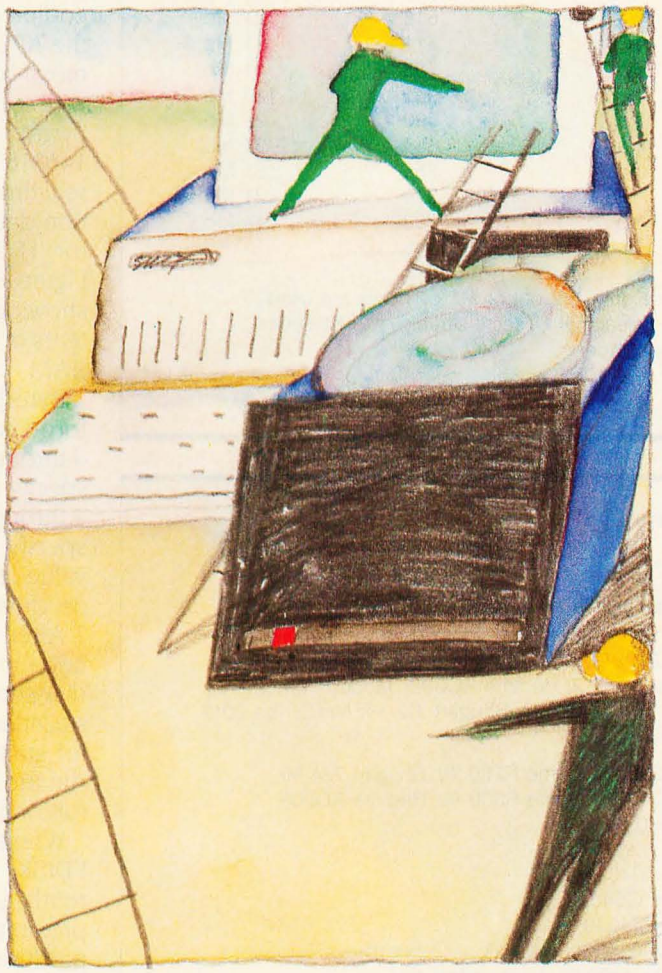
ADDING A HARD DISK TO YOUR PC AT

You can save money and get increased performance

BY JON SHIELL AND JOHN MARKOFF



THE IBM PC AT has rapidly become a new performance standard in the world of IBM and IBM-compatible personal computers. Because of the open-system philosophy of the IBM PC family, a thriving third-party industry has sprung up, offering both price and performance enhancements.

The PC AT comes in two models: the basic system without a hard disk and the enhanced system, which includes a hard disk, extra memory, and I/O (input/output) ports. It is possible to convert a basic model into an enhanced system merely by adding a third-party hard disk and multifunction board. Purchasing a hard disk independently can also offer cost savings and increased performance.

The multifunction card is particularly attractive for this application because of significant cost savings and increased system versatility. You can configure a PC AT with more than 8 megabytes of main memory. However, operating systems now available for the AT cannot productively use this memory. It is doubtful that even a 9-megahertz (MHz) PC AT can effectively use this much main memory. (See the text box "Crystal Change Enhances PC AT's Performance" on page 161.)

It is possible to put 230 megabytes of hard-disk storage on an 8-megabyte 9-MHz PC AT and reduce access time to half that of a factory-standard AT.

For most people, the best way to purchase a hard disk is in kit form. This precludes the necessity of hard-formatting the disk and generally simplifies the installation procedure. However, if you are scavenging a hard disk from another system or have bought a third-party product, you will need to obtain special mounting side rails and hard-format the disk (see the text box "Hard-Formatting a Disk Using the AT Advanced Diagnostics" on page 161).

Everything you need to know about physically installing and soft-formatting the disk is explained in the *AT Installation-and-Setup Manual*.

The first step is to determine the drive type. Refer to table 1 and table 2 and compare the parameters listed to the information supplied with your hard disk. Don't be surprised if you have to trim your disk to fit. Most kitted disks come with information about suggested drive types. IBM has predefined 14 types of disk drives (see table 1).

