

# 5 Storage

**If you're like most computer users,** you aren't much more interested in computer storage than in bookcases. After all, hard disks, floppies, CD-ROM drives, and tape backup units don't actually do much—they just provide a place to leave the files you've created and collected when you're not using them.

In fact, nothing is more critical to the performance and reliability of your computer system than your storage devices. If your drive is slow, you'll be staring at the wristwatch pointer and twiddling your thumbs when you should be working or having fun. If your hard disk crashes, you could lose hours or years of your work, and if you haven't taken the necessary precautions, you may never get those files back. Problems like those can make you rue the day you ever heard of high technology.

No one can guarantee you'll never have such hassles. In this chapter, we provide background information and tips that will help you understand how storage devices work; show you what to look for when purchasing a new drive; and show you how to manage your devices effectively.

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## How Disks Work

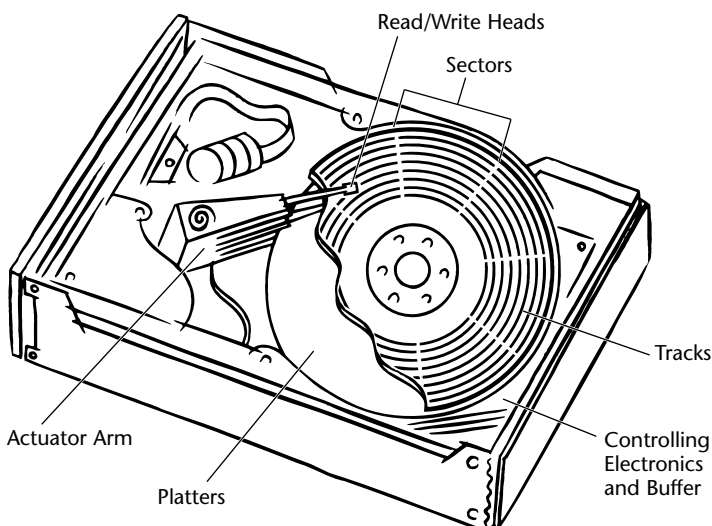
The most common Mac storage technologies, including *hard disks*, floppies, tape, and most other removable media, are magnetic; bits of data are recorded by changing the magnetic polarity of small areas on the surface of the storage media.

### Comparing Floppy and Hard Disks

(AN/SZA/RS/Susan McCallister/HN/JC)

Magnetic media consists of an iron-oxide coating (more commonly known as rust), that is adhered to a foundation layer. In the case of floppy disks, the foundation layer is...well...floppy. It's a flexible plastic similar to recording tape, only slightly more durable. The disk itself is housed inside a rectangular, hard plastic shell to protect it from damage.

With hard disks, the foundation material is usually made of aluminum that is manufactured as a hard disk (hence the name hard disk drive). Typically, a drive has



*Inside a hard disk mechanism. The platters are stacked on a spindle that spins rapidly as the read/write heads, attached to the actuator arm, move back and forth.*

several separate hard disks, or *platters*, that are stacked on top of each other on a center spindle with a motor attached that spins them rapidly.

On hard disks and floppies, read/write heads store data by giving bits of the iron-oxide coating a positive or negative magnetic charge, corresponding to the 1's and 0's of digital data; they read the data by checking to see what the charges are.

Modern floppy drives have heads that read and write data on both sides of the media.

Hard disks have a pair of read/write heads for each platter. The heads are mounted on arms in much the same way that needles are mounted on the tone arms of record turntables, and move rapidly in toward the center and out toward the edge as the platters spin.

Floppy drives rotate the disk at 300 rpm; in a hard disk the platters spin at speeds ranging from 3,600 rpm to 7,200 rpm. While the read/write heads of floppy disk drives actually touch the disk, in hard disks they float over the platters on a cushion of air at a distance less than the width of a human hair. The tolerance is so fine that the hard disk housing is sealed to prevent dust from getting in. Even the tiniest speck of dust could cause serious damage if it came in contact with the read/write heads.

Macintosh hard disks, whether internal or external, have a printed circuit board that contains the electronics that control the drive and manage its communications with the Mac. External drives also include a fan, connectors, a power supply, and of course, the outer case.

In recent years, several technologies that use light as well as magnetism in the process of reading and writing data have become common on the Mac. (For a description of how they work, see [“Removable Media”](#) and [“CD-ROM,”](#) later in this chapter.)

## Formatting and Initializing Disks

(JC)

To keep track of the files you store on a disk, the Macintosh uses its own filing method known as the Hierarchical File System (HFS). Every type of storage media that is used on the Mac must be formatted (sometimes called *initializing*) to set up the filing system and keep track of stored data.

A *hard disk formatter* is required to *format* hard disks and removable media. Typically new hard disks are preformatted by vendors so they can be used right out of the box.

The process of formatting a disk breaks down roughly into three steps: There is the actual formatting which erases the entire surface of the disk, maps out any bad blocks that cannot reliably store data, and creates *tracks* (concentric rings that run around the disk) and *sectors* (small sections that divide the tracks). The next step is the installation of the disk driver so the Macintosh can communicate with the newly formatted drive. Last is initialization which creates the HFS partitions that will be used to store the data.

## Disk Drivers

(JC)

One of the most important elements on a hard disk is software known as the *disk driver*. It is an invisible program that is written to a hard disk or removable cartridge when it is formatted or initialized. The disk driver on your hard disk is loaded into the Mac's memory whenever you start up—it mounts the hard disk on the desktop and displays its icon.

Disk drivers are extremely important because they are used to transfer data between the Mac's memory and all storage devices. Anytime you open or save a file, the driver is used to transfer the data.



Upgrading a disk driver is important when moving up to a new Macintosh, changing operating systems, or adding new storage devices. To upgrade disk drivers you must use a hard disk formatter.

## Hard Disk Formatters

(JC)

A hard disk formatter isn't something you'll need to use every day but you should keep a copy around on a floppy disk. Besides formatting and initializing, formatters can test the media and map out *bad blocks*. They can usually install a new disk driver without reformatting a drive or losing data. In addition, formatters can divide a disk into sections called partitions that help organize files and use space more effectively. (We'll explore partitioning in "Getting the Most Out of Your Hard Disk," later in this chapter.)



