Chapter 21

IBM Personal Computer Family Hardware

This chapter serves as a technical reference to IBM's original family of personal computer system units and accessories. It separates and identifies each personal computer system originally offered by IBM, including the complete original line of PC systems that have been discontinued. Because the entire original line has been discontinued, much of this chapter can be considered a history lesson. The information still is valuable, however, because many people still own and manage these older systems, which are more likely to break down than newer ones. Also, nearly every IBM-compatible or clone system on the market today is based on one or more of these original IBM products. The original line of systems often are called Industry Standard Architecture (ISA) systems, or *Classic* PCs. IBM calls them *Family/1* systems. The PS/2 (or *Family/2*) systems are examined in the following chapter.

This chapter is a reference specific to the original line of true IBM PC, XT, and AT systems. For upgrade and repair purposes, most PC-compatible systems are treated in the same manner as IBM systems. Most compatible systems can exchange parts easily with IBM systems and vice versa. In fact, most of the parts that make up IBM systems are made by third-party companies, and you can purchase these same parts outside of IBM to save money.

In Chapter 2, "Overview of System Features and Components," you learned that all systems can be broken down into two basic types: PC/XT or AT. AT types of systems often are broken down into several subtypes. These subtypes can be classified as systems that use 286 or 386/486/Pentium processors and systems with Industry Standard Architecture (ISA), Extended Industry Standard Architecture (EISA), VL (Video Local) Bus, PCI (Peripheral Component Interconnect), or Micro Channel Architecture (MCA) slots. Use this chapter to compare a compatible system with a specific IBM system in a feature-by-feature comparison. This kind of comparison is often interesting because compatibles usually offer many more features and options at a lower price.

System-Unit Features by Model

In the following sections, you learn the makeup of all the various versions or models of the specific systems and also technical details and specifications of each system. Every system unit has a few standard parts. The primary component is the motherboard, which has the CPU (central processing unit, or microprocessor) and other primary computer circuitry. Each unit also includes a case with an internal power supply, a keyboard, certain standard adapters or plug-in cards, and usually some form of disk drive.

You receive an explanation of each system's various submodels and details about the differences between and features of each model. You learn about the changes from model to model and version to version of each system.

Included for your reference is part-number information for each system and option. This information is *for comparison and reference purposes only* because all these systems have been discontinued and generally are no longer available. IBM still stocks and sells component parts and assemblies, however, for even these discontinued units. You can (and usually should) replace failed components in these older systems with non-IBM replacement parts because you invariably can obtain upgraded or improved components compared to what IBM offers, and at a greatly reduced price.

An Introduction to the PC

IBM introduced the IBM Personal Computer on August 12, 1981, and officially withdrew the machine from marketing on April 2, 1987. During the nearly six-year life of the PC, IBM made only a few basic changes to the system. The basic motherboard circuit design was changed in April 1983 to accommodate 64K RAM chips. Three different ROM BIOS versions were used during the life of the system; most other specifications, however, remained unchanged. Because IBM no longer markets the PC system, and because of the PC's relatively limited expansion capability and power, the standard PC is obsolete by most standards.

The system unit supports only floppy disk drives unless the power supply is upgraded or an expansion chassis is used to house the hard disk externally. IBM never offered an internal hard disk for the PC but many third-party companies stepped in to fill this void with upgrades. The system unit included many configurations with single or dual floppy disk drives. Early on, one version even was available with no disk drives, and others used single-sided floppy drives. The PC motherboard was based on the 16-bit Intel 8088 microprocessor and included the Microsoft Cassette BASIC language built into ROM. For standard memory, the PC offered configurations with as little as 16K of RAM (when the system was first announced) and as much as 256K on the motherboard. Two motherboard designs were used. Systems sold before March 1983 had a motherboard that supported a maximum of only 64K of RAM, and later systems supported a maximum of 256K on the motherboard. In either case, you added more memory (as much as 640K) by installing memory cards in the expansion slots.

The first bank of memory chips in every PC is soldered to the motherboard. Soldered memory is reliable but not conducive to easy servicing because the solder prevents you from easily exchanging failing memory chips located in the first bank. The chips must be unsoldered and the defective chip replaced with a socket so that a replacement can be plugged in. When IBM services the defective memory, IBM advises you to exchange the entire motherboard. Considering today's value of these systems, replacing the motherboard with one of the many compatible motherboards on the market may be a better idea. Repairing the same defective memory chip in the XT system is much easier because all memory in an XT is socketed.

The only disk drive available from IBM for the PC is a double-sided (320 or 360K) floppy disk drive. You can install a maximum of two drives in the system unit by using IBM-supplied drives, or four using half-height third-party drives and mounting brackets.

The system unit has five slots that support expansion cards for additional devices, features, or memory. All these slots support full-length adapter cards. In most configurations, the PC included at least a floppy disk controller card. You need a second slot for a monitor adapter, which leaves three slots for adapter cards.

All models of the PC have a fan-cooled, 63.5-watt power supply. This low-output power supply doesn't support much in the way of system expansion, especially power-hungry items, such as hard disks. Usually, this low-output supply must be replaced by a higher-output unit, such as the one used in the XT. Figure 21.1 shows an interior view of a PC system unit.

An 83-key keyboard with an adjustable typing angle is standard equipment on the PC. The keyboard is attached to the rear of the system unit by a six-foot coiled cable. Figure 21.2 shows the back panel of the PC.

Most model configurations of the PC system unit included these major functional components:

- Intel 8088 microprocessor
- ROM-based diagnostics (POST)
- BASIC language interpreter in ROM
- 256 kilobytes of dynamic RAM
- Floppy disk controller
- One or two 360K floppy drives
- A 63.5-watt power supply
- Five I/O expansion slots
- Socket for the 8087 math coprocessor

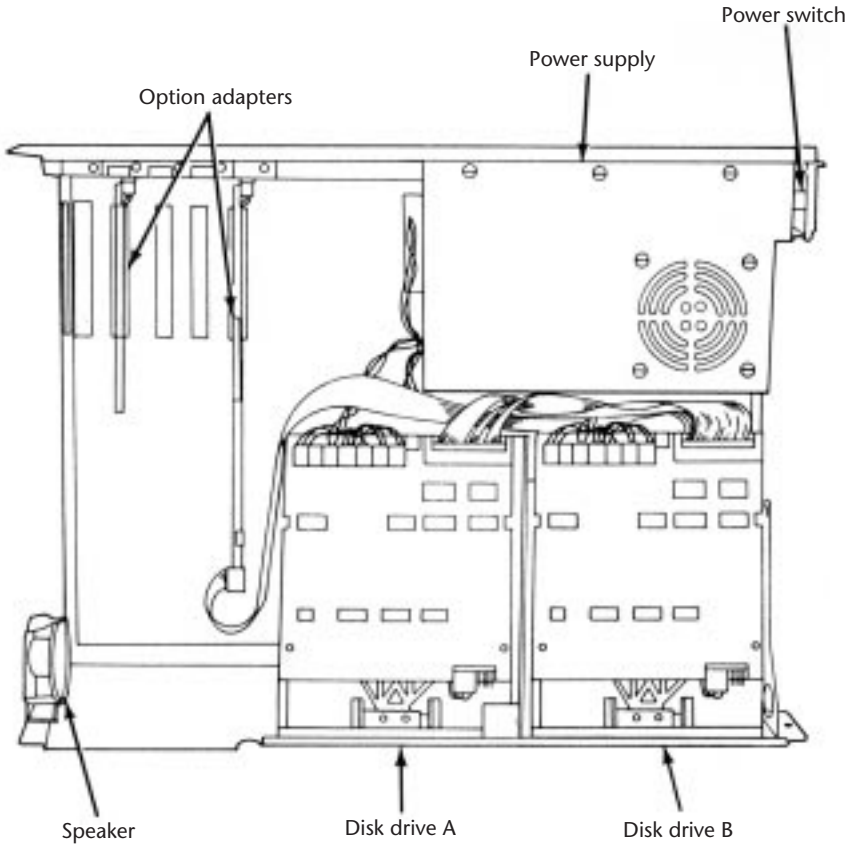

Fig. 21.1
The IBM PC interior view.

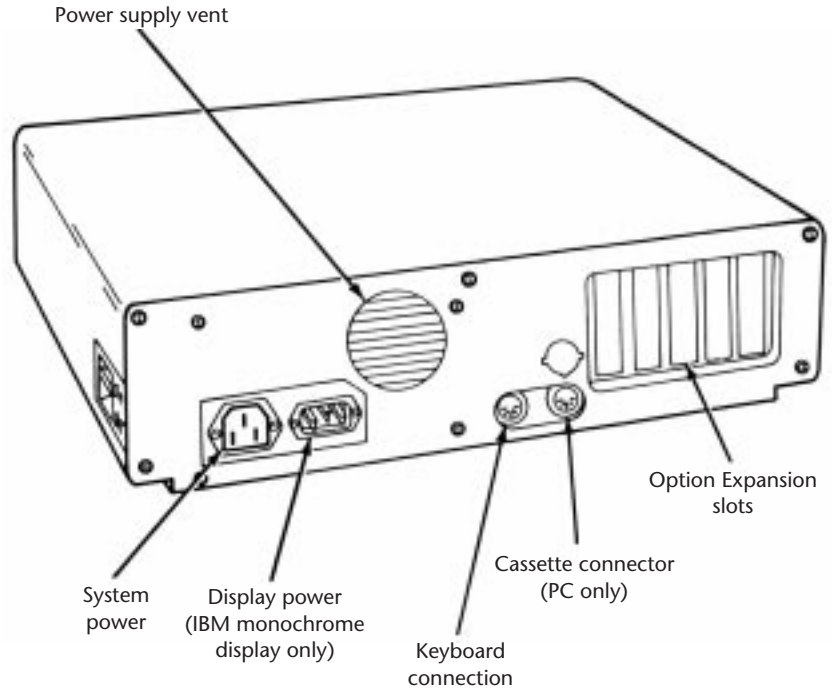

Fig. 21.2
The IBM PC rear view.

PC Models and Features

Although several early-model configurations of the IBM PC were available before March 1983, only two models were available after that time. The later models differ only in the number of floppy drives: one or two. IBM designated these models as follows:

IBM PC 5150 Model 166: 256K RAM, one 360K drive

IBM PC 5150 Model 176: 256K RAM, two 360K drives

The PC never was available with a factory-installed hard disk, primarily because the system unit has a limited base for expansion and offered few resources with which to work. After IBM started selling XTs with only floppy disk drives (on April 2, 1985), the PC became obsolete. The XT offered much more for virtually the same price. Investing in a PC after the XT introduction was questionable.

IBM finally withdrew the PC from the market April 2, 1987. IBM's plans for the system became obvious when the company didn't announce a new model with the Enhanced Keyboard, as it did with other IBM systems.

With some creative purchasing, you can make a usable system of a base PC by adding the requisite components, such as a full 640K of memory and hard and floppy drives. You still may have a slot or two to spare. Unfortunately, expanding this system requires replacing many of the boards in the system unit with boards that combine the same functions in less space. Only you can decide when your money is better invested in a new system.

Before you can think of expanding a PC beyond even a simple configuration, and to allow for compatibility and reliability, you must address the following two major areas:

- ROM BIOS level (version)
- Power supply

In most cases, the power supply is the most critical issue because all PCs sold after March 1983 already have the latest ROM BIOS. If you have an earlier PC system, you also must upgrade the ROM because the early versions lack some required capabilities. Both problems, and also other expansion issues related to all systems in the PC family, are addressed in Chapter 4, "Motherboards," Chapter 8, "The Power Supply," Chapter 14, "Hard Disk Drives and Controllers," and Chapter 17, "System Upgrades and Improvements." Table 21.1 shows the part numbers for the IBM PC system unit.

Table 21.1 IBM PC Part Numbers

Description	Number
PC system unit, 256K, one double-sided drive	5150166
PC system unit, 256K, two double-sided drives	5150176
Options	
PC expansion-unit Model 001 with 10M fixed disk	5161001
Double-sided disk drive	1503810
8087 math coprocessor option	1501002
BIOS update kit	1501005

PC Technical Specifications

Technical information for the Personal Computer system and keyboard is described in this section. Here, you find information about the system architecture, memory configurations and capacities, standard system features, disk storage, expansion slots, keyboard specifications, and physical and environmental specifications. This kind of information may be useful in determining what parts you need when you are upgrading or repairing these systems. Figure 21.3 shows the layout and components on the PC motherboard.

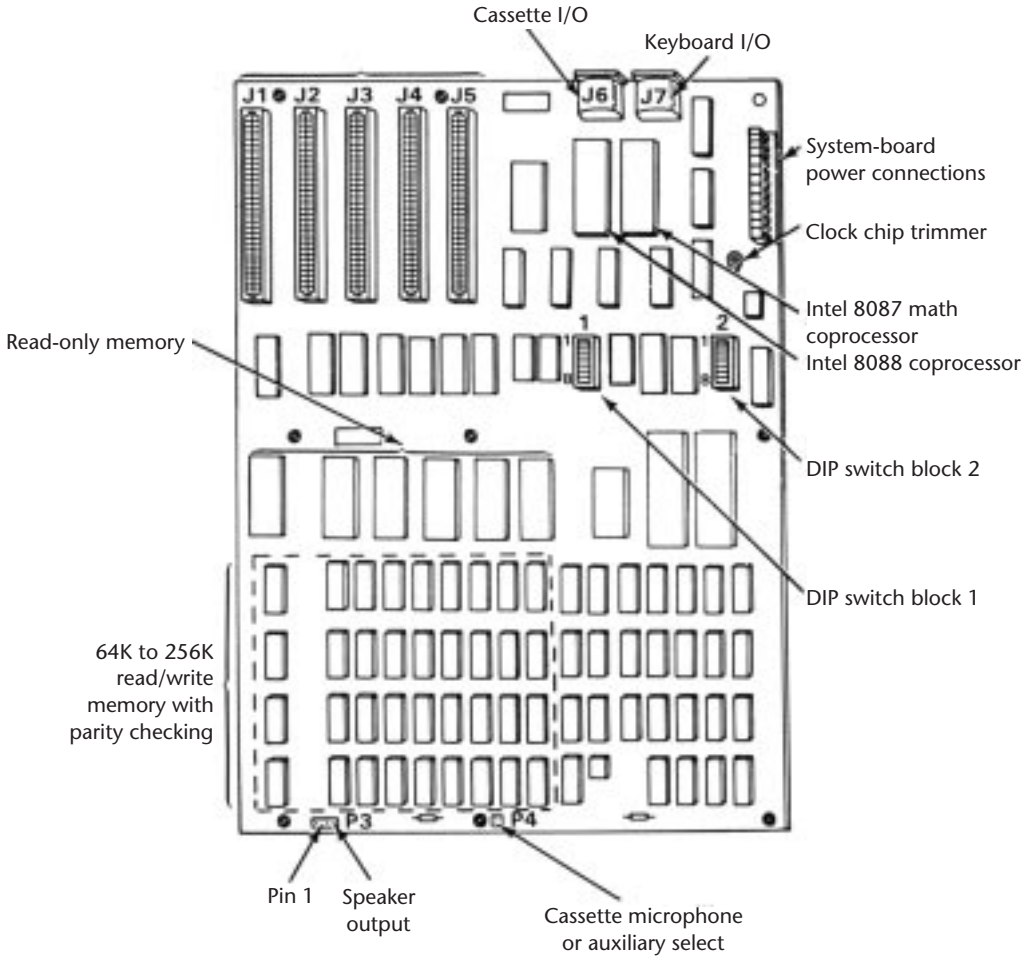

Fig. 21.3
The IBM PC motherboard.

