPU voltages? Standard settings (60 and 66 MHz) are usually recommended, but being able to select settings that are faster than normal (75, 83 and 100 MHz) allow hotrodding and speed-tweaking, which is the main motivation of many computer home-brewers. Through various "overclocking" techniques, users can take a 200-MHz Pentium MMX chip, for example, and make it perform at 225 or 250 MHz, dramatically increasing performance (occasionally at the expense of reliability!). If you really want to get into the guts of your system, see the

Overclocking

We've all been guilty of "over-rotating" our rig's **MIKE GAIN** control to squeeze out that last bit of "talk power." Or loading the final amplifier tubes of our "linear" amplifier just a wee bit heavy for similar purposes. In radio transmitters, thanks to decibels and power ratios, this kind of tweaking rarely produces *desirable* results. For computer tweakers, however, overclocking is a Starsky and Hutch technique that can produce amazing performance gains. It can also make your computer unstable or, on rare occasions, destroy the CPU, hard drive or a plug-in card or two!

Overclocking is now rather mainstream, athough its roots run deep into the underworld of low-budget, high-performance PC builders (of course!). In a simplified sense, it works like this: PC performance is determined by many factors, of which CPU speed is only one. The speed of the memory bus and the PCI bus play major roles as well. Through tweaking these bus speeds and adjusting the clock frequency driving the CPU, overclockers can, for example, make a typical 200-MHz Pentium MMX system run at 225, 250 or 266 MHz, producing noticeable performance gains, especially if the bus speed is increased as well as the CPU frequency. If the resulting system is stable, everyone is happy, money is saved, and so on.

For the most part, running a motherboard's system bus at speeds greater than 60 or 66 MHz isn't officially recommended by chip makers and system vendors, but as thousands of backyard mechanics have discovered—it usually works, within reasonable limits.

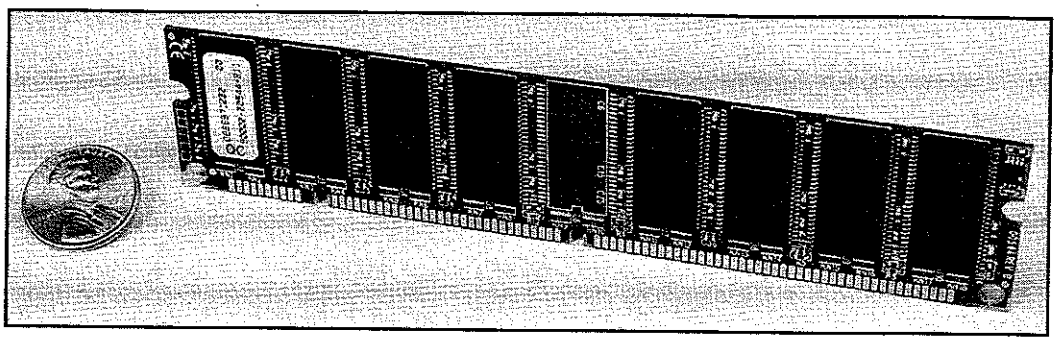
Modern motherboard makers include jumper setting to enable 75, 83 and even 100-MHz system buses. They also provide for many extra CPU voltage settings, which are sometimes required to ensure stable operation at faster-than-rated speeds. A little extra CPU voltage makes for cleaner square-wave (clock) transitions, but produces more heat, which is why overclocked systems sometimes have *massive* CPU heat sinks and fans.

Most new PCI plug-in cards work fine on faster buses (they run a bit hotter, especially video cards), but nothing's guaranteed. Some SCSI controllers and network cards can't handle the strain. Older, slower memory chips can't either, which is why 10-ns SDRAM DIMMs are the universal choice of bus tweakers everywhere.

Emotionally, overclocking *feels a bit naughty*—because you're not supposed to do it. Every time you try a new combination of settings—CPU speed, CPU voltage, bus speed, BIOS memory timings, whatever—you nervously glance around as if someone's watching you.