Several companies publish universal hard disk formatters that work with virtually every kind of drive and most removable media. The best of the formatter crop are FWB's **Hard Disk ToolKit** (\$200) and **Hard Disk ToolKit Personal Edition** (\$80), La Cie's **Silverlining** (\$150), CharisMac's **Anubis** (\$130), and Casa Blanca Works' **Drive7** (\$80). All of these programs offer very reliable disk drivers and are updated regularly by their publishers whenever new system software or storage devices are introduced.

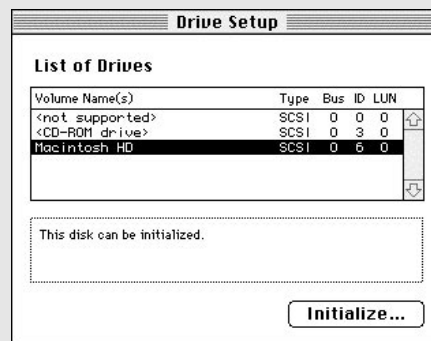
### Apple's Hard Disk Formatters

(JC)

Apple includes its own hard disk formatter on the Disk Tools disk included with the set of System 7 installer floppies or on CD-ROM.

Apple's **HD SC Setup** program is used for all Apple hard disks except those installed in Power Macs and Macs with *IDE* hard disks (see the sidebar "A Look at Macintosh IDE Drives," later in this chapter. **Drive Setup** works for both Power Macs and IDE hard disks. It is the first Apple formatter that can partition a hard disk.

Apple's formatters only work on "Apple drives" which are drives specifically installed by Apple, that have an Apple logo sticker attached, and that come with your Macintosh as original equipment.



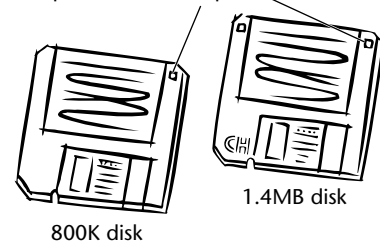
## Dealing With Floppy Disks

Almost everyone has to deal with *floppies* sometime. New software usually comes on floppies, and they remain a convenient medium for moving files between your computer and someone else's.

### 400K, 800K, and 1.4MB Disks (HN/JC)

The earliest Macs had single-sided 400K *floppy* drives. The second generation, starting with the Mac Plus, used double-sided, double-density disks, with a capacity of up to 800K. In 1988 Apple introduced the SuperDrive, a drive that can read and write 1.4MB high-density disks, 800K disks, and 720K or 1.4MB disks formatted for PCs.

You can lock a floppy disk by flipping the tab up so the hole is open.



1.4MB floppy disks have two square holes and the letters "HD" on the plastic case.

### Formatting Floppy Disks

(SZA/AN/RS/HN/JC)

The first time you insert a new floppy disk into your drive, you'll get a dialog box that reads, "This disk is unreadable: Do you want to initialize it?" If you click Initialize, you'll get a series of dialog boxes leading you through the process.

You can save a little time if you purchase Macintosh preformatted floppy disks. They often cost a dollar or two more but you won't have to go through the initialization process, waiting around staring at your screen. If you buy preformatted floppies be sure they specifically say "Macintosh" (not IBM PC). Otherwise you'll have to initialize as usual and have spent the extra money for nothing.



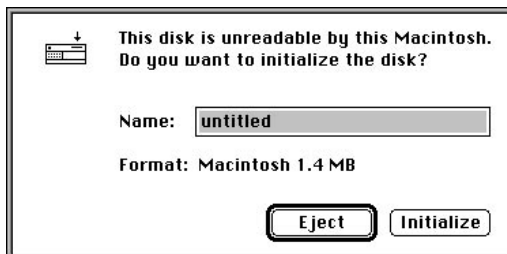
HOT TIP

Sometimes when you insert a floppy that you know is already formatted, you get the same dialog box or one that begins, "This is not a Macintosh disk." Several things can

cause this problem: The disk's directory may be damaged; the floppy drive may be dirty or out of alignment; or you may have inserted a high-density disk formatted for 1.4MB into an 800K drive. If the contents of the disk are important, click Eject and try the methods described in "Unreadable Floppies," in Chapter 7.



WARNING



To initialize or not? Think twice before you click Initialize. Any information already on the disk will be erased and data recovery utilities won't be able to retrieve anything.

## **Floppy Disk Safety Tips**

(SZA/RS/AN/HN/JC)

Get sloppy with your floppies and you and your data may unexpectedly part ways. Using the following safety tips will go a long way toward safeguarding your work.

### **Lock Your Floppy Disks**

When a floppy is locked, nothing can be written, changed, or trashed. To lock, or write-protect a disk simply slide the tab in the upper-right corner so the square hole is open. In the Finder, locked disks have a padlock in the upper-left corner of their directory windows.

### **Keep Floppy Disks Away From Magnetic Fields**

Floppy disks are susceptible to magnetic fields that can demagnetize the media. Magnetic fields are found in common office items including paper clip holders, radio and cassette player speakers, and telephone handsets.

### **Use the Erase Disk Command to Reinitialize**

Floppy disk media break down faster than other storage types so bad blocks (demagnetized areas) tend to appear more frequently. Using the Erase Disk command in the Special menu to reinitialize a floppy will reformat the disk and map out any bad blocks that may develop through constant use.

### **Use Virus Protection**

A good number of viruses are passed around by sharing floppy disks. Invest in a virus protection utility and configure it to scan floppy disks whenever they are inserted into the Macintosh.

### **Floppy Disk Jams**

When a floppy disk does not eject, try restarting your Mac while holding down the mouse button. Or, insert the end of an unfolded paper clip (use a heavy-duty one) into the small hole to the right of the disk slot until the disk pops out.

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## **Choosing a Hard Disk**

For several years all new Macs have had internal hard disks pre-installed, so buying a Mac means owning one of the drives Apple includes. Of course hard disks have a way of filling up fast, and many users find themselves in the market for a second drive, or a bigger replacement sooner than they anticipated.

With scores of vendors in the Mac storage business, each offering dozens of options, choosing a drive can be a daunting task. Fortunately, you have to go out of your way to buy a bad drive these days. If you shop from an established vendor and choose a mechanism from a well-known manufacturer, chances are you'll wind up satisfied.