System Architecture	
Microprocessor	8088
Clock speed	4.77 MHz
Bus type	ISA (Industry Standard Architecture)
Bus width	8-bit
Interrupt levels	8
Type	Edge-triggered
Shareable	No
DMA channels	3
DMA burst mode supported	No
Bus masters supported	No

(continues)

System Architecture	
Upgradable processor complex	No
Memory	
Standard on system board	16K, 64K, or 256K
Maximum on system board	256K
Maximum total memory	640K
Memory speed (ns) and type	200ns dynamic RAM
System board memory-socket type	16-pin DIP
Number of memory-module sockets	27 (3 banks of 9)
Memory used on system board	27 16K×1-bit or 64K×1-bit DRAM chips in 3 banks of 9, one soldered bank of 9 16K×1-bit or 64K×1-bit chips
Memory cache controller	No
Wait states: System board Adapter	 1 1
Standard Features	
ROM size	40K
ROM shadowing	No
Optional math coprocessor Coprocessor speed	8087 4.77 MHz
Standard graphics	None standard
RS232C serial ports UART chip used Maximum speed (bits per second) Maximum number of ports supported	None standard NS8250B 9,600 bps 2
Pointing device (mouse) ports	None standard
Parallel printer ports Bi-directional Maximum number of ports supported	None standard No 3
CMOS real-time clock (RTC)	No
CMOS RAM	None
Disk Storage	
Internal disk and tape drive bays Number of 3 1/2/5 1/4-inch bays	2 full-height 0/2
Standard floppy drives	1×360K

Disk Storage	
Optional floppy drives:	
5 1/4-inch 360K	Optional
5 1/4-inch 1.2M	No
3 1/2-inch 720K	Optional
3 1/2-inch 1.44M	No
3 1/2-inch 2.88M	No
Hard disk controller included	None
Expansion Slots	
Total adapter slots	5
Number of long and short slots	5/0
Number of 8-/16-/32-bit slots	5/0/0
Available slots (with video)	3
Keyboard Specifications	
101-key Enhanced Keyboard	No, 83-key
Fast keyboard speed setting	No
Keyboard cable length	6 feet
Physical Specifications	
Footprint type	Desktop
Dimensions:	
Height	5.5 inches
Width	19.5 inches
Depth	16.0 inches
Weight	25 pounds
Environmental Specifications	
Power-supply output	63.5 watts
Worldwide (110/60, 220/50)	No
Auto-sensing/switching	No
Maximum current:	
104-127 VAC	2.5 amps
Operating range:	
Temperature	60–90 degrees F
Relative humidity	8–80 percent
Maximum operating altitude	7,000 feet
Heat (BTUs/hour)	505
Noise (Average dB, operating, 1m)	43
FCC classification	Class B

Tables 21.2 and 21.3 show the Switch Settings for the PC (and XT) motherboard. The PC has two eight-position switch blocks (Switch Block 1 and Switch Block 2), whereas the XT has only a single Switch Block 1. The PC uses the additional switch block to control the amount of memory the system would recognize, and the XT automatically counts up the memory amount.

Table 21.2 IBM PC/XT Motherboard Switch Settings

SWITCH BLOCK 1 (PC and XT)		
	Switch 1	**IBM PC Function (PC Only):**
	Off	Boot From Floppy Drives
	On	Do Not Boot From Floppy Drives
	Switch 1	**IBM XT Function (XT Only):**
	Off	Normal POST (Power-On Self Test)
	On	Continuous Looping POST
	Switch 2	**Math Coprocessor (PC/XT):**
	Off	Installed
	On	Not Installed
Switch 3	**Switch 4**	**Installed Motherboard Memory (PC/XT):**
On	On	Bank 0 only
Off	On	Banks 0 and 1
On	Off	Banks 0, 1 and 2
Off	Off	All 4 Banks
Switch 5	**Switch 6**	**Video Adapter Type (PC/XT):**
Off	Off	Monochrome (MDA)
Off	On	Color (CGA) - 40x25 mode
On	Off	Color (CGA) - 80x25 mode
On	On	Any Video Card w/onboard BIOS (EGA/VGA)
Switch 7	**Switch 8**	**Number of Floppy Drives (PC/XT):**
On	On	1 floppy drive
Off	On	2 floppy drives
On	Off	3 floppy drives
Off	Off	4 floppy drives

Table 21.3 SWITCH BLOCK 2 (PC Only) Memory Settings

	Switch Number (Switch Block 2, PC Only)							
Memory	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
16K	On	On	On	On	On	Off	Off	Off
32K	On	On	On	On	On	Off	Off	Off
48K	On	On	On	On	On	Off	Off	Off
64K	On	On	On	On	On	Off	Off	Off

Memory	Switch Number (Switch Block 2, PC Only) 1	2	3	4	5	6	7	8
96K	Off	On	On	On	On	Off	Off	Off
128K	On	Off	On	On	On	Off	Off	Off
160K	Off	Off	On	On	On	Off	Off	Off
192K	On	On	Off	On	On	Off	Off	Off
224K	Off	On	Off	On	On	Off	Off	Off
256K	On	Off	Off	On	On	Off	Off	Off
288K	Off	Off	Off	On	On	Off	Off	Off
320K	On	On	On	Off	On	Off	Off	Off
352K	Off	On	On	Off	On	Off	Off	Off
384K	On	Off	On	Off	On	Off	Off	Off
416K	Off	Off	On	Off	On	Off	Off	Off
448K	On	On	Off	Off	On	Off	Off	Off
480K	Off	On	Off	Off	On	Off	Off	Off
512K	On	Off	Off	Off	On	Off	Off	Off
544K	Off	Off	Off	Off	On	Off	Off	Off
576K	On	On	On	On	Off	Off	Off	Off
608K	Off	On	On	On	Off	Off	Off	Off
640K	On	Off	On	On	Off	Off	Off	Off

An Introduction to the PC Convertible

IBM marked its entry into the laptop computer market on April 2, 1986, by introducing the IBM 5140 PC Convertible. The system superseded the 5155 Portable PC (IBM's transportable system), which no longer was available. The IBM 5140 system wasn't a very successful laptop system. Other laptops offered more disk storage, higher processor speeds, more readable screens, lower cost, and more compact cases, which pressured IBM to improve the Convertible. Because the improvements were limited to the display, however, this system never gained respect in the marketplace.

The PC Convertible was available in two models. The Model 2 had a CMOS 80C88 4.77 MHz microprocessor, 64 kilobytes of ROM, 256 kilobytes of Static RAM, an 80-column-by-25-line detachable liquid crystal display, two 3 1/2-inch floppy disk drives, a 78-key keyboard, an AC adapter, and a battery pack. Also included were software programs called Application Selector, SystemApps, Tools, Exploring the IBM PC Convertible, and Diagnostics. The Model 22 is the same basic computer as the Model 2 but with the diagnostic software only. You can expand either system to 512K of RAM by using 128K RAM memory-cards, and you can include an internal 1,200 bps modem in the system unit. With aftermarket memory expansion, the computers can reach 640K.

Although the unit was painfully slow at 4.77 MHz, one notable feature is the use of Static memory chips for the system's RAM. Static RAM does not require the refresh signal that

normal Dynamic RAM requires, which would normally require about seven percent of the processor's time in a standard PC or XT system. This means that the Convertible is about seven percent faster than an IBM PC or XT even though they all operate at the same clock speed of 4.77 MHz. Because of the increased reliability of the Static RAM (compared to Dynamic RAM) used in the Convertible, as well as the desire to minimize power consumption, none of the RAM in the Convertible is parity checked.

At the back of each system unit is an extendable bus interface. This 72-pin connector enables you to attach the following options to the base unit: a printer, a serial or parallel adapter, and a CRT display adapter. Each feature is powered from the system unit. The CRT display adapter operates only when the system is powered from a standard AC adapter. A separate CRT display or a television set attached through the CRT display adapter requires a separate AC power source.

Each system unit includes a detachable liquid crystal display (LCD). When the computer is not mobile, the LCD screen can be replaced by an external monitor. When the LCD is latched in the closed position, it forms the cover for the keyboard and floppy disk drives. Because the LCD is attached with a quick-disconnect connector, you can remove it easily to place the 5140 system unit below an optional IBM 5144 PC Convertible monochrome or IBM 5145 PC Convertible color display. During the life of the Convertible, IBM offered three different LCD displays. The first display was a standard LCD, which suffered from problems with contrast and readability. Due to complaints, IBM then changed the LCD to a Super Twisted type LCD display, which had much greater contrast. Finally, in the third LCD they added a fluorescent backlight to the Super Twisted LCD display, which not only offered greater contrast, but made the unit usable in low light situations.

The PC Convertible system unit has these standard features:

- Complementary Metal-Oxide Semiconductor (CMOS) 80C88 4.77 MHz microprocessor
- Two 32K CMOS ROMs containing these items:

  POST (Power-On Self Test) of system components
  BIOS (basic input-output system) support
  BASIC language interpreter
- 256K CMOS static RAM (expandable to 512K)
- Two 3 1/2-inch 720K (formatted) floppy drives
- An 80-column-by-25-line detachable LCD panel (graphics modes: 640-by-200 resolution and 320-by-200 resolution)
- LCD controller
- 16K RAM display buffer

- 8K LCD font RAM
- Adapter for optional printer (#4010)
- Professional keyboard (78 keys)
- AC adapter
- Battery pack

The system-unit options for the 5140 are shown in this list:

- 128K Static RAM memory card (#4005)
- Printer (#4010)
- Serial/parallel adapter (#4015)
- CRT display adapter (#4020)
- Internal modem (#4025)
- Printer cable (#4055)
- Battery charger (#4060)
- Automobile power adapter (#4065)

The following two optional displays were available for the PC Convertible:

- IBM 5144 PC Convertible Monochrome Display Model 1
- IBM 5145 PC Convertible Color Display Model 1

PC Convertible Specifications and Highlights

This section lists some technical specifications for the IBM 5140 PC Convertible system. The weights of the unit and options are listed because weight is an important consideration when you carry a laptop system. Figure 21.4 shows the PC Convertible motherboard components and layout.

Dimensions	
Depth	360 mm (14.17 inches) 374 mm (14.72 inches) including handle
Width	309.6 mm (12.19 inches) 312 mm (12.28 inches) including handle
Height	67 mm (2.64 inches) 68 mm (2.68 inches) including footpads

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Weight	
Models 2 and 22 (including battery)	5.5 kg (12.17 pounds)
128K/256K memory card	40 g (1.41 ounces)
Printer	1.6 kg (3.50 pounds)
Serial/parallel adapter	470 g (1.04 pounds)
CRT display adapter	630 g (1.40 pounds)
Internal modem	170 g (6 ounces)
Printer cable	227 g (8 ounces)
Battery charger	340 g (12 ounces)
Automobile power adapter	113 g (4 ounces)
5144 PC Convertible monochrome display	7.3 kg (16 pounds)
5145 PC Convertible color display	16.9 kg (37.04 pounds)

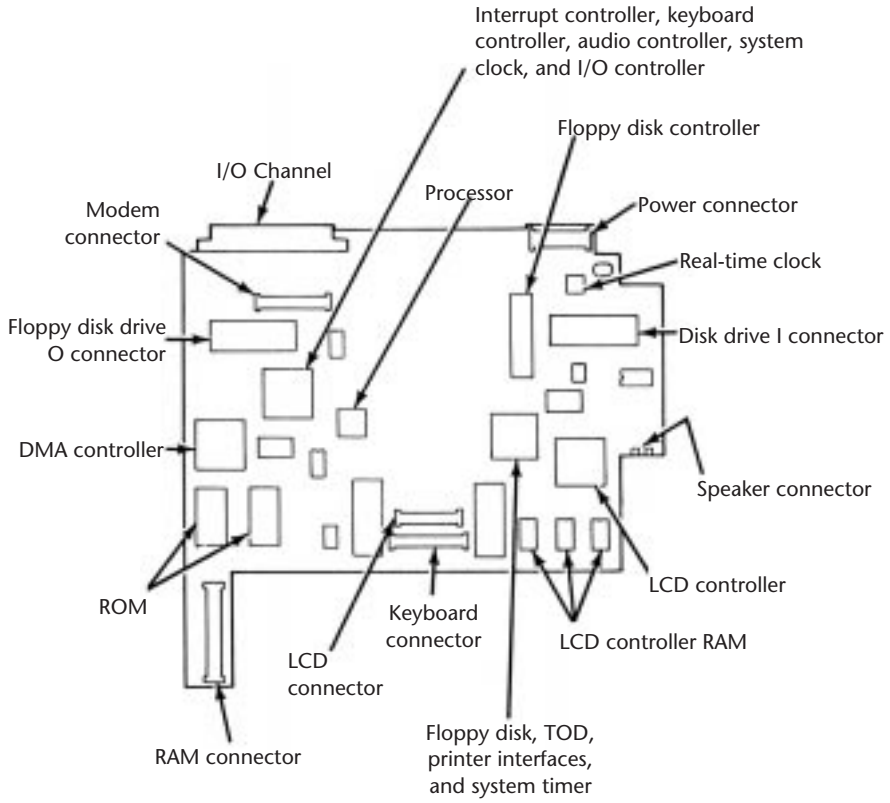

Fig. 21.4
The PC Convertible motherboard.

To operate the IBM 5140 PC Convertible properly, you must have PC DOS version 3.2 or later. Previous DOS versions aren't supported because they don't support the 720K

floppy drive. Using the CRT display adapter and an external monitor requires that the system unit be operated by power from the AC adapter rather than from the battery.

PC Convertible Models and Features

This section covers the options and special features available for the PC Convertible. Several kinds of options were available, from additional memory to external display adapters, serial/parallel ports, modems, and even printers.

Memory Cards

A 128K or 256K memory card expands the base memory in the system unit. You can add two of these cards, for a system-unit total of 640K with one 256K card and one 128K card.

Optional Printers

An optional printer attaches to the back of the system unit or to an optional printer-attachment cable for adjacent printer operation. The printer's intelligent, microprocessor-based, 40 cps, non-impact dot-matrix design makes it capable of low-power operation. The optional printer draws power from and is controlled by the system unit. Standard ASCII
96-character, upper- and lowercase character sets are printed with a high-resolution, 24-element print head. A mode for graphics capability is provided also. You can achieve near-letter-quality printing by using either a thermal transfer ribbon on smooth paper or no ribbon on heat-sensitive thermal paper.