But, it either works or it doesn't. If you're careful you'll rarely smoke your favorite new components. As mentioned, my Pentium 233 MMX worked fine at 292 MHz (on a blazing 83-MHz bus), but I backed it off to 266 MHz to be safe (ratcheting the bus speed down to a more comfortable 75 MHz). My 233-MHz K6 CPU wouldn't "turn on" at 292 MHz or 266 MHz, but cruised along nicely at 250 MHz. I run this machine at its rated 233 MHz, because it's fast enough the way it is, and the K6 runs very hot while overclocked, unlike the Pentium, which is as cool as a cucumber.

If you want to start your complete overclocking education, point your Web browser to Tom's Hardware Guide, **http://www.sysdoc.pair.com/**; Anand's Tech Page, **http://www.anandtech.com/**; and the PC Hardware and Performance Page at **http://www.sysopt.com/**. But don't tell anyone I sent you. In fact, we never had this conversation....—*NTØZ*



This Simple Technology DIMM is wafer thin, ultra compact and packs a whopping 64 Mbytes into one convenient package.

"Overclocking" sidebar for a list of resources.

• Does your new board have enough expansion slots—and are they of the right type? Modern computer plug-in cards live on the PCI bus, which is quickly replacing the older, slower ISA bus. Later this year, systems will show up with no ISA slots—PCI all the way! Typical motherboards have four or five PCI slots and two to four ISA slots.

• What type of RAM chips does your motherboard support, and how many RAM sockets are available? Modern motherboards use 72-pin SIMMs (single in-line memory modules) or 168-pin DIMMs (dual in-line memory modules) ranging in capacity from 4 Mbytes to 128 Mbytes per module (older systems use 30-pin SIMMS, which are now obsolete). When it comes to sockets and maximum RAM capacity, more is better.

• Make sure your motherboard has at least 256 kbytes of pipeline burst cache RAM (512 kbytes or 1 Mbyte preferred). Using a modern CPU with no cache RAM is pointless—although many consumer-grade PCs were shipped this way in the mid "90s!

• Does your motherboard have onboard floppy, serial, parallel and hard disk controllers? Most do. Typical units feature support for four IDE/EIDE devices (hard drives, tape drives, CD-ROMS, etc), but some expensive systems feature built-in SCSI or Ultra-SCSI controllers. On-board controllers free up precious PCI slots and ease system assembly. Some motherboards also have onboard video and sound systems (usually not recommended).

Chipsets

A motherboard's chipset is a specific set of highly integrated circuits that work with the CPU to control all motherboard functions. Chipsets contain the local bus controller, cache controller, main memory controller, DMA and interrupt controllers, and several other key circuits. A motherboard's chipset has a large bearing on a systems speed, functionality, which types of RAM can be used, etc.

As the world's largest CPU manufacturer, Intel is also a leading chipset and motherboard manufacturer. For Pentium-compatible CPUs, Intel chipsets include the 430FX, 430HX, 430VX and the 430TX. The FX is the oldest design and should be avoided. In rough terms, the HX was a high-performance chipset, the VX was the "value" chipset and the TX is the latest-and-greatest Pentium-class chipset. Other Pentium-class chipsets are produced by Opti, VIA and AMD (another CPU contender).

BIOS

A motherboard's BIOS chip, which stands for Basic Input Output System, controls many key system features and determines, among other things, how the motherboard tests its various systems when it's powered up. Make sure your motherboard uses a BIOS manufactured by Award, AMI or Phoenix, the top-tier BIOS makers. Also, make sure your motherboard has a FLASH BIOS, which allows you to download newer versions of your system's BIOS code from the Internet when your BIOS needs updating.

CPUs

Unlike the bad old days of personal computing, when CPU lifetimes were measured in years, modern chips are replaced by faster siblings on a monthly or quarterly basis. Prospective buyers have many (often confusing) CPU choices.

In the Pentium class alone you can choose from the Classic Pentium (133, 166 and 200 MHz, no MMX); the Pentium MMX (166, 200, 233 MHz); AMD's K6 (166, 200, and 233 MHz, all with MMX); Cyrix's 6X86+ (166 and 200 MHz, no MMX); Cyrix's 6X86MX (166, 200 and 233 MHz, with MMX); and IDT's C6 at 166 and 180 MHz, with MMX). Whew! And that doesn't even consider the Pentium II chips (233, 266 and 300 MHz) and the follow-on versions of all the chips mentioned above! It's a CPU pea soup to be sure!