## Capacity

(JC)

One of the first things to think about when buying a new hard disk is its capacity. This is the amount of storage space you will need for your current data and free space you need to expand for the future. First and foremost, purchase the largest capacity drive you can afford, especially if you work with graphics, databases, or sound files. Buying a hard disk with more space than you currently need is actually a good thing since you'll always need more.

The capacity of current new hard disks on the market start as small as 540MB and go as large as 9 gigabytes. For basic home or business use such as word processing or spreadsheets, an 840MB or 1 gig will do.

When looking at the capacity of a new hard disk, keep in mind that some areas of the disk are used for directories and the disk driver so you never get to use the entire capacity of the drive. It's not uncommon to lose about five percent of the drive's total capacity when it is formatted. The larger the drive, the more directory space needed, so the percentage of lost space may be even higher.

Because drive manufacturers have no common way of expressing drive capacity, ask your vendor if the capacity listed is for a formatted or unformatted drive.



## Sizes and Shapes

(HN/JC)

Drives are commonly categorized by two physical dimensions: the diameter of the platters inside and the height of the whole sealed mechanism. Known as the *form factor*, these dimensions are the basis for size standards that make units from different manufacturers interchangeable.

There are five different form factors: Full Height 5.25-inch; Half Height 5.25-inch; Half Height 3.5-inch; Low Profile 3.5-inch; and Low Profile 2.5-inch.

Most modern hard disks are 3.5-inch Low Profile models that are only 1 inch high and can be used in virtually any Mac. Removable-cartridge devices such as CD-ROM and SyQuest drives are Half Height 5.25-inch devices.

## Internal versus External Hard Disks

(AN/RS/HN/JC)

An *external drive* is one that comes in its own box and plugs into the Macintosh via a SCSI cable. An internal hard disk is one that's mounted inside the Mac itself. Internal drives use the Mac's fan and power supply, so they're typically about \$100 cheaper than the equivalent external hard disk.



HOT TIP

There are a few advantages to external drives. Servicing or replacing an internal drive requires opening the computer or taking the Mac to a dealer. If you are going to work at different Macs from time to time, it's easier to bring an external drive than the whole Mac. Later, if you trade in your Mac for a newer model, it's also easier to connect an external drive to the new computer.

## Drive Performance

(HN/JC)

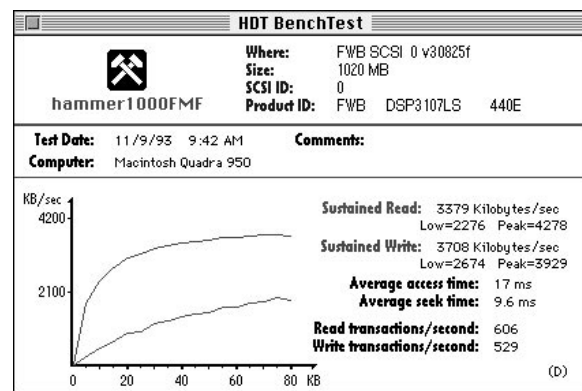
There's no single index for measuring the performance of hard disks. If you care about maximum speed, you need to pay attention to several variables and weigh them differently depending on your Mac and what you do with it.

**Seek and access times.** The simplest variable is *average seek time* or *average access time*. Both are measured in milliseconds (thousandths of a second, abbreviated ms). Technically, average seek time is how long it takes the heads to move to the desired track; nowadays, it's usually somewhere between 8 and 20 ms. Average access time is the sum of that figure plus an additional, smaller amount (normally about 6 or 8 ms) for *latency*, the average wait for the desired sector to come around under the heads once they get to the right track.

Unfortunately, many vendors are sloppy and inconsistent in their use of these terms; some will even tell you they mean the same thing. If milliseconds matter to you, be sure you're using the same standard when comparing products: A drive with an average access time of 15 ms is actually faster than one with an average seek time of 12 ms.

**Throughput or transfer rate.** The *data transfer rate* is a measure of how fast a drive can deliver data to the Mac once it gets to the sectors it's looking for. The transfer rate is counted in megabytes per second (or sometimes, just to confuse things, megabits per second). Today's drives have transfer rates of between 1.5 and 5MB per second.

If you deal mostly with small files or database records, transfer rate is less important than seek or access time, because your drive will spend more time getting to the data you need than transferring it to the Mac. When you open a letter created in Word, say, or look up a customer's record in a FileMaker database, you don't read in large



Curious about hard disk performance? Chart your drive's statistics with HDT BenchTest, part of FWB's Hard Disk Toolkit.

amounts of data, so even large differences in actual transfer rate have negligible consequences. But if you work with large scanned images in Adobe Photoshop, for example, or big QuarkXPress layouts, or giant QuickTime files, transfers actually take whole seconds, so differences in the transfer rate matter—much more than a difference of a few thousandths of a second in seek or access time.

There's also a difference between *burst transfer rates* and *sustained transfer rates*. The former measures how fast a drive can pump out a small amount of data loaded into memory buffers on the drive controller; the latter is how fast it can deliver larger amounts, even after the buffers are empty. Burst rates are much higher, so some vendors focus on those, but for most purposes the sustained rate is more important.

And no matter how fast your drive can deliver data, it won't do you much good unless your Mac can receive the information at the same speed. The SCSI ports on most pre-Quadra Macs couldn't handle more than about 1 to 1.5MB per second, so drives with faster transfer capabilities didn't do much good. Centris/Quadra and Power Mac models have improved SCSI systems that can handle about 5MB per second. Dual SCSI channel Power Mac models such as the 7500, 8500, and 9500 have an internal bus capable of 10MB per second. So drives that are slower than the Mac's data transfer speed can be a bottleneck.

**Spindle speed.** The standard *spindle speed*—the rate at which a hard disk's platters rotate—used to be 3,600 rpm. In the last few years drive manufacturers have begun delivering drives that spin at 4,500, 5,400, even 7,200 rpm. The extra rotation speed reduces latency, but its main value is to boost sustained transfer rates: The faster the disks are spinning, the faster the drive should be able to read in all the data it's after. You'll notice the difference mainly with big files.

**Reliability.** No matter how fast a drive may be, you don't want it if it's not reliable. Fortunately, today's hard disks are less likely to experience hardware failures than those built a few years back.

Drive manufacturers measure the durability of their drives in terms of *mean time between failures*, or MTBF—the number of average power-on hours a drive will last before some component gives out. For most new drives the figure runs around 200,000 hours to 800,000 hours.