Serial/Parallel Adapters

A serial/parallel adapter attaches to the back of the system unit, a printer, or other feature module attached to the back of the system unit. The adapter provides an RS-232C asynchronous communications interface and a parallel printer interface, both compatible with the IBM personal computer asynchronous communications adapter and the IBM personal computer parallel printer adapter.

CRT Display Adapters

A CRT display adapter attaches to the back of the system unit, printer, or other feature module attached to the back of the system unit. This adapter enables you to connect a separate CRT display, such as the PC Convertible monochrome display or PC Convertible color display, to the system. By using optional connectors or cables, you can use the CRT display adapter also to attach a standard CGA monitor. Because composite video output is available, you also can use a standard television set.

Internal Modems

With an internal modem, you can communicate with compatible computers over telephone lines. It runs Bell 212A (1,200 bps) or Bell 103A (300 bps) protocols. The modem comes as a complete assembly, consisting of two cards connected by a cable. The entire assembly is installed inside the system unit. Over the life of the system, IBM made two different internal modems for the Convertible. The original modem was made for IBM by Novation, and did not follow the Hayes standard for commands and protocols. This rendered the modem largely incompatible with popular software designed to use the Hayes command set. Later, IBM changed the modem to one that was fully Hayes compatible, and this resolved the problems with software. IBM never introduced a modem faster than 1,200 bps for the Convertible. Fortunately, you still can operate a standard external modem through the serial port, although you lose the convenience of having it built in.

Printer Cables

The printer cable is 22 inches (0.6 meter) long with a custom 72-pin connector attached to each end. With this cable, you can operate the Convertible printer when it is detached from the system unit and place the unit for ease of use and visibility.

Battery Chargers

The battery charger is a 110-volt input device that charges the system's internal batteries. It does not provide sufficient power output for the system to operate while the batteries are being charged.

Automobile Power Adapters

An automobile power adapter plugs into the cigarette-lighter outlet in a vehicle with a 12-volt, negative-ground electrical system. You can use the unit while the adapter charges the Convertible's battery.

The IBM 5144 PC Convertible Monochrome Display

The 5144 PC Convertible monochrome display is a nine-inch (measured diagonally) composite video display attached to the system unit through the CRT display adapter. It comes with a display stand, an AC power cord, and a signal cable that connects the 5144 to the CRT display adapter. This display does not resemble—and is not compatible with—the IBM monochrome display for larger PC systems. The CRT adapter emits the same signal as the one supplied by the Color Graphics Adapter for a regular PC. This display is functionally equivalent to the display on the IBM Portable PC.

The IBM 5145 PC Convertible Color Display

The 5145 PC Convertible color display is a 13-inch color display attached to the system unit through the CRT display adapter. It comes with a display stand, an AC power cord, a signal cable that connects the 5145 to the CRT display adapter, and a speaker for external audio output. The monitor is a low-cost unit compatible with the standard IBM CGA display.

Special software available for the Convertible includes these programs:

- The *Application Selector* program, installed as an extension to DOS, provides a menu-driven interface to select and run applications software, the SystemApps, and Tools.
- The *SystemApps* program provides basic functions similar to many memory-resident programs on the market. This application, which includes Notewriter, Schedule, Phone List, and Calculator, is equivalent in function to the popular SideKick program.
- You can use the menu-driven *Tools* program as a front end for DOS to control and maintain the system (copying and erasing files, copying disks, and so on). With DOS, additional functions are available, including printing, formatting, and configuring the Application Selector function keys. This program presents many DOS functions in an easy-to-use menu format.

This additional software, except system diagnostics, is not included with the Model 22. Table 21.4 shows the part numbers of the IBM Convertible system units.

Table 21.4 IBM Convertible Part Numbers

5140 PC Convertible System Units	Number
Two drives, 256K with system applications	5140002
Two drives, 256K without system applications	5140022

An Introduction to the XT

Introduced March 8, 1983, the PC XT with a built-in 10M hard disk (originally standard, later optional) caused a revolution in personal computer configurations. At the time, having even a 10M hard disk was something very special. XT stands for eXTended. IBM chose this name because the IBM PC XT system includes many features not available in the standard PC. The XT has eight slots, allowing increased expansion capabilities; greater power-supply capacity; completely socketed memory; motherboards that support memory expansion to 640K without using an expansion slot; and optional hard disk drives. To obtain these advantages, the XT uses a different motherboard circuit design than the PC.

The system unit was available in several models, with a variety of disk drive configurations: one 360K floppy disk drive; two 360K floppy disk drives; one floppy disk and one hard disk drive; or two floppy disk drives and one hard disk drive. The floppy disk drives were full-height drives in the earlier models, and half-height drives in more recent models. With the four available drive bays, IBM had standard configurations with two floppy drives and a single hard disk, with room for a second hard disk provided all half-height units were used.

IBM offered 10M and 20M, full-height hard disks. In some cases they also installed half-height hard disks, but they were always installed in a bracket and cradle assembly that took up the equivalent space of a full-height drive. If you wanted half-height hard disks (to install two of them stacked, for example), then you had to use non-IBM supplied drives or modify the mounting of the IBM supplied half-height unit so that two could fit. Most aftermarket sources for hard disks had mounting kits that would work.

IBM also used double-sided (320/360K) floppy disk drives in full- or half-height configurations. A 3 1/2-inch 720K floppy disk drive was available in the more recent models. The 3 1/2-inch drives were available in a normal internal configuration or as an external device. You could install a maximum of two floppy disk drives and one hard disk drive in the system unit, using IBM-supplied drives. With half-height hard disks, you could install two hard drives in the system unit.

The XT is based on the same 8- and 16-bit Intel 8088 microprocessor (the CPU has 16-bit registers but only an 8-bit data bus) as the PC and runs at the same clock speed. Operationally, the XT systems are identical to the PC systems except for the hard disk. All models have at least one 360K floppy disk drive and a keyboard. For standard memory, the XT offers 256K or 640K on the main board. The hard disk models also include a serial adapter.

The system unit has eight slots that support cards for additional devices, features, or memory. Two of the slots support only short option cards because of physical interference from the disk drives. The XT has at least a disk drive adapter card in the floppy-disk-only models, and a hard disk controller card and serial adapter in the hard disk models. Either five or seven expansion slots (depending on the model) therefore are available. Figure 21.5 shows the interior of an XT.

All XT models include a heavy-duty, fan-cooled, 130-watt power supply to support the greater expansion capabilities and disk drive options. The power supply has more than double the capacity of the PC's supply, and can easily support hard disk drives as well as the full complement of expansion cards.

An 83-key keyboard was standard equipment with the early XT models, but was changed to an enhanced 101-key unit in the more recent models. The keyboard is attached to the system unit by a six-foot coiled cable.

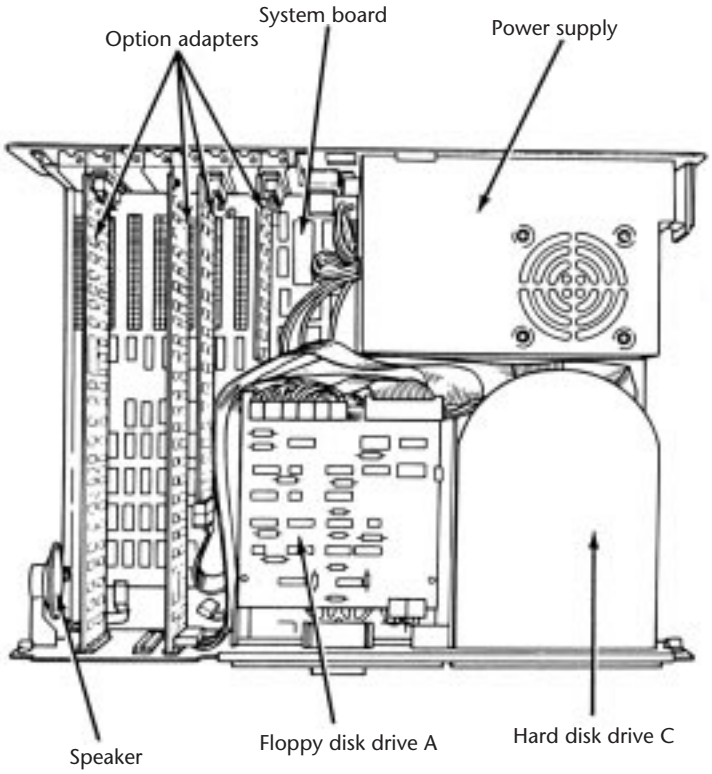

Fig. 21.5
The IBM PC XT interior.

All models of the PC XT system unit contain these major functional components:

- Intel 8088 microprocessor
- ROM-based diagnostics (POST)
- BASIC language interpreter in ROM
- 256K or 640K of dynamic RAM
- Floppy disk controller
- One 360K floppy drive (full- or half-height)
- 10M or 20M hard disk drive with interface (enhanced models)
- Serial interface (enhanced models)
- Heavy-duty, 135-watt power supply
- Eight I/O expansion slots
- Socket for 8087 math coprocessor

XT Models and Features

The XT was available in many different model configurations, but originally only one model was available. This model included a 10M hard disk, marking the first time that a hard disk was standard equipment in a personal computer and was properly supported by the operating system and peripherals. This computer helped change the industry standard for personal computers from normally having one or two floppy disk drives only to now including one or more hard disks.

Today, most people wouldn't consider a PC to be even remotely usable without a hard disk. The original XT was expensive, however, and buyers couldn't *unbundle*, or delete, the hard disk from the system at purchase time for credit and add it later. This fact distinguished the XT from the PC and misled many people to believe that the only difference between the two computers was the hard disk. People who recognized and wanted the greater capabilities of the XT without the standard IBM hard disk unfortunately had to wait for IBM to sell versions of the XT without the hard disk drive.

The original Model 087 of the XT included a 10M hard disk, 128K of RAM, and a standard serial interface. IBM later increased the standard memory in all PC systems to 256K. The XT reflected the change in Model 086, which was the same as the preceding 087 except for a standard 256K of RAM.

On April 2, 1985, IBM introduced new models of the XT without the standard hard disk. Designed for expansion and configuration flexibility, the new models enabled you to buy the system initially at a lower cost and add your own hard disk later. The XT therefore could be considered in configurations that previously only the original PC could fill. The primary difference between the PC and the XT is the XT's expansion capability, provided by the larger power supply, eight slots, and better memory layout. These models cost only $300 more than equivalent PCs, rendering the original PC no longer a viable option.

The extra expense of the XT was justified with the first power-supply replacement you made with an overworked PC. The IBM PC XT was available in two floppy disk models:

5160068 XT with one full-height 360K disk drive

5160078 XT with two full-height 360K disk drives

Both these models have 256K of memory and use the IBM PC XT motherboard, power supply, frame, and cover. The serial (asynchronous communications) adapter wasn't included as a standard feature with these models.

IBM introduced several more models of the PC XT on April 2, 1986. These models were significantly different from previous models. The most obvious difference, the Enhanced Keyboard, was standard with these newer computers. A 20M (rather than 10M) hard disk and high-quality, half-height floppy disk drives were included. The new half-height floppy disk drives allowed for two drives in the space that previously held only one floppy drive. With two drives, backing up floppy disks became easy. A new 3 1/2-inch floppy disk drive, storing 720K for compatibility with the PC Convertible laptop

computer, was released also. These more recent XT system units were configured with a new memory layout allowing for 640K of RAM on the motherboard without an expansion slot. This feature conserved power, improves reliability, and lowered the cost of the system.

One 5 1/4-inch, half-height, 360K floppy disk drive and 256K of system-board memory were standard with the XT Models 267 and 268. Models 277 and 278 have a second 5 1/4-inch floppy disk drive. Models 088 and 089 are expanded PC XTs with all the standard features of the Models 267 and 268: a 20M hard disk, a 20M fixed disk drive adapter, a serial port adapter, and an additional 256K of system-board memory—a total of 512K.

The following list shows the highlights of these models:

- Enhanced Keyboard standard on Models 268, 278, and 089
- 101 keys

  Recappable

  Selectric typing section

  Dedicated numeric pad

  Dedicated cursor and screen controls

  Two additional function keys

  Nine-foot cable
- Standard PC XT keyboard on Models 267, 277, and 088
- More disk capacity (20M)
- Standard 5 1/4-inch, half-height, 360K floppy drive
- Available 3 1/2-inch, half-height, 720K floppy drive
- Capacity for four half-height storage devices within the system unit
- Capacity to expand to 640K bytes memory on system board without using expansion slots

These XT models have an extensively changed ROM BIOS. The BIOS is 64K and internally similar to the BIOS found in ATs. The ROM includes support for the keyboard and 3 1/2-inch floppy disk drives. The POST also was enhanced.

The new XTs were originally incompatible in some respects with some software programs. These problems centered on the new 101-key enhanced keyboard and the way the new ROM addressed the keys. These problems weren't major and were solved quickly by the software companies.

Seeing how much IBM changed the computer without changing the basic motherboard design is interesting. The ROM is different, and the board holds 640K of memory without a card in a slot. The memory trick is a simple one. IBM designed this feature into the board originally and chose to unleash it with these models of the XT.

During the past several years, I have modified many XTs to have 640K on the motherboard, using a simple technique designed into the system by IBM. A jumper and chip added to the motherboard can alter the memory addressing in the board to enable the system to recognize 640K. The new addressing is set up for 256K chips, installed in two of the four banks. The other two banks of memory contain 64K chips—a total of 640K. Chapter 17 has a set of detailed instructions for modifying an IBM XT in this way.

XT Technical Specifications

Technical information for the XT system, described in this section, provides information about the system architecture, memory configurations and capacities, standard system features, disk storage, expansion slots, keyboard specifications, and also physical and environmental specifications. This information can be useful in determining what parts you need when you are upgrading or repairing these systems. Figure 21.6 shows the layout and components on the XT motherboard.