In addition, type 15 has been left open for user-defined drives. Table 2 shows disk-drive type numbers for some common hard disks. In some cases, the drive has been trimmed to fit by not using all available cylinders. It is also possible to trim a drive by not

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Table 1: *Definitions of predefined drive types.*

Disk type	Cylinders	Heads	Write precompensation	Landing zone (cylinder)	Capacity per drive	
1	306	4	128	305	10 Mb	
2	615	4	300	615	21 Mb	
3	615	6	300	615	31 Mb	
4	940	8	512	940	64 Mb	
5	940	6	512	940	48 Mb	
6	615	4	no	615	21 Mb	
7	462	8	256	511	31 Mb	$
8	733	5	no	733	31 Mb	
9	900	15	no	901	115 Mb	
10	820	3	no	820	21 Mb	
11	855	5	no	855	36 Mb	
12	855	7	no	855	51 Mb	
13	306	8	128	319	21 Mb	
14	733	7	no	733	44 Mb	

$ 4 megabytes unused because only 462 out of 511 cylinders are used
Capacity per drive = cylinders * heads * 17 sectors/track * 0.5 Kb/sector
(heads is the same as tracks/cylinder)

Table 2: *Sample drive-type definitions.*

Disk type	Capacity per drive	Examples of this drive type
1	10 Mb	Cogito CGF912; MMI M212 and M312; Seagate ST412, ST212, and ST112; Rodime RO202; Tandon TM252 and TM502; Fujitsu M2233; Shugart 712 %; MiniScribe 2012 and 3412
2	21 Mb	Tulin TL226 %, Qume R200 %, Shugart 724 %
3	31 Mb	Tulin TL240 %, Qume R300 %, Rodime RO206
4	64 Mb	Atasi 3080 %
5	48 Mb	
6	21 Mb	Seagate ST4026
7	31 Mb	Quantum Q540 %
8	31 Mb	Seagate ST4038
9	115 Mb	Maxtor XT-1140 %
10	21 Mb	Micropolis 1302 %, Vertex V130 #%
11	36 Mb	Vertex V150 #%
12	51 Mb	Vertex V170 #%
13	21 Mb	Seagate ST425, MMI M225 and M312, Rodime RO204, Fujitsu M2235
14	44 Mb	

% Not all cylinders used; to use all you must define it as a type 15
# The Vertex drives are an extreme case of trimming to fit, as they actually have 987 cylinders, so only 83 percent of the V130 and 87 percent of the V150 and V170 are used

using all read/write heads, but this tends to be especially wasteful. Using only five out of six heads wastes about 17 percent of the drive's capacity.

After the disk is physically installed, use the AT diagnostic disk-setup option to set the drive-type nybble in the configuration RAM (random-access read/write memory). Unlike the PC and the XT, which use switches to tell the BIOS (basic input/output system)/DOS (disk operating system) what equipment is attached to the system, the AT uses a CMOS (complementary metal-oxide semiconductor) RAM with a battery backup. The RAM (50 bytes) is contained in a Motorola 146818 chip, which also contains a real-time clock. The RAM-configuration-data format and typical entries for 11 drives are given in table 3. Figure 1 is the CMOS RAM map, showing the address offset and contents of each byte in the configuration RAM.

Byte 12 holds the fixed-disk-type information for the C and D drives. Bits 0 through 3 (single hexadecimal digit) specify the drive type for drive C. Bits 4 through 7 (single hexadecimal digit) specify the drive type for drive D. A value of 0 hexadecimal indicates that no drive is present.

After the configuration RAM has been modified (using the diagnostic disk-setup option), complete the installation using the normal procedure for standard IBM fixed disks. Simply run the FDISK and Format programs, following IBM's instructions.