Now, 200,000 hours works out to almost 23 years and 800,000 hours to more than 91 years, so these claims are not based on actual field experience—they're derived by running a bunch of drives simultaneously in a lab and somehow extrapolating from the rate of breakdown during the test period.

## ***A Look at Macintosh IDE Drives***

(KD)

Years ago, Apple pioneered ease-of-use by including a SCSI bus on all its computers. In recent years it has deviated from this technology by including Integrated Drive Electronics or IDE drives in a few models.

IDE drives have long been the standard on PC and Windows machines and they have a few advantages. They are slightly cheaper and easier to find, especially 2.5-inch drives for PowerBooks.

Apple isn't dodging its commitment to SCSI. All Macintoshes will continue to have an external SCSI bus connection. IDE drives will only come internally, and support only one drive.

Apple is using IDE drives in models it doesn't expect users to typically open themselves. This includes new PowerBooks, starting with the PowerBook 150 and 190, and the Duo 2300, and 5300 series; also some of the lower end Macs and their Performa cousins including the Quadra 630, LC 630, and Power Mac 5200 series.

IDE has a reputation for being slower, but in fact having a single drive on the bus gives it a performance advantage. In most respects IDE drives work and feel just like SCSI drives. The only exception is that some older disk utilities may not see the drive.

Still, MTBF probably means something, at least as an indicator of relative reliability, so it's worth considering when you are choosing a product. But try to supplement it with reviews in Mac publications and first-hand reports from users.

**Warranty.** Next to reliability, the length of time a drive is covered by warranty is extremely important. You can expect the warranty period to be at least one year for drives with a capacity of less than 500MB. One-gigabyte drives and larger tend to have longer warranty periods that can last as long as five years.

Should the drive mechanism or any components inside an external case fail (power supply, fan, and so on), the vendor will typically replace the drive at no charge. They will not, however, cover the cost to recover or re-create any data lost as a result of a drive failure, so be sure you back up religiously.

## **Choosing a Good Brand**

(HN)

Almost all storage vendors get their drive mechanisms from the same manufacturers: Quantum, Seagate, Conner, Maxtor, Micropolis, Fujitsu, and IBM. All of these manufacturers provide high-quality drives, so it may not appear to make much difference where you buy, and price may seem to be the only consideration. This simply isn't true.

Sure, the mechanism is the single most important variable in a storage product. But between two drives with the same mechanism, the bundled formatter and any additional utility software and, in the case of external drives, the quality of the other components, such as the fan, power supply, case, connectors, cables, and shielding, can make a huge difference in performance and reliability. Even if the hardware and software are identical, warranties, service, and support vary widely for each vendor.

## The Formatter and Disk Driver

(HN/JC)

Whether or not they ship their drives preformatted, nearly all Mac storage vendors include a formatting utility. For most users the formatter that comes with their drive is good enough. But the various packages do differ, in features as well as performance and reliability. Most formatters, for instance, let you partition a drive into separate volumes, but not all let you password-protect a volume.

The quality of the disk driver can also make a real difference in the performance you get out of a given disk. You can always upgrade your formatter if you don't like the one you got with your drive. (See [“Hard Disk Formatters,”](#) earlier in the chapter.)

## Recommended Drive Vendors

(HN/JC)

It's difficult to recommend specific mechanisms because they change so fast. But generally speaking, Quantum drives tend to be among the best in relatively low capacities (500MB or less); they're usually quick, quiet, and reliable. In the mid range (500MB to 1.2GB), Quantum and Seagate make good drives. At higher capacities, Seagate, with its Elite and Barracuda lines, has been the dominant supplier in the Mac market, but Quantum and Micropolis are coming on strong, and Fujitsu has its fans too. Many multimedia users recommend Micropolis's AV drives, which are specially designed to ensure good performance with long sound and video files.

As for vendors, two of the largest and most respected in the mail-order category are APS Technologies and La Cie. APS offers a wide variety of storage products and accessories, its prices are competitive, and its products are solid and well-made. It provides a toll-free support number, which is staffed by knowledgeable, friendly people. The company is celebrated for near-heroic feats of service and repair.

La Cie specializes in many types of storage devices including tape drives, removable-media devices, and other peripherals. Like APS, La Cie provides good prices, solid if not chart-topping performance, and attractive and innovative case designs. La Cie drives come with the excellent Silverlining formatter.



At the high end, MicroNet and FWB are regularly on the leading edge in performance. Both provide good technical support and update their formatters regularly.

There are many other fine companies in the Mac storage market, so don't take these as exclusive recommendations. Ask around, read the reviews, and check the ads that appear in various Mac publications. Just remember how dependent on your hard disk you're likely to become; buy from a vendor you have reason to believe is worthy of your trust, and hope the company doesn't change.

## Getting the Most Out of Your Hard Disk

Ordinarily, you shouldn't have to think about your hard disk—just turn it on and it should do its thing. But to get all the performance and capacity you paid for, you do need to pay some attention to setup and maintenance.

### The Interleave Ratio

(HN/JC)

Because older Macs couldn't digest data as fast as it could be read off a hard disk, you had to tell your formatting software to go through some special tricks to give the Mac a little time to catch up between each bit it read from the disk. This process was called setting the *interleave ratio*, or just the *interleave*.

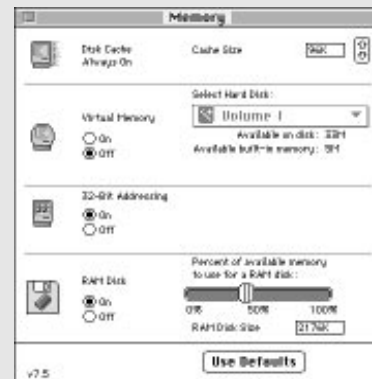
Using an interleave of 3:1, for example, allows the Macintosh to skip over two sectors and read every third sector on the disk. This gives the Macintosh enough time to swallow the data before the next sector passes underneath the read/write head.

### Setting the Disk Cache

(JC)

You can get a slight boost in your Mac's performance by setting the Disk Cache in the System 7 Memory control panel. The Disk Cache sets aside a portion of the Mac's memory to store directories and commands. This helps the Mac run faster because data held in the cache doesn't have to be read repeatedly from the hard disk.