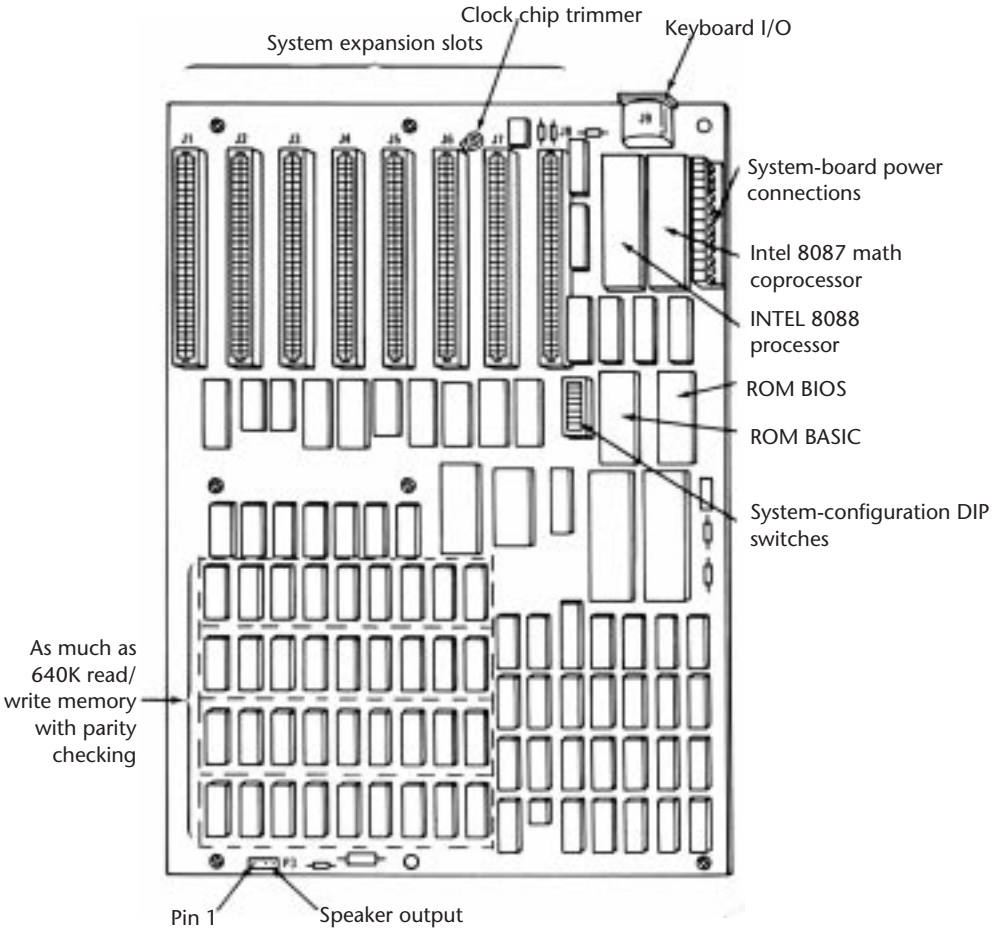

Fig. 21.6
The XT motherboard.

System Architecture	
Microprocessor	8088
Clock speed	4.77 MHz
Bus type	ISA (Industry Standard Architecture)
Bus width	8-bit
Interrupt levels	8
Type	Edge-triggered
Shareable	No
DMA channels	3
DMA burst mode supported	No
Bus masters supported	No
Upgradable processor complex	No
Memory	
Standard on system board	256K or 640K
Maximum on system board	256K or 640K
Maximum total memory	640K
Memory speed (ns) and type	200ns dynamic RAM
System board memory-socket type	16-pin DIP
Number of memory-module sockets	36 (4 banks of 9)
Memory used on system board	36 64K×1-bit DRAM chips in 4 banks of 9, or 2 banks of 9 256K×1-bit and 2 banks of 9 64K×1-bit chips
Memory cache controller	No
Wait states:	
System board	1
Adapter	1
Standard Features	
ROM size	40K or 64K
ROM shadowing	No
Optional math coprocessor	8087
Coprocessor speed	4.77 MHz
Standard graphics	None standard
RS232C serial ports	1 (some models)
UART chip used	NS8250B
Maximum speed (bits per second)	9,600 bps
Maximum number of ports supported	2
Pointing device (mouse) ports	None standard
Parallel printer ports	1 (some models)
Bi-directional	No
Maximum number of ports supported	3
CMOS real-time clock (RTC)	No
CMOS RAM	None

(continues)

Disk Storage		
Internal disk and tape drive bays	2 full-height or 4 half-height	
Number of 3 1/2- or 5 1/4-inch bays	0/2 or 0/4	
Standard floppy drives	1×360K	
Optional floppy drives:		
5 1/4-inch 360K	Optional	
5 1/4-inch 1.2M	No	
3 1/2-inch 720K	Optional	
3 1/2-inch 1.44M	No	
3 1/2-inch 2.88M	No	
Hard disk controller included	ST-506/412 (Xebec Model 1210)	
ST-506/412 hard disks available	10/20M	
Drive form factor	5 1/4-inch	
Drive interface	ST-506/412	
Drive capacity	10M	20M
Average access rate (ms)	85	65
Encoding scheme	MFM	MFM
BIOS drive type number	1	2
Cylinders	306	615
Heads	4	4
Sectors per track	17	17
Rotational speed (RPMs)	3600	3600
Interleave factor	6:1	6:1
Data transfer rate (kilobytes/second	85	85
Automatic head parking	No	No
Expansion Slots		
Total adapter slots	8	
Number of long/short slots	6/2	
Number of 8-/16-/32-bit slots	8/0/0	
Available slots (with video)	4	
Keyboard Specifications		
101-key Enhanced Keyboard	Yes	
Fast keyboard speed setting	No	
Keyboard cable length	6 feet	

Physical Specifications	
Footprint type	Desktop
Dimensions:	
Height	5.5 inches
Width	19.5 inches
Depth	16.0 inches
Weight	32 pounds
Environmental Specifications	
Power-supply output	130 watts
Worldwide (110/60, 220/50)	No
Auto-sensing/switching	No
Maximum current:	
90-137 VAC	4.2 amps
Operating range:	
Temperature	60–90 degrees F
Relative humidity	8–80 percent
Maximum operating altitude	7,000 feet
Heat (BTUs/hour)	717
Noise (Average dB, operating, 1m)	56
FCC classification	Class B

The following table shows the XT motherboard switch settings. The XT motherboard uses a single eight-position switch block to control various functions as detailed in table 21.5.

Table 21.5 IBM PC/XT Motherboard Switch Settings

SWITCH BLOCK 1 (PC and XT)		
	Switch 1	**IBM PC Function (PC Only):**
	Off	Boot From Floppy Drives
	On	Do Not Boot From Floppy Drives
	Switch 1	**IBM XT Function (XT Only):**
	Off	Normal POST (Power-On Self Test)
	On	Continuous Looping POST
	Switch 2	**Math Coprocessor (PC/XT):**
	Off	Installed
	On	Not Installed
Switch 3	**Switch 4**	**Installed Motherboard Memory (PC/XT):**
On	On	Bank 0 only
Off	On	Banks 0 and 1

(continues)

Table 21.5 Continued

SWITCH BLOCK 1 (PC and XT)		
On	Off	Banks 0, 1 and 2
Off	Off	All 4 Banks
Switch 5	**Switch 6**	**Video Adapter Type (PC/XT):**
Off	Off	Monochrome (MDA)
Off	On	Color (CGA) - 40x25 mode
On	Off	Color (CGA) - 80x25 mode
On	On	Any Video Card w/onboard BIOS (EGA/VGA)
Switch 7	**Switch 8**	**Number of Floppy Drives (PC/XT):**
On	On	1 floppy drive
Off	On	2 floppy drives
On	Off	3 floppy drives
Off	Off	4 floppy drives

Table 21.6 shows the part numbers of the XT system units.

Table 21.6 IBM XT Model Part Numbers

Description	**Number**
XT system unit/83-key keyboard, 256K:	
one full-height 360K drive	5160068
one half-height 360K drive	5160267
two full-height 360K drives	5160078
two half-height 360K drives	5160277
XT system unit/101-key keyboard, 256K:	
one half-height 360K drive	5160268
two half-height 360K drives	5160278
XT system unit/83-key keyboard, 256K, one serial, one full-height 360K drive, 10M hard disk	5160086
XT system unit/83-key keyboard, 640K, one serial, one half-height 360K drive, 20M fixed disk	5160088
XT system unit/101-key keyboard, 640K, one serial, one half-height 360K drive, 20M fixed disk	5160089
Option Numbers	
PC expansion-unit Model 002, 20M fixed disk	5161002
20M fixed disk drive	6450326
20M fixed disk adapter	6450327
10M fixed disk drive	1602500
10M fixed disk adapter	1602501
5 1/4-inch, half-height, 360K drive	6450325
5 1/4-inch, full-height, 360K drive	1503810
3 1/2-inch, half-height, 720K internal drive	6450258
3 1/2-inch, half-height, 720K external drive	2683190

Description	Number
Option Numbers	
8087 math coprocessor option	1501002
Asynchronous serial adapter	1502074
Enhanced Keyboard Accessories	
Clear keycaps (60) with paper inserts	6341707
Blank light keycaps	1351710
Blank dark keycaps	1351728
Paper inserts (300)	6341704
Keycap-removal tools (6)	1351717

An Introduction to the 3270 PC

On October 18, 1983, IBM announced a special version of the XT, the 3270 PC. The 3270 PC combines the functions of IBM's 3270 display system with those of the XT. This system was basically a standard XT system unit with three to six custom adapter cards added to the slots. The keyboard and display for this system also are special and attach to some of the special adapter cards. The 3270 PC Control Program runs all this hardware. This combination can support as many as seven concurrent activities: one local PC DOS session, four remote mainframe sessions, and two local electronic notepads. With the help of the 3270 PC Control Program, information can be copied between windows, but a PC DOS window cannot receive information.

The 3270 PC includes a new keyboard that addresses some complaints about the Personal Computer keyboard. The keyboard has more keys and an improved layout. The Enter and Shift keys are enlarged. The cursor keys are separate from the numeric keypad and form a small group between the main alphanumeric keys and the numeric keypad. At the top of the keyboard, 20 function keys are arranged in two rows of ten. To help clarify keystroke operations, the new keyboard is annotated. Blue legends designate PC-specific functions; black legends indicate 3270 functions. The keyboard is greatly improved, but most keys and features don't work in PC mode. Often, you must obtain special versions of programs or disregard most of the keys.

3270 PC Models and Features

The 3270 PC includes several specialized expansion boards that can be added to an XT. This section examines those expansion boards.

The 3270 System Adapter

The 3270 system adapter supports communication between the 3270 PC and the remote 3274 controller through a coaxial cable. One physical 3274 connection can support four logical connections.

The Display Adapter

A display adapter is used in place of the PC's monochrome or Color/Graphics Display Adapter and provides text-only displays in eight colors. The PC's extended-character graphics are available, but bit-mapped graphics capabilities are not supported unless you add the accessory extended graphics card.

The Extended Graphics Adapter

The Extended Graphics Adapter provides storage and controls necessary for displaying local graphics in high- or medium-resolution mode. High-resolution mode is available in two colors at 720-by-350 or 640-by-200 pixels. Note that this isn't the same as the newer XGA (eXtended Graphics Array), which is either available for, or included with, certain PS/2 systems.

Medium-resolution mode is available with a choice of two sets of four colors at 360-by-350 or 320-by-200 pixels. To run in medium-resolution mode, your system must have an available system-expansion slot adjacent to the display adapter card. If you install a Programmed Symbols feature (discussed in the following section) next to the display adapter, you must use the slot adjacent to the PS feature. Because the aspect ratio differs for each display monitor, applications programs must control the aspect ratio parameter; a circle on the 5150/5160 PC with the Color Graphics Adapter looks slightly elliptical on the 3270 PC with the XGA unless you change this parameter.

Programmed Symbols

The Programmed Symbols (PS) adapter provides graphics capabilities available on IBM 3278/3279 display stations. This card provides storage for as many as six 190-symbol sets whose shapes and codes are definable. Symbol sets are loaded (and accessed for display) under program control. To accept this board, your system must have an available system-expansion slot adjacent to the display adapter card. If an XGA feature is installed, you must use the slot adjacent to the XGA. The PS card is available in distributed-function terminal (DFT) mode only and can be used in only one of the four host sessions.

The Keyboard Adapter

You use the keyboard adapter to adapt the 3270-style keyboard to the system unit. The keyboard connects to this board rather than to the motherboard, as it does for the PC. The board is short and must be installed in the special eighth slot in the XT system unit.

The standard XT system unit provides eight expansion slots; at least five of the slots normally were filled upon delivery with the 3270 system adapter, the display adapter, the keyboard adapter, the disk drive adapter, and the hard disk controller. If you add options such as the graphics adapter and a memory multifunction card, you can see that even with the XT as a base, slots are at a premium in this system.

Software

The 3270 PC runs under control of the 3270 PC Control Program in conjunction with PC DOS and supports concurrent operation of as many as four remote-host interactive sessions, two local notepad sessions, and one PC DOS session. The Control Program enables users to associate sessions with display screen windows and to manage the windows by a set of functions that IBM named *advanced screen management*.

Windows

You can define windows that permit viewing of all (as many as 2,000 characters) or part of a presentation space. In IBM's vocabulary, a *presentation space* is a logical display area presented by a single host. PC DOS presentation spaces are 2,000 characters (25 lines by 80 characters); remote host spaces are as many as 3,440 characters; and notepad presentation spaces are 1,920 characters.

As many as seven windows can appear on-screen at one time. Every window is associated with a distinct presentation space. Windows can be as large as the screen or as small as one character and can be positioned at any point within their presentation space. A window 20 characters wide and four lines long, for example, shows the first 20 characters of the last four lines of a host session display. You can change window size and position in the presentation space at any time without affecting the content of the presentation space.

At any time, only one window on the 3270 PC screen can be the active window. When you enter information from the keyboard, the information is directed to the session associated with the active window. You can switch between active windows by using keystroke commands.

You can define the foreground and background colors of host session windows not using extended data-stream attributes. You can define the background color for the 5272 screen also (the color to be displayed in areas not occupied by windows).

Special Facilities

In addition to advanced screen-management functions, the Control Program offers a number of related special facilities that help you take further advantage of the 3270 environment.

Data can be copied within or between any presentation spaces except into the PC DOS screen. You copy by marking a block of data in one window and a destination in some other window, much the same as a block copy in a word processor.

Think of the notepads as local electronic scratch pads that you can use at your convenience. You can save and restore the contents of a notepad at any time by using PC DOS files as the storage medium.

You can define as many as ten screen configurations, each of which describes a set of windows configured in any way, and they can display on command any one configuration. Use PC DOS files to store the configuration information.

You can print a full copy of the display screen on a local printer. Similarly, you can print a full copy of a PC DOS presentation space on a local printer. You also can print a full copy of any host presentation space on a local printer, a 3274 attached printer, or a 43xx display/printer.

The Control Program maintains a status line at the bottom of the screen that displays current configuration information, including the name of the active window. The program includes a help function and displays active workstation functions and sessions and an on-line tutorial that explains and simulates system functions. The tutorial is a standard PC DOS program that can be run on any IBM PC.

The Control Program, assisted by a host-based IBM 3270 PC file-transfer program, can initiate transfers of ASCII, binary, and EBCDIC files to and from remote hosts.

A drawback to this software is that it is memory resident and consumes an enormous amount of space. The result is that in the PC DOS session, not many applications can run in the leftover workspace. Your only option—reboot the computer without loading the Control Program—is a clumsy and time-consuming procedure. Even with this tactic, the drastic differences in the display hardware and the keyboard still render this computer much less than "PC compatible." The AT version of this system offers a solution to the memory problem by enabling much of the Control Program to reside in the AT's extended memory, above the 1M memory limit of the PC and XT.