When partitioning your disk with FDISK, keep in mind that DOS currently supports a maximum of approximately 64K sectors per disk or partition. This requires that disks larger than 32 megabytes be split into a number of 32-megabyte partitions. Most kits for these large disks contain the software required to allow use of more than one active—but only one bootable—partition. Table 3a, for use with FDISK, shows the relationship between number of data heads, number of sectors per cylinder, and maximum number of cylinders allowed for 64K-sector DOS partitioning. Table 4

(*continued*)

Crystal Change Enhances PC AT's Performance

Changing the timing crystal voids the warranty! You should not change the crystal before the machine has had time to shake down for at least 90 days.

The speed of your PC AT is controlled by the crystal that determines the clock rate of the 80286 processor and its support chips. This clock rate is half of the crystal's frequency (the standard 12-MHz crystal gives a clock rate of 6 MHz).

Table A is a list of the common crystal frequencies and the clock rates they yield.

You should have a number of crystals with different frequencies because some ATs run faster than others. The ones we tested varied between 8 MHz and 9.8 MHz.

Your clock crystal should be tested with all add-on and multifunction boards present. Some high-performance multifunction boards will run at speeds of 8 MHz or higher, so test your system fully configured to be sure.

Table A: *Crystal frequencies and clock rates for the* PC AT.

Crystal frequencies (MHz)	Clock rate (approx., MHz)
12.0000	6.00
14.3181	7.16
15.0000	7.50
16.0000	8.00
18.4320	9.22
19.6608	9.83
20.0000	10.00

Crystals are available at most major electronics supply houses for less than $5 each. The ones we used were from Nymph and BME and had HC-18 cases.

The Nymph crystals had long, thin leads that needed to be trimmed.

To change the crystal:

1. Turn the machine off and unplug it.
2. Remove the cover and locate the 12-MHz crystal on the motherboard. It's above and to the left of the 80286 chip as you look from the front of the machine. Before removing the old crystal, touch the chassis to ground yourself. Use a thin flat-bladed screwdriver to remove the old crystal (be sure that you don't damage any traces on the motherboard).
3. Insert the new crystal (save the old 12-MHz crystal). Which side of the crystal is face up doesn't matter.
4. Close the cover and give it a try.

Try the fastest crystal first; if the crystal is too fast, the machine will not show the memory check or boot. In some borderline cases the machine will run fine after it has warmed up, but it may need to be rebooted first. Try each crystal starting with a cold machine.

Hard-Formatting a Disk Using the AT Advanced Diagnostics

Before beginning, note that the disk type must have been set in the configuration RAM prior to hard-formatting.

If you get a 17XX error when the system powers up or resets, press the F1 button to continue.

Enter the fixed-disk test menu and do an unconditional format by selecting the following:

1. System-checkout routine (option 0): Enter "y" if the options list is correct; otherwise, go back to setup and correct the list.
2. Run tests one at a time (option 0).
3. Test fixed-disk drive (option 17): If at this point another menu is not displayed, but instead the test begins, you know that you are not using the advanced diagnostics.
4. Select format menu and drive letter (options 7,c or 7,d).
5. Select unconditional format (option 2).

The current screen should ask you to enter the known flaws. A list of known flaws is printed on a label on the top of all hard disks. The list contains the cylinder, head number, and byte offset from the index, but you need enter only the cylinder and head numbers. After you have entered all the flaws listed on the top of the drive, press "y" to format the disk.

You now have a hard-formatted disk. Enter 9s to get back to the main menu. The next step is to run FDISK, then the normal format program on the DOS partition.