The rule of thumb for setting the correct cache size is 32K for each megabyte of RAM installed in your Mac. The Memory control panel in System 7 includes a Use Defaults button that sets the proper size for you based on the amount of RAM installed in the Mac.



The Memory control panel in System 7.5.

The Mac Plus required an interleave ratio of 3:1; for the SE, the Classic, and the PowerBook 100, the requisite ratio is 2:1.

All recent Macs however, have been able to handle a 1:1 ratio, which makes performance much better. An interleave of 1:1 means that every consecutive sector is read with no “digestion time” required.

Most formatters now suggest or automatically set the optimal ratio, so you shouldn't have to think about the issue at all—if you confront a choice, just leave it at 1:1 unless you're working with one of the earlier models mentioned.

## Partitioning Your Hard Disk

(HN/JC)

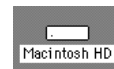
*Partitioning* means dividing a single physical disk into two or more logical volumes—separate sections that look to the Mac like completely separate disks. Partitioning allows you to minimize the amount of space a file uses on a drive and configure options that let you control access to specific data.

**Allocation block size.** The most popular reason to partition a drive is to reduce the *allocation block size*. This is basically the size of the blocks recorded on the media that are used to store your files.

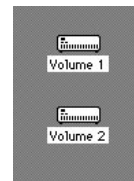
The allocation block size grows larger for every 32MB of hard disk capacity. On a drive that holds less than 60MB, each allocation block occupies 1K; on an 80MB drive, they're each 1.5K; on a 300MB drive, they're 5K each; and so on, all the way up to 32K on 2GB drives. The Mac permits only one file in an allocation block. So if the file is small but the allocation block is big, the rest of the allocation block goes to waste. Because partitioning a drive divides it into smaller volumes, each partition has its own smaller allocation blocks so small files use up less space.

**Partition sizes.** What's the optimal partition size? It all depends, but on my 1GB drive I usually don't make any volume smaller than about 200MB. If you make too many volumes, you'll have too many icons cluttering your desktop, and you are apt to run out of space on the individual volumes.

If your drive's capacity is 400MB or larger and you use your Mac for mostly small files such as text or spreadsheets, you could be wasting space if you don't partition. If your drive is smaller than, say, 300MB, the space savings probably won't justify partitioning. Likewise, if you mostly have big files, partitioning is not necessary since big files are spread over many allocation blocks; the percentage of capacity going to waste will be small.



*Normally your hard disk icon appears alone on the desktop.*



*After partitioning the drive a separate icon appears on the Mac's desktop for each partition. Each of these icons represents a separate partition on a single hard disk.*



HOT TIP

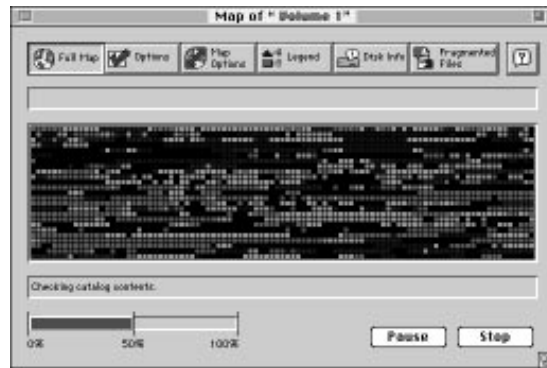
**Partition options.** Even if you're not worried about wasting space, there may be other reasons to partition your drive: You can, for example, create separate partitions for your personal or work files and your children's games. Depending on the options your formatter offers, you may be able to set a volume not to appear on the desktop automatically at startup, but only when you explicitly call it up; for even stronger protection, some formatters provide a measure of security by requiring anyone trying to mount your volume to enter a password.

## Fighting Fragmentation

(HN/JC)

Whenever you save a new file, the Mac attempts to write it in the largest contiguous space it can find on your hard disk. When it can't, it breaks the file up into pieces or fragments and writes them wherever the Mac finds empty spaces. The problem is called *fragmentation*, and it can slow down your hard disk because it takes longer to retrieve all the fragments that are scattered around the media. (Databases are frequently fragmented because data is constantly being added or changed.)

*Defragmenters* or *optimizers* (because they optimize disk performance) are utility programs that work by analyzing your disk and shuffling fragments of files around until each forms a neat, contiguous whole.



Using the optimizer in Symantec's MacTools Pro reveals a heavily fragmented hard disk.



GOOD FEATURE

The best of the bunch is Alsoft's **DiskExpress II** (\$90). DiskExpress can do its thing on command or whenever your Mac is sitting idle, any time or during hours you specify. Besides defragmenting, it can track what files you use most often and group them at the most accessible parts of the disk. Altogether, it's a great tool for the compulsive hard disk jockey.

You'll find simpler optimizers in the leading disk-utility packages: Symantec's **Norton Utilities** or **MacTools Pro**. (Disk-utility packages are discussed in Chapter 7 and Chapter 13.) Owning one of these packages is a good precaution anyway; the optimizers are an extra bonus. (There's also an optimization command in La Cie's Silverlining disk formatter.)

All of the optimization programs take precautions to ensure your disk won't be scrambled if there's a crash or a power outage during the defragmentation process. But it's always a good idea to make sure you have an up-to-date backup before letting an optimizer loose.



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## Removable Media

If you're in the market for a second drive, it might make sense to consider a *removable-media* drive—a SyQuest, Iomega, or a *magneto-optical* drive. These very different storage technologies have one thing in common: They all put your data on cartridges that can be easily removed and replaced. That means you can lock up the data at night, carry it with you to a service bureau, mail it to a client, or simply put it aside while you work on something else. It also means you can expand your storage capacity just by adding more cartridges—in many cases a much more economical approach than buying another hard disk.

### SyQuest Drives

(HN/JC)

**SyQuest** drives (or just SyQuests, in everyday usage) were the first popular removable-media devices for the Mac, and they remain the most common. They are so named because they all incorporate mechanisms manufactured by one company, SyQuest Technology, but virtually every vendor that sells Mac storage products sells them.

SyQuest technology is close to that of ordinary hard disks, except that there's only one platter and it's encased in a plastic cartridge. When you insert the cartridge, a shutter door opens up to give the read/write heads access to the recording surface.