The Significance of the 3270

The 3270 PC is a great system to use if you are a corporate worker who deals every day with many information sources (most of which are available through an IBM mainframe SNA network). Corporate information managers greatly appreciate the concurrent access to several SNA-based databases. The 3270 PC provides essential tools for viewing, extracting, combining, and manipulating information: multiple concurrent-terminal sessions, cut-and-paste capability between sessions, PC productivity tools, and up- and downloading host files from PC DOS files.

For simple 3270 terminal-emulation capability, however, this system is more than you need. In addition, the display and keyboard make this system partially incompatible with the rest of the PC world. Many PC applications do not run properly on this system. If you depend more on PC DOS applications than on the mainframe, or if you consider the multiple mainframe sessions unimportant, using one of the simpler 3270 emulation adapters is more cost-effective.

An Introduction to the XT 370

On October 18, 1983, IBM introduced another special version of the XT, the XT 370, consisting of a standard PC XT chassis with three special cards added. These adapters are special S/370-emulation cards that enable the computer to execute the mainframe system 370 instruction set. The boards enable you to run VM/CMS and emulate 4M of virtual memory. You can download programs and compilers from the mainframe and execute them directly on the XT. You switch between 370 mode and the standard XT I by using a *hot key*, or special keystroke, sequence.

XT/370 Models and Features

The three cards that make up the XT 370—the PC 370-P card, the PC 370-M card, and the PC 3277-EM card—are examined in this section.

The P card implements an emulation of the 370 instruction set. The card has three microprocessors. One processor is a heavily modified Motorola 68000 produced under license to IBM. This chip implements the general-purpose registers, the PSW, instruction fetch and decode logic, and 72 commonly used S/370 instructions. Because Motorola manufactures the chip under license to IBM, the chip probably will not appear as a Motorola product.

A second processor is a slightly modified Motorola 68000, which is listed in Motorola's catalog. The chip emulates the remaining nonfloating-point instructions, manipulates the page table, handles exception conditions, and performs hardware housekeeping.

The third microprocessor, a modified Intel 8087 that executes S/370 floating-point instructions, is interfaced as a peripheral rather than the normal 8087 coprocessor linkage.

The M card has 512K of parity-checked RAM. You can access this memory from the P card or from the XT's native 8088 processor. Concurrent requests are arbitrated in favor of the 8088. The M card resides in an XT expansion slot but is connected to the P card by a special edge connector. Sixteen-bit-wide transfers between M card memory and the P card are carried out through this connector (normal XT memory transfers operate in 8-bit-wide chunks).

Operating in native PC mode, the M card's memory is addressed as contiguous memory beginning at the end of the 256K memory of the system's motherboard. In native PC mode, the XT 370 has 640K of usable RAM; some of the M card's memory is not used.

Operating in 370 mode, only the 512K RAM of the M card is usable. (The memory on the motherboard is not available.) The first 480K of this memory implements 480K of real S/370 space. The remaining 32K on the M card functions as a microcode control-storage area for the second P card microprocessor.

The first 64K (of 480K) of S/370 memory are consumed by VM/PC; 416K of real memory remains for user programs. User programs larger than 416K are handled through paging.

The PC 3277-EM card attaches the XT 370 to an S/370 mainframe by a local or remote 3274 control unit (connection through coaxial cable). When VM/PC is running, the EM card uses the IBM monochrome or color display. Under VM/PC, the EM card is used also to up- and download data between a host VM system and the XT 370.

The XT 370 can run in native PC XT mode or in S/370 mode under the VM/PC Control Program. Under VM/PC, the user can use a "hot key" to alternate between a local CMS session and a remote 3277 session (or, optionally, a 3101-emulation session). VM/PC does not offer a true VM-like environment. Rather, VM/PC provides an environment in which CMS applications can run. Non-CMS VM applications do not run on the XT 370.

The VM/PC system, which must be licensed, is provided on six floppy disks and includes the VM/PC Control Program, CMS, XEDIT, EXEC2, local and remote file-transfer utilities, and the 370 Processor Control package.

Estimations of the XT 370 CPU's performance indicate that it is about half of a 4331 when the XT 370 is running a commercial instruction mix. When the XT 370 is running scientific codes, you can expect twice the performance as from the 4331. The CPU generally is categorized as a 0.1 MIPS (million instructions per second) processor. This size does not sound impressive when you're used to multi-MIPS, single-chip microprocessors, but remember that 0.1-million S/370 instructions likely will produce substantially more computing than 0.1-million instructions of your standard microprocessor chip.

The XT 370 running in S/370 mode can access the 512K on the M card. Of this 512K, 32K is reserved for microcode control storage, and 65K is used by the VM/PC Control Program; 416K remains for user programs. If a user program requires more memory than 416K, VM/PC uses a paging area on the XT 370's hard disk and swaps pieces of the program in and out of memory according to use.

Swapping on the small 10M or 20M hard disks is considerably slower than on the large disks used with mainframes. Programs larger than 416K, therefore, probably will run very slowly. Field test users report long delays in loading large programs into memory, even when the programs are well under the maximum for nonpaging operation. Delays are due to the relatively slow operation of the XT 370 hard disks. Because of size and speed problems, many users of these systems should consider larger and faster hard disks.

An Introduction to the Portable PC

IBM introduced the Portable PC on February 16, 1984. The IBM Portable PC, a "transportable" personal computer, has a built-in, nine-inch, amber composite video monitor; one 5 1/4-inch, half-height floppy disk drive (with space for an optional second drive); an 83-key keyboard; two adapter cards; a floppy disk controller; and a Color Graphics Adapter (CGA). The unit also has a universal-voltage power supply capable of overseas operation on 220-volt power. Figure 21.7 shows the Portable PC exterior.

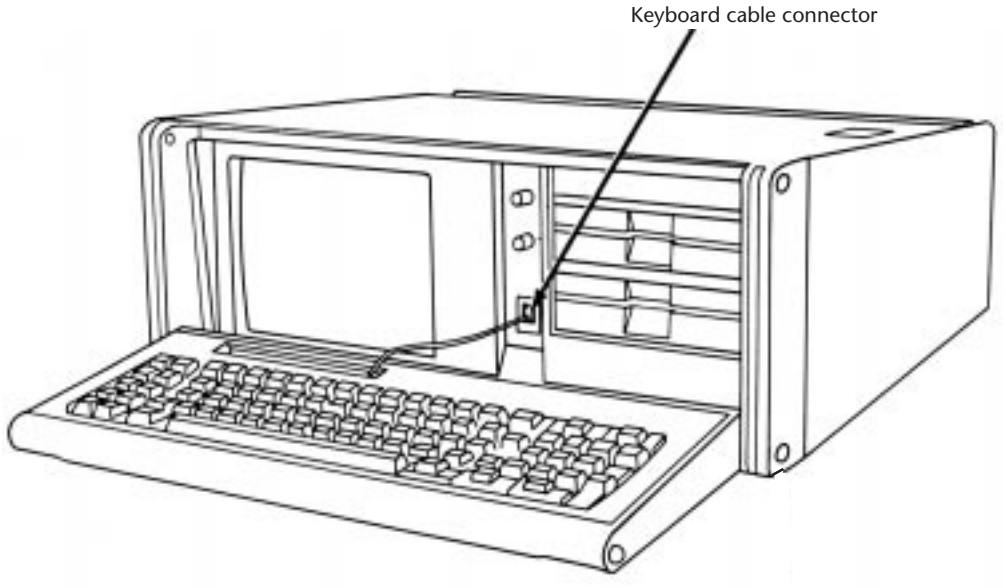

Fig. 21.7
The IBM Portable PC.

The system board used in the IBM Portable PC is the same board used in the original IBM XT, with 256K of memory. Because the XT motherboard is used, eight expansion slots are available for the connection of adapter boards, although only two slots can accept a full-length adapter card due to internal space restrictions. The power supply is basically the same as an XT's, with physical changes for portability and a small amount of power drawn to run the built-in monitor. In function and performance, the Portable PC system unit has identical characteristics to an equivalently configured IBM PC XT system unit. Figure 21.8 shows the Portable PC interior view.

IBM withdrew the Portable PC from the market on April 2, 1986, a date that coincides with the introduction of the IBM Convertible laptop PC. The Portable PC is rare because not many were sold. The system was largely misunderstood by the trade press and user community. Most did not understand that the system was really a portable XT and had more to offer than the standard IBM PC did. Maybe if IBM had called the system the Portable XT, it would have sold better.

The Portable PC system unit has these major functional components:

- Intel 8088 4.77 MHz microprocessor
- ROM-based diagnostics (POST)
- BASIC language interpreter in ROM
- 256K of dynamic RAM
- Eight expansion slots (two long slots, one 3/4-length slot, and five short slots)

- Socket for 8087 math coprocessor
- Color/Graphics Monitor Adapter
- 9-inch, amber, composite video monitor
- Floppy disk interface
- One or two half-height 360K floppy drives
- 114-watt universal power supply (115 V to 230 V, 50 Hz to 60 Hz)
- Lightweight 83-key keyboard
- Enclosure with carrying handle
- Carrying bag for the system unit

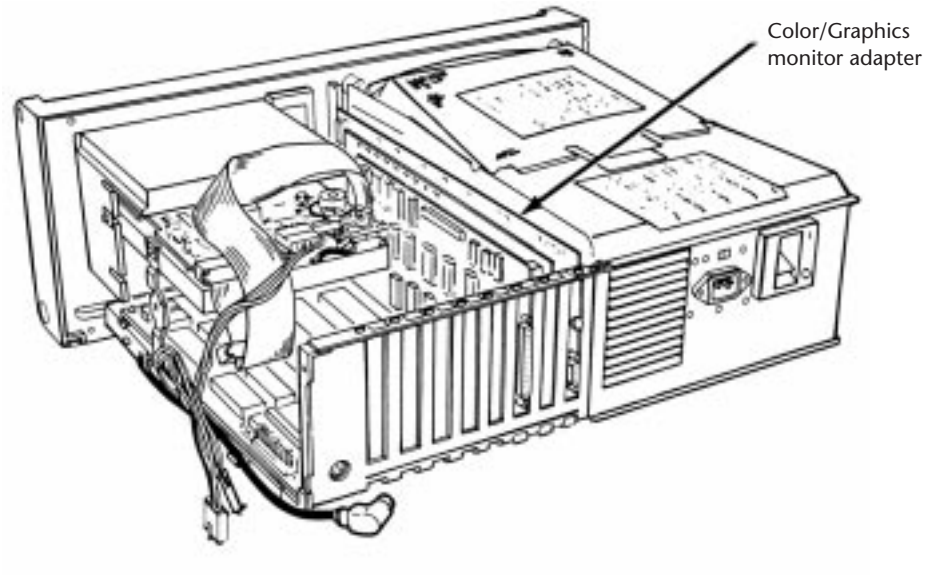

Fig. 21.8
The IBM Portable PC interior.

Portable PC Technical Specifications

The technical data for the Portable PC system is described in this section, which includes information about the system architecture, memory configurations and capacities, standard system features, disk storage, expansion slots, keyboard specifications, and also physical and environmental specifications. This information can be useful in determining what kinds of parts you need when you are upgrading or repairing these systems. Figure 21.6 previously showed the XT motherboard, also used in the Portable PC.

System Architecture	
Microprocessor	8088
Clock speed	4.77 MHz
Bus type	ISA (Industry Standard Architecture)
Bus width	8-bit
Interrupt levels	8
Type	Edge-triggered
Shareable	No
DMA channels	3
DMA burst mode supported	No
Bus masters supported	No
Upgradeable processor complex	No
Memory	
Standard on system board	256K
Maximum on system board	256K
Maximum total memory	640K
Memory speed (ns) and type	200ns dynamic RAM
System board memory-socket type	16-pin DIP
Number of memory-module sockets	36 (4 banks of 9)
Memory used on system board	36 64K×1-bit DRAM chips in 4 banks of 9 chips
Memory cache controller	No
Wait states:	
System board	1
Adapter	1
Standard Features	
ROM size	40K
ROM shadowing	No
Optional math coprocessor	8087
Coprocessor speed	4.77 MHz
Standard graphics	CGA adapter with built-in 9" amber CRT
RS232C serial ports	None standard
UART chip used	NS8250B
Maximum speed (bits per second)	9,600 bps
Maximum number of ports supported	2
Pointing device (mouse) ports	None standard
Parallel printer ports	None standard
Bi-directional	No
Maximum number of ports supported	3
CMOS real-time clock (RTC)	No
CMOS RAM	None

(continues)

Disk Storage	
Internal disk and tape drive bays	2 half-height
Number of 3 1/2-/5 1/4-inch bays	0/2
Standard floppy drives	1 or 2×360K
Optional floppy drives:	
5 1/4-inch 360K	Optional
5 1/4-inch 1.2M	No
3 1/2-inch 720K	Optional
3 1/2-inch 1.44M	No
3 1/2-inch 2.88M	No
Hard disk controller included	None
Expansion Slots	
Total adapter slots	8
Number of long/short slots	2/6
Number of 8-/16-/32-bit slots	8/0/0
Available slots (with video)	6
Keyboard Specifications	
101-key Enhanced Keyboard	No
Fast keyboard speed setting	No
Keyboard cable length	6 feet
Physical Specifications	
Footprint type	Desktop
Dimensions:	
Height	8.0 inches
Width	20.0 inches
Depth	17.0 inches
Weight	31 pounds
Environmental Specifications	
Power-supply output	114 watts
Worldwide (110/60, 220/50)	Yes
Auto-sensing/switching	No
Maximum current:	
90-137 VAC	4.0 amps
Operating range:	
Temperature	60–90 degrees F
Relative humidity	8–80 percent
Maximum operating altitude	7,000 feet
Heat (BTUs/hour)	650
Noise (Average dB, operating, 1m)	42
FCC classification	Class B

Table 21.7 shows the part numbers for the Portable PC:

Table 21.7 IBM Portable PC Model Part Numbers

Description	Number
256K, one 360K half-height drive	5155068
256K, two 360K half-height drives	5155076
Half-height 360K floppy disk drive	6450300

The disk drive used in the Portable PC was a half-height drive, the same unit specified for use in the PC*jr*. When the Portable PC was introduced, PC*jr* was the only one IBM sold with the half-height drive.

An Introduction to the AT

IBM introduced the Personal Computer AT (Advanced Technology) on August 14, 1984. The IBM AT system included many features previously unavailable in IBM's PC systems such as increased performance, an advanced 16-bit microprocessor, high-density floppy disk and hard disk drives, larger memory space, and an advanced coprocessor. Despite its new design, the IBM AT incredibly retained compatibility with most existing hardware and software products for the earlier systems.

In most cases, IBM AT system performance was from three to five times faster than the IBM XT for single applications running DOS on both computers. The performance increase was due to the combination of a reduced cycle count for most instructions by the 80286 processor, an increased system clock rate, 16-bit memory, and faster hard disk and controller.