Offset	Contents
00	Seconds
01	Second alarm
02	Minutes
03	Minute alarm
04	Hours
05	Hour alarm
06	Day of the week
07	Day of the month
08	Month
09	Year
0A	Status register A
0B	Status register B
0C	Status register C
0D	Status register D
0E	Diagnostic status byte
0F	Shutdown status byte
10	Disk-drive type for drives A and B
11	Reserved
12	Fixed-disk-drive type for drives C and D
13	Reserved
14	Equipment byte (corresponds to switch 1 on PC and XT)
15–16	Base memory size (low,high)
17–18	Expansion memory size (low,high)
19–20	Reserved
21–2D	Reserved (not checksumed)
2E–2F	Checksum over bytes 10 through 20 (low,high)
30–31	Expansion memory size as determined by power-on routine (low,high)
32	Date century byte
33	Information flags (set during power-on)
34–3F	Reserved

The Alarm function is used by the operating system/BIOS to drive the Wait function, INT15h ah = 90h

The drive-type bytes use bits 0:3 for the first drive and 4:7 for the other

Disk-drive types:

0	No drive present
1	Double-sided disk (360 Kb)
2	High-capacity disk (1.2 Mb)
3–F	Reserved

The equipment byte is used to define the configuration for the power-on diagnostics

Base memory is all memory below the 1-megabyte line, the range is 256 Kb to 640 Kb

Expansion memory is all memory above (at) the 1-megabyte line, range between 0 (none) and 15 Mb, although you can currently get only to 3 Mb with 64K-byte RAMs without using an expansion chassis (which doesn't currently exist)

Bytes 00–0Dh are defined by the chip for timing functions, and 0E–3F are defined by IBM

To access the configuration RAM:

1) Write the byte address (00–3F) you want to access to I/O port 70h
2) Access (read/write) the data via I/O port 71h

Figure 1: CMOS RAM *map*.

Table 3: *Sample drive-type entries, for use as type-15 disks.*

Byte	MMI M206	Tandon TM503	Tandon TM703	Quantum Q540	Vertex V170	MiniScribe 6085	Micropolis 1324	Micropolis 1325	Maxtor XT-1105	Maxtor XT-1140	Largest defined disk	
	5 Mb	15 Mb	30 Mb	35 Mb	59 Mb	71 Mb	52 Mb	70 Mb	85 Mb	117 Mb	139 Mb	Disk capacity
0	306	306	695	512	987	1024	1024	1024	918	918	1024	Number of cyl.
2	2	6	5	8	7	8	6	8	11	15	16	Number of heads
3	0	0	0	0	0	0	0	0	0	0	0	Not used
5	0	128	0	0	0	0	0 *	0 *	0	0	0 *	Write precomp.
7	0	0	0	0	0	0	0	0	0	0	0	Not used
8	0	0	0	256	0	0	0	0	8	8	8	Control byte
9	0	0	0	0	0	0	0	0	0	0	0	Not used
12	306	306	695	512	987	1024	1024	1024	918	918	1024	Landing zone
14	17	17	17	17	17	17	17	17	17	17	17	Sectors/track
15	0	0	0	0	0	0	0	0	0	0	0	Not defined

The TM503 is a "generic 15-megabyte hard disk"; many other disks, like the Seagate ST419, would also use this setup
The Maxtor XT-1140 appears here to show how it would be defined for maximum capacity
Largest defined disk is the largest (highest-capacity) disk that can be defined under the PC AT BIOS; a dedicated servo is assumed
Write precompensation depends on the actual drive used; an asterisk by a 0 write precompensation means that a dedicated servo is used and has a whole platter instead of just one side dedicated to it (thus the even number of data heads)

```
Offset
  0   Number of cylinders on the drive      [0–1023 allowed, for 1024 cyl.]
  2   Number of heads per drive             [0–15 allowed, for 16 heads]
  3   -n/u  (starting reduced write current cyl. on PC XT)
  5   Starting cylinder for write precompensation
  7   -n/u  (maximum ECC data-burst length on PC XT) {recheck not used}
  8   Control byte
        Bit
         7     Disable disk-access retries
         6     Disable ECC retries
        5-4    -n/d  (zero)
         3     More than eight heads
        2-0    -n/u  (drive option on PC XT)
  9   -n/u  (time-out values on PC XT)
 12   Landing zone, cylinder to use as a
 14   Number of sectors/track [0–17 allowed, 17 is the IBM standard]
 15   -n/d

-n/u   Field not used by PC AT
-n/d   Field reserved for future use
```

Figure 2: *Format of a drive-type entry.*

Table 3a: *Disk-partitioning data, for use with* FDISK.