The original SyQuests used 5.25-inch cartridges and had a capacity of 44MB. SyQuest now makes drives that use 5.25-inch cartridges with capacities of 88MB and 200MB, and has added 3.5-inch versions with cartridge capacities of 105MB, 135MB, and 270MB.

Among the various SyQuest models, the 3.5-inch units (especially the EZ135 drive) are the fastest and, on a per-megabyte basis, cheapest; they are the best bet if you are buying for only personal use or for exchanging data with others who have a similar drive.

If you plan to use the cartridges to carry your images or layouts to a service bureau, you should go with a 5.25-inch unit. The 200MB version offers the best performance and is backward compatible with 44MB and 88MB cartridges.

Pursuing the old Gillette razor strategy, SyQuest prices its drives low and makes its money on cartridges. At this writing, mail-order prices run about \$400 for an external 200MB, 5.25-inch, or 270MB, 3.5-inch model. Cartridge prices range from as little as \$25 up to \$100.



## Iomega Drives

(HN/JC)

The Iomega Corporation is best known for its **Bernoulli** drive, a device that uses special 5.25-inch cartridges. In the last couple of years, Iomega has made big advances in storage technology by introducing low-cost removable storage devices such as the **Zip** and **Jaz** drives.

Iomega's Bernoulli drives were first introduced in 1980. Since then, the drives have graduated up through various cartridge capacities which currently peak at 230MB.

Bernoulli drives do not use a rigid disk platter like a hard disk—the medium inside the cartridge is floppy. The disk itself floats on a cushion of air as it spins, making the media immune to the head crashes (physical contact between the head and media) that can ruin a standard hard disk.

Iomega currently sells two models of Bernoulli drives, the **MultiDisk 150** (\$470) and **230** (\$500). Since earlier models are no longer made, the 150 and 230 are capable of reading and writing 150, 105, 90, 65, and 35MB Bernoulli disks. The 150 model can also read 44MB cartridges. 230MB and 150 cartridges run about \$100 and smaller capacity cartridges are still available.

The main disadvantage of the Bernoulli drives is they are less common than SyQuests. If you need to send large amounts of data to a service bureau or any other company that depends on the Mac, you should check in advance if they have a Bernoulli drive. These days they probably have a 5.25-inch SyQuest drive and a Zip drive on hand; the odds that they'll have a Bernoulli drive are much slimmer.



With the 100MB Zip drive, Iomega broke the removable drive price barrier down to a mere \$200. The Zip has been well-received, gained a loyal following, and forced competitors to introduce comparable products such as SyQuest's **EZ135**. (See [how the Zip stacks up against the EZ in the sidebar, "Storage Wars"](#).)



Iomega's latest feat is the Jaz drive (\$600), a high-capacity removable that uses 1 gigabyte and 540MB cartridges with two platters inside. The Jaz is as fast, if not faster than an average hard disk with a seek time of 12ms. The drive's design is compact for easy transport and it's lightweight. Cartridges cost \$120 for the 1GB, and \$70 for the 540MB.

The Jaz is good for backing up if you have a large capacity hard disk, and is the perfect solution for transporting large files like sound and video. Because the drive is fast it can be used to run multimedia presentations that often require high data transfer rates.

### **Storage Wars: Iomega ZIP versus SyQuest EZ135** (KD)

Removable storage manufacturers have been battling each other, producing some great bargains. Iomega started the fight with the ZIP drive; SyQuest retaliated with the EZ135 drive. Both of these new generation small, easy-to-use removable drives cost about \$200, with cartridges for about \$20. They are particularly useful for single-user backups and both come with software to help automate the task.

Iomega has been touting the ZIP drive as the next floppy. It may never become that universal, but it has been selling well. When the drives were first introduced, Iomega was scrambling to keep up with demand. The more popular the ZIP drive is, the more likely it is you'll be able to use a ZIP cartridge to send data to a friend.

The ZIP drive is lighter and smaller than the SyQuest drive. The cartridges are also more likely to survive being dropped. Like a floppy, the cartridge pops out when you drag it to the trash. One drawback is that Iomega cut corners on the SCSI ID switch; it only lets you set the drive to ID 5 or 6.

The SyQuest EZ135 has only one weapon, but it's a doozy. The EZ135 is the fastest removable drive on the market. It's twice as fast as the Zip drive. SyQuest has dramatically increased the reliability of its cartridges in recent years. They are still somewhat susceptible to damage if dropped, but each cartridge comes in a cushioned case to protect it.

Either of these drives is a good choice as a backup device. If speed is your main concern, go with the EZ135. Otherwise the ZIP drive is a better choice for transportability and ease of use. Besides, the ZIP drive is just plain cool.

### **Magneto-Optical Drives**

(HN/JC)

*Magneto-optical* (MO) drives—also known as *erasable optical* drives—read and write 5.25-inch or 3.5-inch removable disks enclosed in a hard plastic case. The media inside consists of a rigid plastic or glass substrate coated by several kinds of metallic alloy, in layers. One of the characteristics of the coating is that its polarity can be changed only at very high temperatures. When you write data to an MO disk, a laser heats a tiny spot on the media to about 150° C, at which point the polarity of that spot can be changed by an electromagnet located underneath it. Areas of the surface with different polarities reflect light differently, and that's how the laser reads the information.

First-generation MO drives used 5.25-inch cartridges, and most used a standard format that allowed up to 650MB of data per cartridge (325MB per side—you have to flip them over). The latest drives from most vendors support a 1.3GB or 2.6GB format, but as time marches on capacities are expanding. Pinnacle Micro recently introduced an MO capable of storing 4.6GB on a two-sided cartridge.

The original MO drives were painfully slow, but the new ones alleviate that problem. The fastest of them, from Pinnacle Micro, are almost as fast as a mid-range hard disk. Most 5.25-inch MO drives cost between \$1,400 and \$1,700. Cartridges cost about \$100 to \$300—not bad if you need to archive gigs of data in an easily readable format.

In recent years, 3.5-inch MO drives using cartridges only a little thicker than a floppy have appeared on the market. The most common capacity currently is 230MB per (single-sided) cartridge. The drives are available from many Mac storage vendors, at prices ranging from \$460 to \$500; extra cartridges are around \$30 to \$50.