The AT system unit has been available in several models: a floppy-disk-equipped base model (068) and several hard-disk-enhanced models. Based on a high-performance, 16-bit, Intel 80286 microprocessor, each computer includes Cassette BASIC language in ROM and a CMOS (Complementary Metal Oxide Semiconductor) clock and calendar with battery backup. All models are equipped with a high-density (1.2M) floppy disk drive, a keyboard, and a lock. For standard memory, the base model offers 256K, and the enhanced models offer 512K. In addition, the enhanced models have a 20M or a 30M hard disk drive and a serial/parallel adapter. Each system can be expanded through customer-installable options. You can add memory (to 512K) for the base model by adding chips to the system board. You can expand all models to 16M by installing memory cards.

Besides the standard drives included with the system, IBM only offered two different hard disks as upgrades for the AT: a 30M hard disk drive and a 20M hard disk drive. IBM also offered only three different types of floppy drives for the AT; a second, high-density (1.2M) floppy disk drive; a double-density (320/360K) floppy disk drive; and a new 3 1/2-inch 720K drive. The original 068 and 099 models of the AT did not support the 720K

drive in the BIOS; you had to add a special driver (DRIVER.SYS—supplied with DOS) for the drive to work. The later model ATs also supported a 1.44M high-density 3 1/2-inch floppy drive, however IBM never sold or supported such a drive.

You can install as many as two floppy disk drives and one hard disk drive or one floppy disk drive and two hard disk drives in the system unit. To use the high-density 5 1/4-inch floppy disk drives properly, you must have special floppy disks—5 1/4-inch, high-coercivity, double-sided, soft-sectored disks. Due to track width problems between the high-density (1.2M) drives and the double-density (360K) drives, a double-density floppy disk drive (320/360K) was available for compatibility with the standard PC or XT systems. You can exchange disks reliably between the 1.2M and the standard 360K drives if you use the proper method and understand the recording process. For transferring data between a system with a 1.2M drive to a system with a 360K drive you must start with a blank, (never previously formatted), 360K disk, which must be formatted and written only by the 1.2M drive. There are no special precautions to transfer the data the other way. This information is covered in Chapter 13. For complete interchange reliability, however, IBM recommended you purchase the 360K drive.

The system unit has eight slots that support cards for additional devices, features, or memory. Six slots support the advanced 16-bit or 8-bit option cards. Two slots support only 8-bit option cards. All system-unit models, however, use one 16-bit slot for the fixed disk and floppy disk drive adapter. The enhanced models use an additional 8-bit slot for the serial/parallel adapter. The result is seven available expansion slots for the base model and six available expansion slots for enhanced models. Figure 21.9 shows the interior of an AT system unit.

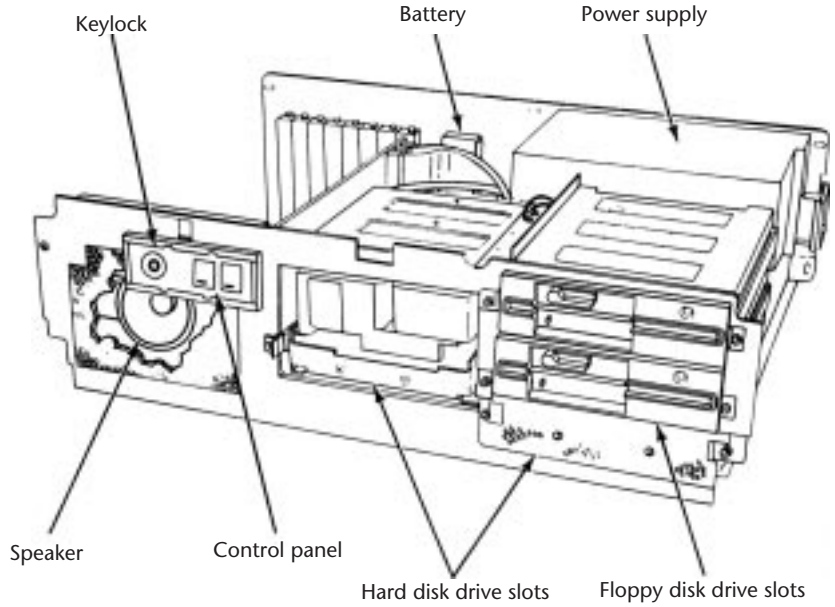

Fig. 21.9
The IBM AT unit interior.

All models include a universal power supply; a temperature-controlled, variable-speed cooling fan; and a security lock with key. The user selects the power supply for a country's voltage range. The cooling fan significantly reduces the noise in most environments; the fan runs slower when the system unit is cool and faster when the system unit is hot. When the system is locked, no one can remove the system-unit cover, boot the system, or enter commands or data from the keyboard, thereby enhancing the system's security.

The keyboard is attached to the system unit by a nine-foot, coiled cable that enables the AT to adapt to a variety of workspace configurations. The keyboard includes key-location enhancements and mode indicators for improved keyboard usability. Figure 21.10 shows the rear panel of an AT.

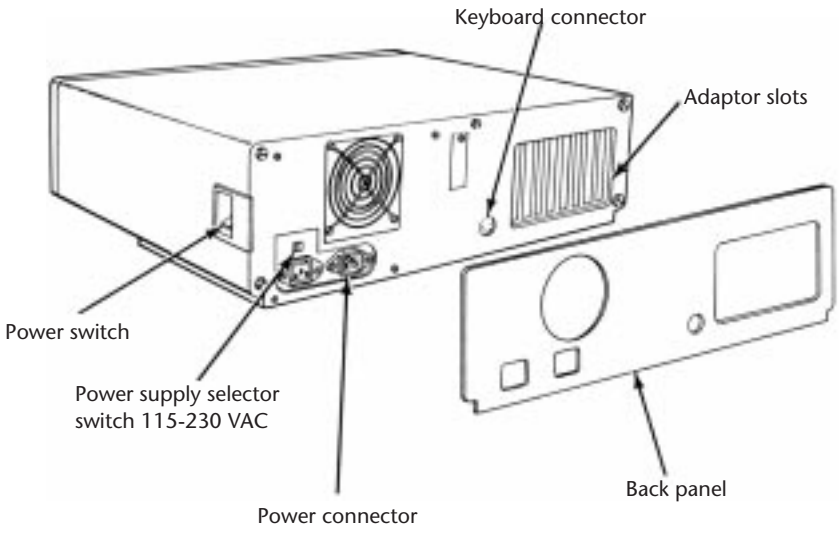

Fig. 21.10
The IBM AT rear panel.

Every system unit for the AT models has these major functional components:

- Intel 80286 (6 MHz or 8 MHz) microprocessor
- Socket for 80287 math coprocessor
- 8086-compatible real address mode
- Protected virtual address mode
- Eight I/O expansion slots (six 16-bit, two 8-bit)
- 256K of dynamic RAM (base model)
- 512K of dynamic RAM (enhanced models)
- ROM-based diagnostics (POST)

- BASIC language interpreter in ROM
- Hard/floppy disk controller
- 1.2M HD floppy drive
- 20M or 30M hard disk drive (enhanced models)
- Serial/parallel interface (enhanced models)
- CMOS clock-calendar and configuration with battery backup
- Keylock
- 84-key keyboard
- Enhanced, 101-key keyboard (standard on newer models)
- Switchable worldwide power supply

AT Models and Features

Since the introduction of the AT, several models became available. First, IBM announced two systems: a base model (068) and an enhanced model (099). The primary difference between the two systems is the standard hard disk that came with the enhanced model. IBM introduced two other AT systems since the first systems, each offering different features.

The first generation of AT systems have a 6 MHz system clock that dictates the processor cycle time. The *cycle time*, the system's smallest interval of time, represents the speed at which operations occur. Every operation in a computer takes at least one or (usually) several cycles to complete. Therefore, if two computers are the same in every way except for the clock speed, the system with the faster clock rate executes the same operations in a shorter time proportional to the difference in clock speed. Cycle time and clock speed are two different ways of describing the same thing. Discussions of clock speed are significant when you consider buying the AT because not all models have the same clock speed.

All models of the AT included a combination hard/floppy disk controller that was really two separate controllers on the same circuit board. The board was designed by IBM and Western Digital, and manufactured for IBM by Western Digital. This controller had no on-board ROM BIOS like the Xebec hard disk controller used in the XT. In the AT, IBM built full support for the hard disk controller directly into the motherboard ROM BIOS. To support different types of hard disks, IBM encoded a table into the motherboard ROM that listed the parameters of various drives that could be installed. In the first version of the AT, with a ROM BIOS dated 01/10/84, only the first 14 types in the table were filled in. Type 15 itself was reserved for internal reasons, and was not usable. Other table entries from 16 through 47 were left unused and were actually filled with zeros. Later versions of the AT added new drive types to the tables, starting from type 16 and up.

The first two AT models were the 068 (base) model, which had 256K on the motherboard and a single 1.2M floppy disk drive; and the model 099 (enhanced), which had a 20M hard disk drive, a serial/parallel adapter, and 512K on the motherboard. IBM designated the motherboard on these computers as Type 1, which is larger than the later Type 2 board and used an unusual memory layout. The memory is configured as four banks of 128K chips—a total of 512K on the board. This configuration sounds reasonable until you realize that a 128K chip does not really exist in the physical form factor that IBM used. IBM actually created this type of memory device by stacking a 64K chip on top of another one and soldering the two together. My guess is that IBM had many 64K chips to use, and the AT was available to take them.

On October 2, 1985, IBM announced a new model of the AT, the Personal Computer AT Model 239. The system has all the standard features of the AT Model 099, but also has a 30M hard disk rather than a 20M hard disk. A second, optional 30M hard disk drive expands the Model 239's hard disk storage to 60M. This unit's motherboard, a second-generation design IBM calls Type 2, is about 25 percent smaller than the Type 1 but uses the same mounting locations, for physical compatibility. All important items, such as the slots and connectors, remain in the same locations. Other major improvements in this board are in the memory. The 128K memory chips have been replaced by 256K devices. Now only two banks of chips were needed to get the same 512K on the board.

The AT Model 239 includes these items:

- 512K of RAM (standard)
- 6 MHz Type 2 motherboard with 256K memory chips
- Serial/parallel adapter (standard)
- 30M hard disk (standard)
- New ROM BIOS (dated 06/10/85)

  ROM supports 3 1/2-inch 720K floppy drives without using external driver programs

  ROM supports 22 hard disk types (up to type 23), including the supplied 30M disk

  POST fixes clock rate to 6 MHz

The Type 2 motherboard's design is much improved over Type 1's; the Type 2 motherboard improved internal-circuit timing and layout. Improvements in the motherboard indicated that the system would be pushed to higher speeds—exactly what happened with the next round of introductions.

In addition to obvious physical differences, the Model 239 includes significantly different ROM software from the previous models. The new ROM supports more types of hard and floppy disks, and its new POST prevents alteration of the clock rate from the standard 6 MHz models. Because support for the 30M hard disk is built into the new ROM, IBM sells also a 30M hard disk upgrade kit that includes the new ROM for the original AT systems. Unfortunately, this $1,795 kit represents the only legal way to obtain the newer ROM.

The 30M hard disk drive upgrade kit for the Personal Computer AT Models 068 and 099 includes all the features in the 30M hard disk drive announced for the AT Model 239. The upgrade kit also has a new basic input-output subsystem (BIOS), essential to AT operation. The new ROM BIOS supports 22 drive types (compared to the original 14 in earlier ATs), including the new 30M drive. To support the 30M hard disk drive, a new diagnostics floppy disk and an updated guide-to-operations manual were shipped with this kit.

The 30M update kit included these items:

- 30M hard disk drive
- Two new ROM BIOS modules
- Channel keeper bar (a bracket for the fixed disk)
- Data cable for the hard disk
- Diagnostics and Setup disk
- An insert to the AT guide-to-operations manual

Some people were upset initially that IBM had "fixed the microprocessor clock" to 6 MHz in the new model, thereby disallowing any possible "hot rod" modifications. Many people realized that the clock crystal on all the AT models was socketed so that the crystal could be replaced easily by a faster one. More important, because the AT circuit design is modular, changing the clock crystal does not have repercussions throughout the rest of the system, as is the case in the PC and PC XT. For the price of a new crystal (from $1 to $30) and the time needed to plug it in, someone easily could increase an AT's speed by 30 percent, and sometimes more. Because IBM now retrofits the ROM into earlier models or the 30M hard disk upgrade, you no longer can implement a simple speedup alteration without also changing the ROM BIOS as well.

Many people believed that this change was made to prevent the AT from being "too fast" and therefore competing with IBM's minicomputers. In reality, the earlier motherboard was run intentionally at 6 MHz because IBM did not believe that the ROM BIOS software and critical system timing was fully operational at a higher speed. Also, IBM used some components that were rated only for 6 MHz operation, starting of course with the CPU. Users who increased the speed of their early computers often received DOS error messages from timing problems, and in some cases, total system lockups due to components not functioning properly at the higher speeds. Many companies selling speedup kits sold software to help smooth over some of these problems, but IBM's official solution was to improve the ROM BIOS software and motherboard circuitry and to introduce a complete new system running at the faster speed. If you want increased speed no matter what model you have, several companies used to sell clock-crystal replacements that were frequency synthesizers rather than a fixed type of crystal. The units can wait until the POST is finished and change midstream to an increased operating speed. Unfortunately, I know of nobody still making or selling these upgrades. If you are really interested in speeding up your AT in this manner, Chapter 17, "System Upgrades and Improvements,"

discusses a technique for patching the existing ROM to ignore the speed test so that a faster crystal will still pass the POST procedure.

On April 2, 1986, IBM introduced the Personal Computer AT Models 319 and 339. These two similar systems were an enhancement of the earlier Model 239. The primary difference from the Model 239 is a faster clock crystal that provides 8 MHz operation. The Model 339 has a new keyboard, the Enhanced Keyboard, with 101 keys rather than the usual 84. Model 319 is the same as Model 339, but includes the original keyboard.

Highlights of the Models 319 and 339 are shown in this list:

- Faster processor speed (8 MHz)
- Type 2 motherboard, with 256K chips
- 512K of RAM (standard)
- Serial/parallel adapter (standard)
- 30M hard disk (standard)
- New ROM BIOS (dated 11/15/85)

  ROM support for 22 types (up to type 23) of hard disks

  ROM support for 3 1/2-inch drives, at both 720K and 1.44M capacities

  POST fixes clock rate to 8 MHz
- 101-key Enhanced Keyboard (standard on Model 339)

  Recappable keys

  Selectric typing section

  Dedicated numeric pad

  Dedicated cursor and screen controls

  12 function keys

  Indicator lights

  Nine-foot cable

The most significant physical difference in these new systems is the Enhanced Keyboard on the Model 339. The keyboard, similar to a 3270 keyboard, has 101 keys. It could be called the IBM "corporate" keyboard because it is standard on all new desktop systems. The 84-key PC keyboard still was available, with a new 8 MHz model, as the Model 319.