Choosing a CPU depends on how your system will be used and how much money you'd like to spend. CPU choices are a hotly debated topic; here are some general considerations:

• Avoid CPUs that don't incorporate the MMX instruction set (57 new microprocessor instructions that make for better quality multimedia).

• The Pentium MMX, even at 233 MHz, isn't the strongest contender for 32-bit applications such as *Windows 95/98/NT*. If your machine is intended primarily for *Windows* computing, you may want to look elsewhere. On the other hand, the Pentium MMX chips have superior 16-bit (DOS) and floating-point (math coprocessor) performance required by DOS-based scientific and game applications. It's a strong all-around performer, and it's the king of overclocking (my Pentium 233 MMX system runs fine at 292 MHz and loafs along at 266 MHz—while generating almost no heat!).

• AMD's K6 has many advanced design features and excels in *Windows 95/98/NT* systems (Fast K6 systems can keep pace with some 300-MHz Pentium II offerings). Its DOS and floating-point specs aren't quite up to Pentium MMX standards, but they're not too shabby, either. The K6 also costs less than the Pentium MMX, making it a great multi-purpose CPU (it's very overclockable, but it runs hotter than the Pentium, so be sure to provide adequate cooling).

• Cyrix's 200-MHz 6X86+ is perfect for a budget screamer, and the 6X86MX, with MMX, turns in killer Windows benchmarks but falls short in DOS and floating-point performance. It, too, is less expensive than its Intel counterparts, and a bit more difficult to overclock.

• At press time, Intel's Pentium 200 MMX and AMD's K6 200 MMX are the price/performance champs. Either chip, matched with suitable system components, will make for a fine system.

Memory (RAM)

As of early 1998, 16 Mbytes of system RAM is a bare minimum, and 32 or 64 Mbytes is desirable (especially for *Windows 95/98/NT* systems). Be sure to buy EDO SIMMS or SDRAM DIMMS. These newer-technology chips are stable at high bus speeds and cost only pennies more than old technology memory modules.

Also, be sure to buy memory from reputable dealers/manufacturers. Tons of "gray market" RAM floods US distributors. Although attractively priced, it's often second-grade silicon. You might get lucky, but you might just pull your hair out troubleshooting operating system errors and mysterious crashes. (For a detailed look at PC memory, see "Upgrade Your Memory" in January 1997 *QST*.)

Hard Drives

These days, your hard drive choices are practically limited to two main technology families: IDE and SCSI. In practical terms, IDE drives are reliable, reasonably fast and very affordable. The fastest IDE "flavors" are Enhanced IDE (EIDE, sometimes called ATA-2) and Ultra-IDE (sometimes called Ultra-DMA). Every IDE hard drive

Resources

"Where can I find that?" "How do I do that?" "Which company makes the best Thingamabob?" I hear these questions all the time. There's rarely one correct answer, of course. And although your choices may certainly vary, as an example of one PC builder's decision-making process, here's a look at the guts of the two systems I built while writing this article—plus some excellent information resources in general.

Case/Power Supplies. For years I used bargain cases when building my systems—which I now regret. Both new computers are snugly nestled into 6800-series medium tower cases made by Enlight. These sturdy and roomy cases assemble/disassemble without screws or fasteners of any kind, allowing easy access to the innards. Parts, drive bays and panels fit together precisely. No wonder they're sold just about everywhere. Browse their US corporate site at **www.enlightcorp.com/**.

Motherboards. The K6-233 system is built around Shuttle's HOT-569, a TX-chipset board that's nearly jumperless for easy set-up. Thanks to superb manuals and user-friendly design, Shuttle motherboards are ISO-9002 certified and are popular with system builders. Shuttle boards are widely available. Check out their Web site at **http://www.spacewalker.com/**.

The Pentium-233 MMX system (overclocked to 266 MHz) is set up on a Tyan 1571S TX-chipset board that has five handy PCI slots and four ISA slots. The Tyan board, also ISO-9002 certified, isn't as easy to set up as the Shuttle 569, and the user manual is somewhat spartan, but the board, like many Tyans before it, works great. You can browse the Tyan Web site at **http://www.tyan.com/.** Tyan boards are widely available.