MO performance levels are in the hard disk range. They are too slow to make a good primary working drive, but they're not bad as a place to put files and projects you don't require regularly—those you open up occasionally or might need for reference or reuse in the future. Because the cartridges show up on your desktop just like a hard disk and the files are stored in standard format, it's easy to open them from the MO or drag them to your hard disk; you don't have to run a special program to retrieve the file, as you ordinarily do if you use a tape drive for backup.

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## CD-ROM

A few years ago *CD-ROM* (compact disk, read-only memory) drives were a specialty item mainly used in libraries. Today they are standard equipment built into new desktop Macs.

A CD-ROM drive (sometimes called a player) isn't essential to the functioning of your computer in the way that a hard disk and a floppy drive are; if you use your machine for word processing, spreadsheets, and communications, and the like, you can get along fine without one. But if you hope to take advantage of the increasing wealth of multimedia reference and entertainment titles available on the Mac, you're missing the boat if you don't equip your system with this third kind of drive.

### What's It For?

(HN)

CD-ROMs are the ideal medium for products that involve quantities of data so vast they can't practically be distributed on floppies and stored on your hard disk: games and encyclopedias that incorporate lots of graphics, music, and video; collections of high-resolution images; ZIP code directories; research databases; and technical manuals.

Even with files that have to be installed on your hard disk before you can use them—system software, development tools, and major applications—it's easier, and better for the environment to use a single CD instead of a mountain of floppies.

## CD-ROM Hardware: What to Look For

(HN)

As their name suggests, CD-ROM drives read discs that look like standard audio CDs. The technologies are so similar that most CD-ROM drives can also play audio CDs. In both cases, the 5-inch disks are made of an aluminum inner layer with a rigid plastic outer coating. Information is stored on these disks in the form of tiny pits, which reflect light differently from the nondented portions. Audio CD players and CD-ROM drives read the discs by shining a laser beam on the surface and interpreting the pattern of reflection.

CD-ROM drives connect to the Mac via the SCSI port. Drives can be installed internally in most recent Macs (except PowerBooks and other small-case Macs), or you can hook up an external drive. As with hard disks, each approach has its pros and cons: internal mechanisms cost less and take up no desk space; external drives are easier to move around.

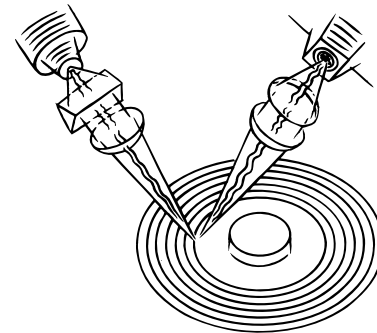
Current CD-ROM drives can read Photo CD discs, a format developed by Kodak for storing digitized photographs; most drives offer multisession Photo CD support, meaning they can read all the images on a disc even if they were recorded at different times. You can get your family photos developed on disc, so you can use programs such as Adobe Photoshop to retouch them. If you're a graphic designer, you can take advantage of stock photo collections in Photo CD format. There's no significant price premium for a drive with Photo CD capability, so you don't have anything to lose by getting it, and it just might come in handy some day.

## CD-ROM Speed

(HN/JC)

CD-ROM technology is intrinsically slow: Access times and data transfer rates are more like those of floppies than hard disks. As of this writing, state-of-the-art drives offer average access times of between 140 and 300 ms.

For years, single-speed CD-ROM drives were limited to a transfer rate of 150K per second, the standard set for music CDs. But a few years ago manufacturers figured out a way to make their drives spin faster and thus deliver higher throughput. The fastest CD-ROM drives on the market are 6x and 4x drives. These drives spin six times and four times faster respectively, than the original single-speed drives.



*Light produced by a laser beam is reflected off the surface of a compact disc and collected by a photocell detector.*



At this writing, Sony, NEC, and Apple all market quadruple-speed CD players. NEC also has a sextuple-speed unit and other manufacturers are likely to follow. The faster spindle speeds do make copying files faster, but the performance of current games and other programs played directly from the CD don't benefit appreciably. That won't happen until the software is rewritten to take advantage of the extra speed.

## Brand Names

(HN/JC)

Over the years, most Apple-brand storage products have been mediocre at best; people bought them because they came with the Mac, not because of their merits.

That's not the case with Apple's recent CD-ROM drives: the **CD 600e** (external) and **600i** (internal). The 600 model offers excellent performance, supports multisession Photo CDs, and comes with good software for playing audio CDs and manipulating Photo CD images. In its efforts to establish the Mac as the leading platform for multimedia, Apple has set a surprisingly low price, just \$330 for the external and \$250 for the internal.

**HOT TIP**

Some Toshiba and top-of-the-line NEC mechanisms may be a tad faster; NEC's low-end drives are cheaper; and many users report satisfaction with **Plextor** drives. On the whole, when it comes to CD-ROM, there's no reason not to buy Apple.

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## Riding the SCSI Bus

*SCSI* is the standard bus, or electrical communications channel, for connecting storage devices and other peripherals to the Mac. It works well if you follow the rules, use quality cables, and properly terminate devices. (For the complete rundown [see "Termination"](#) later in this chapter.)

**WARNING**

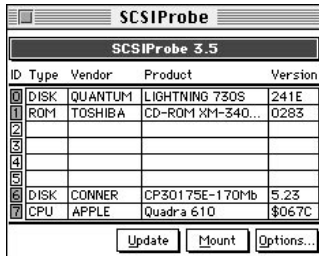
A word of caution: Never change any SCSI addresses, or plug or unplug any SCSI cables, without turning off the Macintosh and all the devices on the chain.

### SCSI ID Numbers

(Michael Bradley/SZA/AN/Chris Allen/HN/JC)

A SCSI chain can contain seven devices. Each device on the chain gets a SCSI ID number (also known as an address), from 0 to 6. The Mac itself, acting as the SCSI host, is assigned ID number 7 and cannot be changed. Apple's internal hard disks are always set to address 0. ID numbering has no necessary relationship to the physical order of the devices on the chain.

Most external SCSI devices provide switches that make it easy to change the ID number. Before you add a new peripheral to your system, check the numbers and, with all devices powered off, make the changes necessary to eliminate any conflicts. If any two



ID	Type	Vendor	Product	Version
0	DISK	QUANTUM	LIGHTNING 730S	241E
1	ROM	TOSHIBA	CD-ROM XM-340...	0283
2				
3				
4				
5				
6	DISK	CONNER	CP301 75E-170Mb	5.23
7	CPU	APPLE	Quadra 610	067C

*SCSIProbe displays all the devices attached to your Mac's SCSI bus and can mount removable cartridges and hard disks too.*

devices on the chain have the same ID, your system will crash, and you may even wipe out data on one or more hard disks.