These new 8 MHz systems were available only in an enhanced configuration with a standard 30M hard drive. If you wanted a hard disk larger than IBM's 30M, you could either add a second drive or simply replace the 30M unit with something larger.

ROM support for 3 1/2-inch disk drives at both 720K and 1.44M exists only in Models 339 and 319. In particular the 1.44M drive, although definitely supported by the ROM

BIOS and controller, was not ever offered as an option by IBM. This means that the IBM Setup program found on the Diagnostics and Setup disk did not offer the 1.44M floppy drive as a choice when configuring the system! Anybody adding such a drive had to use one of the many Setup replacement programs available in the public domain, or "borrow" one from an IBM-compatible system that used a floppy disk-based setup program. Adding the 1.44M drive became one of the most popular upgrades for the AT systems because many newer systems came with that type of drive as standard equipment. Earlier AT systems still can use the 720K and 1.44M drives, but they need to either upgrade the ROM to support it (recommended) or possibly use software drivers to make them work.

AT Technical Specifications

Technical information for the AT system is described in this section. You will find information about the system architecture, memory configurations and capacities, standard system features, disk storage, expansion slots, keyboard specifications, as well as physical and environmental specifications. This type of information can be useful in determining what types of parts are needed when you are upgrading or repairing these systems. Figures 21.11 and 21.12 show the layout and components on the two different AT motherboards.

System Architecture	
Microprocessor	80286
Clock speed	6 or 8 MHz
Bus type	ISA (Industry Standard Architecture)
Bus width	16-bit
Interrupt levels	16
Type	Edge-triggered
Shareable	No
DMA channels	7
DMA burst mode supported	No
Bus masters supported	No
Upgradeable processor complex	No
Memory	
Standard on system board	512K
Maximum on system board	512K
Maximum total memory	16M
Memory speed (ns) and type	150ns dynamic RAM
System board memory-socket type	16-pin DIP
Number of memory-module sockets	18 or 36 (2 or 4 banks of 18)
Memory used on system board	36 128K×1-bit DRAM chips in 2 banks of 18, or 18 256K×1-bit chips in one bank
Memory cache controller	No
Wait states:	
System board	1
Adapter	1

Standard Features		
ROM size	64K	
ROM shadowing	No	
Optional math coprocessor	80287	
Coprocessor speed	4 or 5.33 MHz	
Standard graphics	None standard	
RS232C serial ports	1 (some models)	
UART chip used	NS16450	
Maximum speed (bits per second)	9,600 bps	
Maximum number of ports supported	2	
Pointing device (mouse) ports	None standard	
Parallel printer ports	1 (some models)	
Bi-directional	Yes	
Maximum number of ports supported	3	
CMOS real-time clock (RTC)	Yes	
CMOS RAM	64 bytes	
Battery life	5 years	
Disk Storage		
Internal disk and tape drive bays	1 full-height and 2 half-height	
Number of 3 1/2-/5 1/4-inch bays	0/3	
Standard floppy drives	1×1.2M	
Optional floppy drives:		
5 1/4-inch 360K	Optional	
5 1/4-inch 1.2M	Standard	
3 1/2-inch 720K	Optional	
3 1/2-inch 1.44M	Optional (8 MHz models)	
3 1/2-inch 2.88M	No	
Hard disk controller included:	ST-506/412 (Western Digital WD1002-WA2 or WD1003-WA2)	
ST-506/412 hard disks available	20/30M	
Drive form factor	5 1/4-inch	
Drive interface	ST-506/412	
Drive capacity	20M	30M
Average access rate (ms)	40	40
Encoding scheme	MFM	MFM
BIOS drive type number	2	20
Cylinders	615	733
Heads	4	5
Sectors per track	17	17
Rotational speed (RPMs)	3600	3600
Interleave factor	3:1	3:1
Data transfer rate (kilobytes/second)	170	170
Automatic head parking	Yes	Yes

(continues)

Expansion Slots	
Total adapter slots	8
Number of long and short slots	8/0
Number of 8-/16-/32-bit slots	2/6/0
Available slots (with video)	5
Keyboard Specifications	
101-key Enhanced Keyboard	Yes (8 MHz models)
Fast keyboard speed setting	Yes
Keyboard cable length	6 feet
Physical Specifications	
Footprint type	Desktop
Dimensions:	
Height	6.4 inches
Width	21.3 inches
Depth	17.3 inches
Weight	43 pounds
Environmental Specifications	
Power-supply output	192 watts
Worldwide (110/60, 220/50)	Yes
Auto-sensing/switching	No
Maximum current:	
90-137 VAC	5.0 amps
Operating range:	
Temperature	60–90 degrees F
Relative humidity	8–80 percent
Maximum operating altitude	7,000 feet
Heat (BTUs/hour)	1229
Noise (Average dB, operating, 1m)	42
FCC classification	Class B

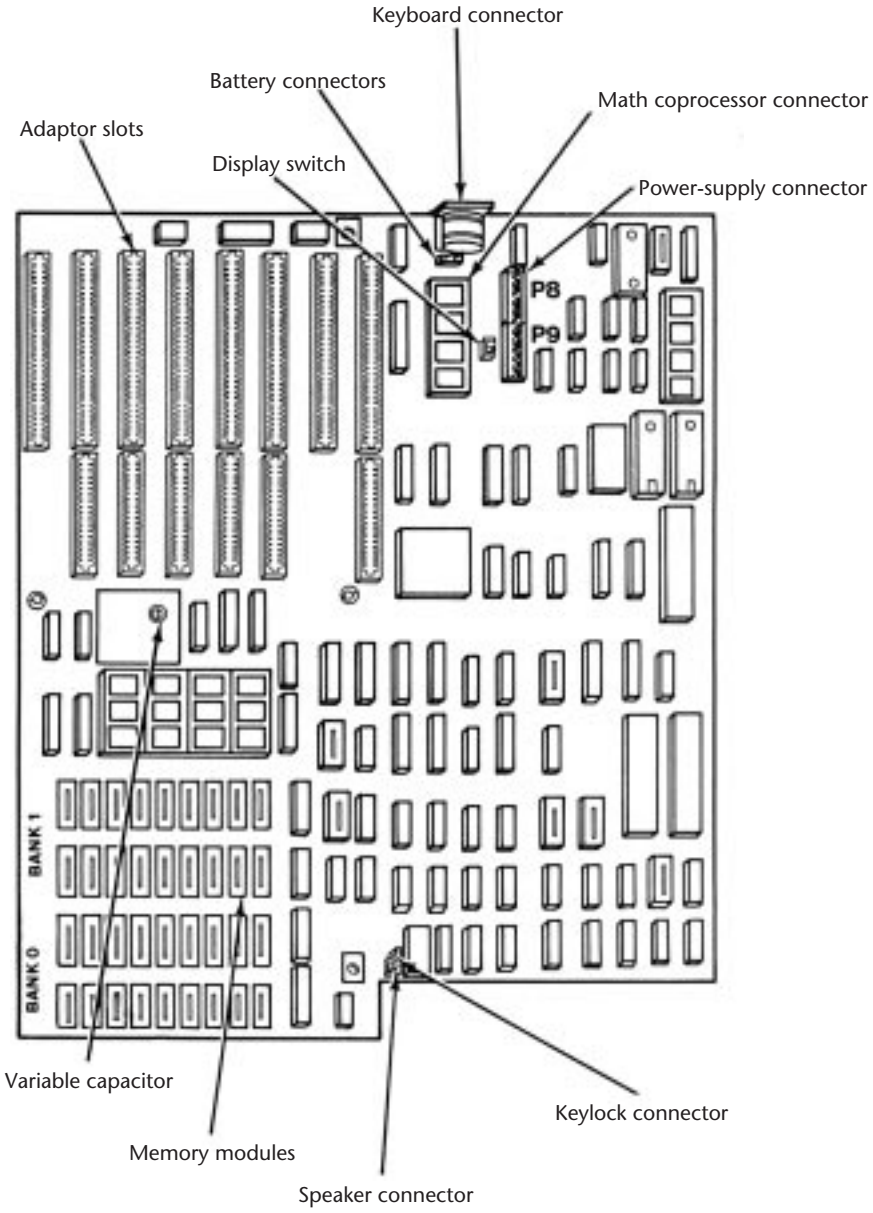

Fig. 21.11
The IBM AT Type 1 motherboard.

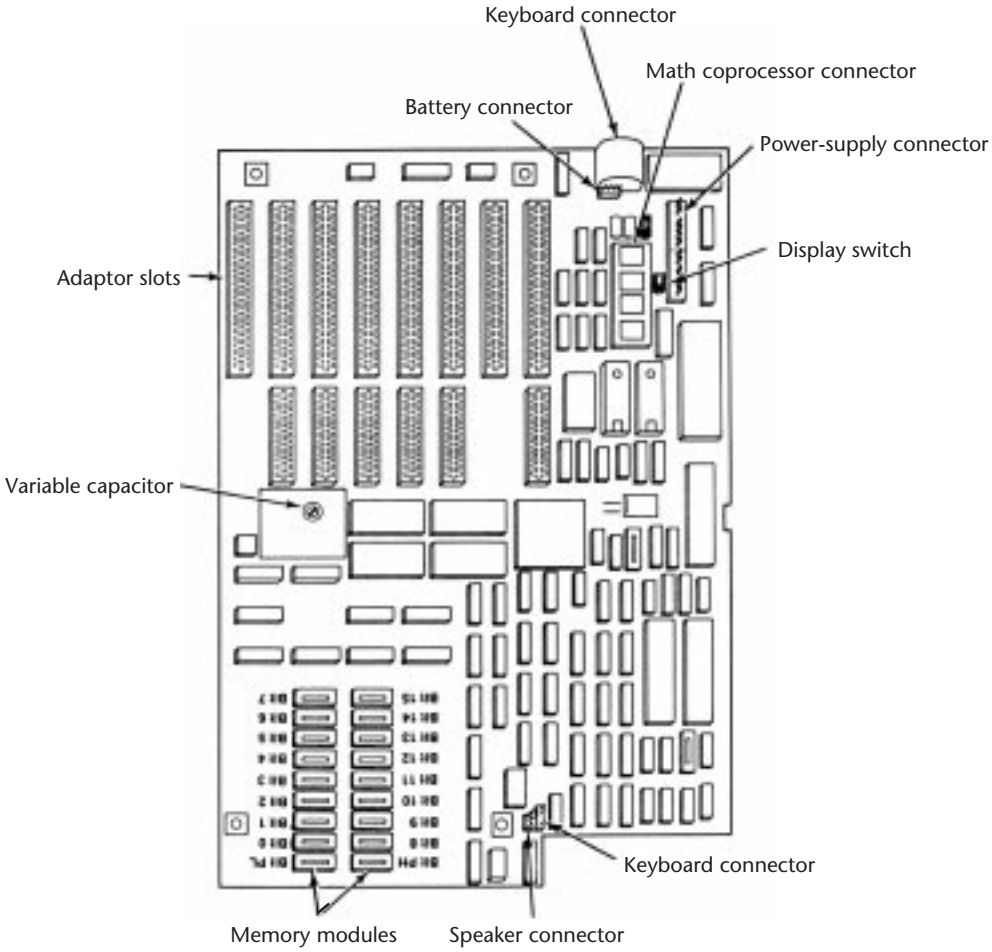

Fig. 21.12
The IBM AT Type 2 motherboard.

Table 21.8 shows the AT system-unit part-number information.

Table 21.8 IBM AT Model Part Numbers

Description	Number
AT 6 MHz/84-key keyboard, 256K:	
one 1.2M floppy drive	5170068
AT 6 MHz/84-key keyboard, 512K, serial/parallel:	
one 1.2M floppy drive, 20M hard disk	5170099
one 1.2M floppy drive, 30M hard disk	5170239
AT 8 MHz/84-key keyboard, 512K, serial/parallel:	
one 1.2M floppy drive, 30M hard disk	5170319
AT 8 MHz/101-key, 512K, serial/parallel:	
one 1.2M floppy drive, 30M hard disk	5170339

Description	Number
System Options	
20M fixed disk drive	6450205
30M fixed disk drive	6450210
30M fixed disk drive upgrade kit	6450468
360K half-height floppy disk drive (AT)	6450207
1.2M high-density drive	6450206
3 1/2-inch, half-height, 720K external drive (AT)	2683191
Serial/parallel adapter	6450215
80287 math coprocessor option	6450211
Floor-standing enclosure	6450218
Enhanced Keyboard Accessories	
Clear keycaps (60) with paper inserts	6341707
Blank light keycaps	1351710
Blank dark keycaps	1351728
Paper inserts (300)	6341704
Keycap-removal tools (6)	1351717

AT 3270

IBM announced the AT 3270 on June 18, 1985. This computer, basically the same as the original 3270 PC, is configured with an AT, rather than an XT, as the base. New software enhancements and adapter cards use the DOS memory space better than its predecessors and can place much of the Control Program in the extended-memory area, beyond the 1M boundary. Much of this capability comes from the *XMA card*, from IBM. Because much of the Control Program can reside in the area above 1M, DOS can find more room for applications software. Although this configuration doesn't eliminate the incompat-ibilities in the display hardware or keyboard, it at least makes available the memory needed to run an appli-cation.

The AT 3270 system has the same basic adapters as the standard 3270 PC. This system differs, however, in the capability of enabling the Control Program to reside in the memory space above 1M (*extended* memory), which doesn't exist on a standard PC or XT. IBM made several changes in the Control Program for this system and in special memory adapters, such as the XMA card. These changes enhanced the compatibility of the AT 3270 system over the original 3270 PC.

For more information about the AT 3270 system, refer to the section on the 3270 PC in this chapter.

The AT-370

The AT-370 is basically the same system as the XT-370 except for its use of an AT as the base unit. The same three custom processor boards that convert an XT into an XT-370 also plug into an AT. This system is at least two to three times faster than the XT version. The custom processor boards also were available as an upgrade for existing ATs. For a more complete description of this system, refer to the section "3270 PC Models and Features" earlier in this chapter.

An Introduction to the XT Model 286

On September 9, 1986, IBM introduced a new AT-type system disguised inside the chassis and case of an XT. This XT Model 286 system featured increased memory over its predecessors an Intel 80286 microprocessor, and as many as three internal drives standard. The computer combined an XT's cost-effectiveness, flexibility, and appearance with the high-speed, high-performance technology of the Intel 80286 microprocessor. This model looked like an XT, but underneath the cover, it was all AT.

The IBM XT Model 286 can operate as much as three times faster than earlier models of the XT in most applications. It has a standard 640K of memory. Various memory-expansion options enable users to increase its memory to 16M.