CPUs. The K6 system cuts through *Windows 95* chores like a laser beam. For all the gory technical details, see Advanced Micro Device's home page at **http://www.amd.com/**. If your local vendor can't offer you a good price, try Way 2 Cheap in Austin, Texas: **http://www.way2cheap.com/index1.htm**. For details on the Pentium MMX chip, try Intel's main page at **http://www.intel.com.**

RAM. Both systems have 64 Mbytes of SDRAM from Simple Technology. I've used Simple Technology memory products for years, so why change now? For specs and info, see **http://www.simpletech.com/**.

Hard Drives. New hard drives are impressive. They're bigger, faster and more affordable! The drive in the K6 system is no exception. It's a hefty 6.4-Gbyte Quantum Fireball ST Ultra-IDE hard drive. It slings bits awfully fast—and its platters spin so fast that the drive actually becomes warm to the touch! The Pentium system is running an 8.4-Gbyte Maxtor DiamondMax Ultra-DMA (Ultra-IDE) drive. It's *very* roomy—with performance to match. Both drives are widely available. See **www.quantum.com/** and **www.maxtor.com/**, respectively.

CD-ROM Drives. The K6 system "sports" a 24X Cyberdrive, which is a rather generic unit sold most everywhere. It's died twice (replaced by the vendor both times) and I wouldn't buy another one. The Pentium system uses an Acer 624A 24X drive. It's garnered several performance honors from the computer mags, and it's very affordable. See **http://www.acer.com/aac/index.htm**. for product details. Both drives sound like turbine engines when they're spinning up. Cool *and* fast!

Sound Cards. Both systems use low-cost Ensoniq AudioPCI sound cards. They're good-sounding, inexpensive, plug-and-play compatible cards with wavetable synthesis. And because the cards live on the PCI bus, they don't hog CPU resources like traditional ISA sound cards can. See **www.ensoniq.com/** for details. Some hams may want to use Creative Labs brand Sound Blaster cards. See the text.

Video Cards. For 2D pixel pumping, both systems use ATI's venerable All-in-Wonder cards with 4 Mbytes of video RAM. Relatively fast in DOS and *Windows 95/98/NT*, these cards have built-in TV tuners and video-capture modules. For 3D gaming, the K6 uses a Diamond Monster 3D accelerator, while the Pentium has Orchid's close cousin, the Righteous 3D accelerator. The nearly identical cards are based on the 3Dfx Voodoo chipset. Web sites: **http://www.atitech.com/**, **http://www.diamondmm.com/**, and **http://www.orchid.com/**.

System-Building Details. Step-by-step instructions for building your computer can be found on the Web sites listed in the Overclocking sidebar. If you like impressively thick manuals, look for the sixth edition of *Upgrading and Repairing PCs*, published by QUE. It's comprehensive.

Magazines. Several magazines feature reliable product reviews and technology news and features. My favorites include *PC Magazine*, *PC World*, *Computer Shopper* and *Boot* (one of the few magazines that cater to overclockers, speed-tweakers and the computer irreverant). All are available at newsstands and libraries.

will work with just about every Pentium-class motherboard, but getting the performance boost provided by Ultra-IDE drives requires motherboards that use Intel's TX chipset (or a separate plug-in card that adds Ultra-IDE capability). Most motherboards have built-in EIDE controllers.

SCSI hard drives come in several flavors (SCSI, Wide-SCSI, Ultra-Wide-SCSI, etc) and provide blistering performance—at a price! They cost 30% to 100% more than their IDE cousins and require expensive adapter cards/controllers.

Floppy Disks

Here's the only no-brainer in the bunch: Buy a 3.5-inch, 1.44 Mbyte (high density) floppy drive. These are $20 "commodity items" made by many manufacturers. Older floppy drives are obsolete.