Number of data heads	Number of sectors per cylinder	Maximum number of cylinders allowed in a 64K-sector DOS partition
3	51	1024
4	68	936
5	85	771
6	102	642
7	119	550
8	136	481
9	153	428
10	170	385
11	187	350
12	204	321
13	221	296
14	238	275
15	255	257
16	272	240

(continued)

Table 4: *Comparison of drive performance.*

	PC XT	Seagate ST425	PC AT	Qume R300	Quantum Q540	Tandon TM703	Vertex V170	MiniScribe 6085	Maxtor XT-1140
Type	1	13	2	3	7	15	15	15	9
Disk capacity	10 Mb	20 Mb	20 Mb	31 Mb	31 Mb	30 Mb	59 Mb	71 Mb	115 Mb
Number of cyl.	306	306	615	615	462	695	987	1024	900
Number of heads	4	8	4	6	8	5	7	8	15
Cyl. capacity	34 Kb	68 Kb	34 Kb	50 Kb	68 Kb	42.5 Kb	58.5 Kb	68 Kb	127.5 Kb
Access times $									
Track to track	16 ms	23 ms	14 ms	19 ms	10 ms	5 ms	5 ms	3 ms	5 ms
Mean	85 ms	65 ms	52 ms	93 ms	45 ms	45 ms	30 ms	30 ms	30 ms
Maximum	205 ms	170 ms	97 ms	213 ms	80 ms	65 ms	65 ms	50 ms	48 ms

$ Access times include head-settling time; average latency for all of the above disks is 8.33 ms
The access times for the XT are based on the Seagate ST412
The access times for the Maxtor XT-1105 are the same as those of the XT-1140

RANDOM NOTES

Jumper J18 remaps the second 256K bytes of memory from the system board into the I/O channel, so that non-IBM expansion boards can be used. Thus, you don't need to buy the 256K-byte motherboard RAM option if you buy a minimum system. We used a Sigma Designs 512K-byte (with 384K bytes enabled) multifunction card, scavenged from a PC, in our AT until we could get a 16-bit AT version.

You can't use 64K- or 256K-byte RAMs in the AT motherboard because the pin-outs of the 128K-byte DRAMs are different from industry standards (see table B).

You can add ROM to the AT motherboard in sockets U17 and U37. It appears at address E0000 to EFFFF hexadecimal. The ROM must have the same header as an I/O channel ROM except that byte 2 (ROM length) is not used.

The two 8-bit slots on the AT are wired for the addition of the 36-pin extended connectors.

Table B: *Pin-outs for standard* DRAMs *versus* IBM 128K-*byte* DRAMs.

Standard 64K/256K signal name	PC AT 128K*	Pin number
N/C	Din	1
Din	WE	2
WE	*RAS1	3
RAS	*RAS0	4
A0	A0	5
A2	A2	6
A1	A1	7
PWR	PWR	8
A7	A7	9
A5	A5	10
A4	A4	11
A3	A3	12
A6	A6	13
Dout	Dout	14
CAS	CAS	15
GND	GND	16

* IBM 128K-byte DRAMs are actually two 64K-byte dies encapsulated in piggyback fashion. One die is connected to RAS0, and the other is connected to RAS1. Otherwise, they are the same.

shows the relative performance characteristics of some popular drives.

You can define your own drive types; for example, you may want to add your old 5-megabyte drive, left over from your PC, as the second hard disk (drive D, fixed disk 1).

You must first build a drive-type entry like the sample shown in table 3. Place the address of the drive-type entry in INT 46 hexadecimal (at address 0:118 hexadecimal).

Using the setup program on your PC AT diagnostic disk, change the fixed-disk-type nybble in the configuration RAM to 15 hexadecimal. This tells the system that your disk is a type 15. See figure 1 for a complete definition of the configuration-RAM contents. Figure 2 shows the format of a drive-type entry. ■