Standard features in this system include a half-height, 1.2M, 5 1/4-inch, high-density floppy disk drive; a 20M hard disk drive; a serial/parallel adapter card; and the IBM Enhanced Keyboard. You can select an optional, internal, second floppy disk drive from the following list:

- Half-height, 3 1/2-inch, 720K floppy drive
- Half-height, 3 1/2-inch, 1.44M floppy drive
- Half-height, 5 1/4-inch, 1.2M floppy drive
- Half-height, 5 1/4-inch, 360K floppy drive

The IBM XT Model 286's performance stems primarily from the AT motherboard design, with 16-bit I/O slots and an Intel 80286 processor running at 6 MHz. In addition to the type of processor used, clock speed and memory architecture are the primary factors in determining system performance. Depending on the model, the IBM AT's clock speed is 6 or 8 MHz, with one wait state; and the XT Model 286 processes data at 6 MHz, with zero wait states. The elimination of a wait state improves performance by increasing processing speed for system memory access. The zero-wait-state design makes the XT Model 286 definitely faster than the original AT models that ran at 6 MHz and about equal in speed to the 8 MHz AT systems. Based on tests, the XT Model 286 also is about three times faster than an actual XT.

Because the XT Model 286 is an AT-class system, the processor supports both real and protected modes. Operating in real address mode, the 80286 is 8088 compatible; therefore, you can use most software that runs on the standard PC systems. In real address

mode, the system can address as much as 1M of RAM. Protected mode provides a number of advanced features to facilitate multitasking operations. Protected mode provides separation and protection of programs and data in multitasking environments. In protected mode, the 80286 can address as much as 16M of real memory and 1 gigabyte of virtual memory. In this mode, the XT Model 286 can run advanced operating systems such as OS/2 and UNIX. When the XT Model 286 was introduced, it was the least-expensive IBM system capable of running a true multitasking operating system.

The IBM XT Model 286 has a standard 640K of RAM. Memory options enable the system to grow to 15 1/2M, much higher than the 640K limit in other PC XTs. If you add an operating system such as OS/2 or Windows, you can take advantage of the larger memory capacities that the XT Model 286 provides.

A 20M hard disk drive is a standard feature in the XT Model 286, as is a 5 1/4-inch, 1.2M, high-density floppy disk drive. A similar floppy disk drive is standard on all models of the AT. Floppy disks formatted on a 1.2M floppy disk drive therefore can be read by an AT or an XT Model 286. The 1.2M floppy disk drive also can read floppy disks formatted with PC-family members that use a 360K floppy disk drive. Figure 21.13 shows the interior of an XT 286 system unit.

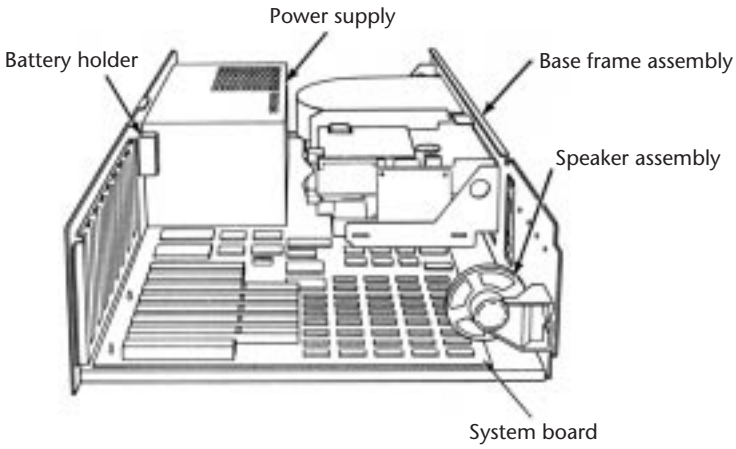

Fig. 21.13
The IBM XT Model 286 interior.

The XT Model 286 features the IBM Enhanced Keyboard with indicator lights. Many IBM personal computers use the Enhanced Keyboard, but the XT Model 286 was the first PC XT to feature keyboard indicator lights. The Caps Lock, Num Lock, and Scroll Lock lights remind users of keyboard status, which helps to prevent keyboard-entry errors.

The IBM XT Model 286 has eight I/O slots, to accommodate peripheral-device adapter cards and memory-expansion options. Five slots support the advanced 16-bit cards or 8-bit cards; three support only 8-bit cards. Two of the three 8-bit slots support only short cards.

A hard disk and floppy drive adapter card are standard features in the XT Model 286. This multifunction card takes only one 16-bit slot and supports as many as four disk drives (two floppy disk drives and two hard disk drives).

The serial/parallel adapter, another standard feature, is a combination card that requires only one slot (either type) and provides a serial and a parallel port. The parallel portion of the adapter has the capacity to attach devices, such as a parallel printer, that accept eight bits of parallel data. The fully programmable serial portion supports asynchronous communications from 50 bps to 9,600 bps, although even higher speeds are possible with the right software. The serial portion requires an optional serial-adapter cable or a serial-adapter connector. When one of these options is connected to the adapter, all the signals in a standard EIA RS-232C interface are available. You can use the serial port for interfacing a modem, a remote display terminal, a mouse, or other serial device. The XT Model 286 supports as many as two serial/parallel adapters.

A standard IBM XT Model 286 offers these features:

- 80286 processor at 6 MHz with 0 wait states
- 640K of motherboard memory
- 1.2M floppy drive
- 20M hard disk
- Five 16-bit and three 8-bit expansion slots
- Fixed disk/floppy disk drive adapter (occupies one 16-bit expansion slot)
- Serial/parallel adapter (occupies one 16-bit expansion slot)
- Enhanced Keyboard with indicator lights
- CMOS time-and-date clock with battery backup

XT Model 286 Models and Features

The XT Model 286 processor is as much as three times faster internally than the preceding XT family and as much as 25 percent faster than the AT Model 239, depending on specific applications. A 20M fixed disk and a 1.2M, 5 1/4-inch floppy disk drive were standard on the XT Model 286. One additional floppy disk drive can be installed internally as drive B. You can add as a second half-height floppy drive any type of floppy drive, including both the double and high-density versions of the 5 1/4- and 3 1/2-inch drives.

If you want to be able to read standard 5 1/4-inch data or program floppy disks created by the XT Model 286 on other PC systems, you might want to add a 5 1/4-inch 360K floppy disk drive, which provides full read/write compatibility with those systems. This is due to the fact that the 1.2M drives write a narrower track than the 360K drives, and are

unable to properly overwrite a floppy disk first written on by a 360K drive. If full read/write compatibility with 360K drives is not important, you can add a second 1.2M high-density floppy disk drive.

You can add any 3 1/2-inch drive, including the 720K and 1.44M versions. Because the 1.44M does not have any read/write compatibility problems with the 720K drives, however, and the 1.44M drives always can operate in 720K mode, I suggest adding only the 1.44M 3 1/2-inch drives rather than the 720K versions. The higher-density drive is only a small extra expense compared to the double-density version. Most people do not know that full ROM BIOS support for these 1.44M drives is provided in the XT Model 286. Unfortunately, because IBM never offered the 1.44M drive as an option, the supplied Setup program does not offer the 1.44M drive as a choice in the Setup routine. Instead you have to use one of the many available public domain AT type setup programs, or "borrow" such a program from an AT-compatible system.

XT Model 286 Technical Specifications

The technical information for the XT 286 system described in this section covers the system architecture, memory configurations and capacities, standard system features, disk storage, expansion slots, keyboard specifications, and also physical and environmental specifications. You can use this information to determine the parts you need when you are upgrading or repairing these systems. Figure 21.14 shows the layout and components on the XT 286 motherboard.

System Architecture	
Microprocessor	80286
Clock speed	6 MHz
Bus type	ISA (Industry Standard Architecture)
Bus width	16-bit
Interrupt levels	16
Type	Edge-triggered
Shareable	No
DMA channels	7
DMA burst mode supported	No
Bus masters supported	No
Upgradeable processor complex	No
Memory	
Standard on system board	640K
Maximum on system board	640K
Maximum total memory	16M
Memory speed (ns) and type	150ns dynamic RAM
System board memory-socket type	9-bit SIMM
Number of memory-module sockets	2

(continues)

Memory	
Memory used on system board	One bank of 4 64K×4-bit and 2 64K×1-bit DRAM parity chips, and one bank of 2 9-bit SIMMs
Memory cache controller	No
Wait states:	
System board	0
Adapter	1
Standard Features	
ROM size	64K
ROM shadowing	No
Optional math coprocessor	80287
Coprocessor speed	4.77 MHz
Standard graphics	None standard
RS232C serial ports	1
UART chip used	NS16450
Maximum speed (bits per second)	9,600 bps
Maximum number of ports supported	2
Pointing device (mouse) ports	None standard
Parallel printer ports	1
Bi-directional	Yes
Maximum number of ports supported	3
CMOS real-time clock (RTC)	Yes
CMOS RAM	64 bytes
Battery life	5 years
Disk Storage	
Internal disk and tape drive bays	1 full-height and 2 half-height
Number of 3 1/2-/5 1/4-inch bays	0/3
Standard floppy drives	1×1.2M
Optional floppy drives:	
5 1/4-inch 360K	Optional
5 1/4-inch 1.2M	Standard
3 1/2-inch 720K	Optional
3 1/2-inch 1.44M	Optional
3 1/2-inch 2.88M	No
Hard disk controller included:	ST-506/412 (Western Digital WD1003-WA2)
ST-506/412 hard disks available	20M
Drive form factor	5 1/4-inch
Drive interface	ST-506/412
Drive capacity	20M
Average access rate (ms)	65
Encoding scheme	MFM
BIOS drive type number	2
Cylinders	615

Disk Storage	
Heads	4
Sectors per track	17
Rotational speed (RPMs)	3600
Interleave factor	3:1
Data transfer rate (kilobytes/second)	170
Automatic head parking	No
Expansion Slots	
Total adapter slots	8
Number of long and short slots	6/2
Number of 8-/16-/32-bit slots	3/5/0
Available slots (with video)	5
Keyboard Specifications	
101-key Enhanced Keyboard	Yes
Fast keyboard speed setting	Yes
Keyboard cable length	6 feet
Physical Specifications	
Footprint type	Desktop
Dimensions:	
Height	5.5 inches
Width	19.5 inches
Depth	16.0 inches
Weight	28 pounds
Environmental Specifications	
Power-supply output	157 watts
Worldwide (110v/60Hz,220v/50Hz)	Yes
Auto-sensing/switching	Yes
Maximum current:	
90-137 VAC	4.5 amps
Operating range:	
Temperature	60–90 degrees F
Relative humidity	8–80 percent
Maximum operating altitude	7,000 feet
Heat (BTUs/hour)	824
Noise (Average dB, operating, 1m)	42
FCC classification	Class B

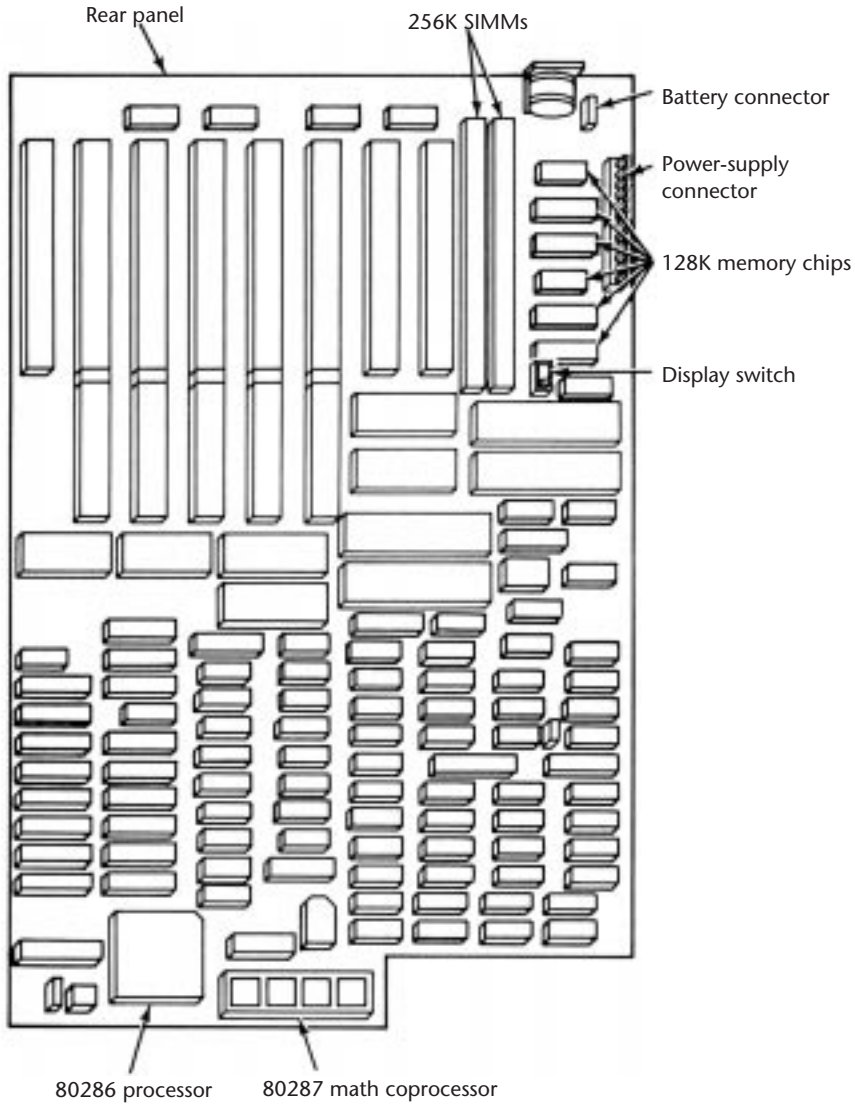

Fig. 21.14
The IBM XT 286 motherboard.

Table 21.9 lists the XT Model 286 system-unit part numbers.

Table 21.9 IBM XT-286 Model Part Numbers

Description	Number
XT Model 286 system unit, 6 MHz 0 wait state, 640K, serial/parallel, 1.2M floppy drive, one 20M hard disk	5162286

Description	Number
Optional Accessories	
5 1/4-inch, half-height 360K drive	6450325
3 1/4-inch, half-height 720K internal drive	6450258
3 1/2-inch, half-height 720K external drive	2683190
80287 math coprocessor option	6450211
Enhanced Keyboard Accessories	
Clear keycaps (60) with paper inserts	6341707
Blank light keycaps	1351710
Blank dark keycaps	1351728
Paper inserts (300)	6341704
Keycap removal tools (6)	1351717

Summary

This chapter examined all the systems that make up the original line of IBM personal computers. Although these systems have long since been discontinued, I am amazed to find many of these systems still in everyday use. From individuals to large corporations to the United States government, I regularly encounter many of these old systems in my training and consulting practice. Because these systems still are used, and probably will be for years, the information in this chapter is useful as a reference tool. Much of this information also is a sort of history lesson; it is easy to see how far IBM-compatible computing has come when you look over the specifications of these older systems!

The chapter described the makeup of all the versions or models of each system, as well as their technical details and specifications. Each system unit's main components also were listed. Each system's submodels were discussed, which should help you better understand the differences among systems that might look the same on the outside but differ internally.