CD-ROM Drives

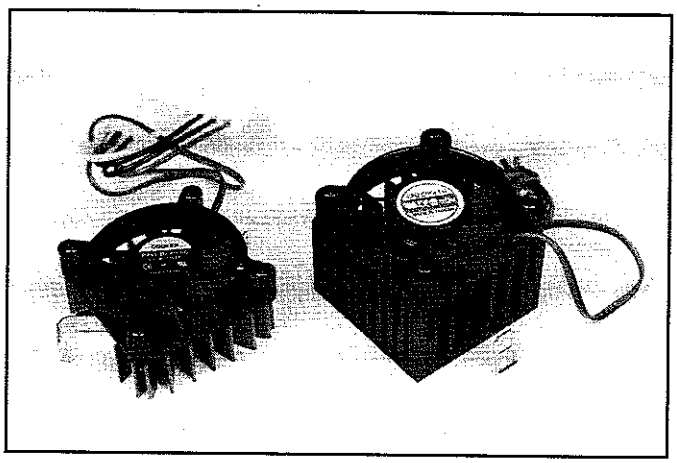
CD-ROM drives are now a necessity (as well as a commodity), as almost all software ships on CD-ROMs. Original units (single-speed drives) read data at a paltry 150 kbytes per second. Today's drives can read data up to 24 times as fast or more—and they're getting faster by the day. You'll have a hard time buying a new CD-ROM drive that's slower than 12X—and for another $10 or so you can get a 20X or 24X model. Your multimedia applications won't necessarily run faster, but you'll really notice the difference when installing software. Speed (spin) ratings aside, other factors that influence CD-ROM performance include access time (less than 100 ms is best), memory buffer size (128 kbytes is average) and interface type (the fastest CD-ROM drives have SCSI interfaces, but up-to-date EIDE models aren't far behind and cost much less).

Sound Cards

When generic $15 plug-in cards can bring decent sound to any modern PC, it's easy to see that we've come a long way from the bad old days. But before you get lazy, there are a few things to remember in going beyond the basics.

First, many Amateur Radio applications that use sound cards as DSP processors and data decoders require name-brand Sound Blaster cards manufactured by Creative Labs—"Sound Blaster compatible" isn't good enough (as the *de facto* standard, almost every sound card made today is Sound Blaster compatible).

Second, traditional sound cards plug into the slower, older ISA bus, while the newest cards work on the faster PCI bus, which offers huge performance increases in *Windows 95/98/NT*, but may present problems in DOS. In addition to ensuring Sound Blaster compatibility, remember that better-sounding cards tend to offer General MIDI compliance and use wavetable synthesis instead of the older FM synthesis technology. And if you're planning to run any flavor of *Windows*, be sure to get a sound card that's "plug-and-play" (PnP) compliant. It makes setup a snap.



Cool is king—so don't use an old-style, whimpy CPU cooler (shown at left) on your expensive new hardware. Although not massive by "overclocking" standards, the beefy cooler shown on the right will keep any Pentium-class CPU running cool.

Video Cards

The hot topic in video cards these days is definitely 3D—but unless you plan to do a lot of computer gaming or artistic rendering, a 3D video card or add-on 3D accelerator may be a waste of money. For most DOS and *Windows 95/98/NT* apps, affordable, fast, plain-old video cards do just fine. In fact, you'd be hard pressed to even find a non-game title that uses 3D acceleration. Factors to consider include the amount of video memory required, which screen resolutions you'll be using, the size of your monitor and its refresh rates, and which system bus you're using.

Basically, *more* video RAM is required to display more simultaneous colors at higher screen resolutions, and *faster* video RAM is required to support faster screen refresh rates (slow rates tend to produce "flicker," while faster rates require more advanced monitors).

For typical DOS/*Windows* users, a PCI-bus video card with 2 Mbytes of video RAM will handle most applications as displayed on 14- and 15-inch monitors. For 17-inch-and-larger monitors, which often lead to faster refresh rates and greater "color depths," a 4-Mbytes PCI-bus card should suffice.

As you probably noticed, the PCI bus is *the* bus for Pentium-class video cards. Forget older ISA-based cards; they're way too slow. And, for the time being, forget about motherboards that support Intel's Advanced Graphics Port (AGP). AGP technical bugs are a year away from being solved, and only a handful of system board makers will implement AGP on Socket 7 boards (AGP was originally intended for Pentium II systems only).

Many premium video cards offer other amenities such as built-in TV tuners (watch TV or video on-screen while you work in *Windows*); TV outputs (watch computer stuff on the TV screen); and video capture (save video frame "stills" or digital "full-motion digital video" to your hard drive for later manipulation). Your needs will determine the relative value of these extras.

3D alert: Although it's hotly debated (no flame wars, please!), at press time the best-performing all-around 3D video card performance is obtained by using a fast 2D/*Windows* video card in conjunction with a companion 3D accelerator card. The most popular 3D add-on cards (by a large margin) use the Voodoo chipset manufactured by 3Dfx. If you buy a 3D accelerator, make sure it has Voodoo chips under the hood (unless Voodoo 2 has been released, that is!).

With a few exceptions, most 2D/3D cards—single cards that handle 2D and 3D functions—do not yet perform to specs. And 2D/3D cards with non-3Dfx chipsets tend to fare even worse.

Monitors

Monitors have evolved greatly over the past few years, and prices have fallen, although not as fast as other computer parts. Getting into great detail about monitor features and technology would take too much space, so we'll have to get by with some basics:

- Although 14-inch monitors are the low-price leaders, 15-inchers tend to offer superior value. In the big-iron class, 17-inch monitors are much more affordable than 19, 20 and 21-inch models (and still seem *huge* when compared to their smaller cousins).
- Although the display areas of most cathode-ray tubes are sections of spheres or cylinders, newer monitors have much flatter screens than their ancestors, and some are perfectly flat, which reduces distortion.
- Look for monitors that support refresh rates of 75 Hz or more at the screen resolutions you will be using.
- Quality monitors have dot-pitch (or slot-width) specs of 0.25 to 0.28 mm, and smaller is generally better. Avoid older 0.39 mm models like the plague!
- Quality units usually have digital controls to adjust screen geometry, contrast, brightness, etc.
- Avoid the temptation to buy no-name bargain monitors. These are usually of poor quality. If you look at a computer screen most of the day (and most of the night for diehard gamers and propagation forecasters!), a quality monitor is a must. Monitors can be transferred from system to system, so get a good one.

Operating Systems

Like many computing topics, operating systems are choice debate topics. High-power users extol the virtues of *Linux* and *Unix;* diehard DOS fanatics, much like Winston Churchill, "shall never surrender"; OS/2 boosters claim their OS is what multitasking always wanted to be; and "path of least resistance" types like me (and most of the universe) choose some flavor of *Windows* as a base of operations and dabble in other operating systems (mostly DOS) as necessary. Thanks to tricky software solutions like *System Commander*, if you're really undecided you can have dozens of your favorite operating systems on one machine.

Mainstreamers, in not bucking the system, enjoy better technical support, the benefits of critical mass, lower prices—and we don't have to buck *every* computing stream we come to. Sure, *Windows* is the OS we love to hate, but it works—and it's the devil you know versus the one you don't. Besides, if *Windows* gets ugly we can always boot up with a DOS floppy.... And someday, software and operating systems will come close to keeping pace with hardware performance. Someday!

All the Rest

What about all of the stuff I didn't cover? Modems, printers, scanners, joysticks—you name it. That's the great challenge with computing technology: It's almost impossible to keep up with and keep track of. For me, that's half of the fun!

So, there you have it. As much info and advice as I could cram into a few pages (when 5000 would just about do). Like ham radio in general, building computers is an adventure in technology—with a lot of mythology and a bit of magic, to boot (pun intended). Every computer builder starts somewhere, however, and I hope I've given you enough of a push, or enough reinforcement, to go out and build your next dream computer. The resources listed here will get you off to a solid start.

Since I built my first 386-class PC (help *and* sarcastic laughter provided by several staffers in the ARRL Lab!), I have enjoyed tinkering with PCs as much as I've enjoyed ham radio itself. And the two units I assembled while writing this article? They're cookin' with gas—zapping aliens and churning through huge databases with equal aplomb. Next month, of course, they'll need major tweaking....

Get the picture? Good luck with your own PC addiction!

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