SCSI address switches are almost always tiny and in the back of the drive (and therefore hard to get to). If you write the ID number on a sticker or spot of masking tape and place it on the front of each device, you can see at a glance which addresses are used and which are free. (You can also determine the SCSI ID of any device with your disk formatting software or with SCSIProbe, an invaluable freeware device-management utility.)



**WARNING**



**HOT TIP**

## SCSI Connectors

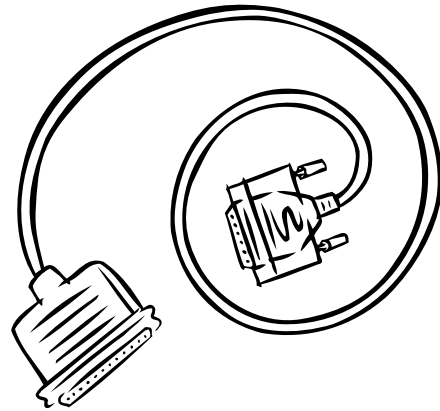
Desktop Macs have a 25-pin DB-25 SCSI port for connecting external devices. To add a single external SCSI device to your Mac you typically need a (male) DB25-to-50 pin (male) Centronics cable (Apple calls it a system cable).

To connect (or daisy-chain) two external devices you need a 50-pin (male) Centronics cable to 50-pin (male) Centronics cable. Apple calls this one a SCSI Peripheral Interface Cable.

Some external SCSI devices have a smaller 25-pin port, and some recent ones use a newer, smaller 50-pin connector design called Micro-SCSI or MicroD. High performance add-on SCSI cards that support Fast/Wide SCSI have a 68-pin micro connector.

PowerBooks have a rectangular SCSI port that requires a special cable called HDI-30 that comes in two forms. The Apple **HDI-30 SCSI System Cable** is used for connecting to an external SCSI device. The other cable is the Apple **HDI-30 SCSI Disk Adapter** that allows PowerBooks to be connected to a desktop Mac using the SCSI ports. This lets your PowerBook appear like an external drive on a desktop Mac. The PowerBook must support the SCSI disk mode feature for this to work. Don't try it if you're not sure as you could permanently damage both Macs! Check your PowerBook manual or contact your local Apple dealer.

(HN/JC)



*You'll need this DB25-to-50-pin Centronics cable if you want to connect an external SCSI device.*



**POWERBOOK**

## Cable Quality

(RS/HN/JC)

The quality of your cables can make the difference between constant hassles and a bus that hums along smoothly. It may seem silly to spend \$40 or \$50 for a few feet of wire, but if you are building a complex SCSI chain, this is not the place to economize—especially if you are working with one of the Macs noted for its SCSI sensitivities, such as the Quadra AV models and the Power Macs. Look for double-shielded cables—they're usually thick and heavy because they have lots of shielding around the separate wires inside the cable to minimize the possibility of signals on one line generating noise on another. We recommend gold-plated connectors.

The cables Apple sells are pretty good quality, and many peripheral vendors supply good cables. But few, if any, match the extra-high-quality cables offered by a small company called Berkeley Data Access. It offers old-fashioned personal service and very reasonable prices. The only catch is that the minimum order is four cables.

Other excellent sources for high-quality cables are APS Technologies and Granite Digital. APS offers a lifetime warranty on cables sold through its quarterly catalog. Granite Digital doesn't sell its cables direct but instead will refer you to the nearest dealer in your area. The nice thing about these companies is that they are all Mac friendly, so even if you're not sure what you need they'll go the distance to help.

## SCSI Cable Lengths

(HN)

If your SCSI chain is too long, signals may be too weak to be received clearly and you are likely to experience a variety of problems. Theoretically, the chain can extend up to 7 meters (about 23 feet), measured from your computer to the last device in a SCSI chain, including all internal ribbon cables. Apple recommends a maximum of 6 meters (about 20 feet). A general rule: The shorter, the better.



As for the length of individual cables, that's one of the murkiest areas in SCSI. Some people have problems with long cables; still others have trouble with very short ones (about 12 to 18 inches is the shortest available). If you are buying new cables, you might as well stick to the middle ground: 3-foot lengths.

## Termination

(HN)

The electrical signals that race up and down your SCSI cables generate electrical echoes, or *noise*. If they're not suppressed, these reflections can be strong enough to confuse devices on the bus. That can cause an array of problems, including slow-downs, data errors, drives refusing to appear on the desktop, and crashes.



That's why you need *terminators*, or *resistors*, at either end of the SCSI chain. Terminators can be internal (attached to a drive's circuit board) or external (plugged into one of the device's SCSI ports). They require a small amount of electrical power—termination power—which is supposed to be, but is not always, provided by the SCSI device. The rules for termination vary according to the Mac model you're using.

**For most Macs.** Generally speaking—here's one of those rules that usually works—the first and last devices on the SCSI chain should be terminated. The first device is the Mac: If you have an internal hard disk, it should be terminated with resistors installed on the drive's circuit board (if it's a factory-installed drive, or if it's dealer-installed, it will come with terminators). If you don't have an internal drive, most Macs require a special terminator for the internal SCSI port. (If you normally have an internal drive but have to remove it for servicing, don't forget to have your dealer add termination.)



The last device—the one at the other end of the SCSI chain—should also be terminated. In between—normally—the other devices on the chain should not be terminated. If you have an external device with internal termination, put it at the end of the chain, if that's convenient; if not, or if you have more than one internally terminated device, you or a technician will probably have to remove the terminating resistor from one of them.

**The Mac Plus.** Because the Mac Plus has no internal SCSI connector, your first external device (the one closest to the Mac) is considered the first device and should be terminated, as should the last device on the chain. If you have only one drive on the chain, it should be terminated.

**The Mac IIx.** The Mac IIx follows the general rules above, but it requires a special terminator at the end of the chain. It's black, and Apple calls it the SCSI Terminator II. One should have come with your IIx.

**PowerBooks.** PowerBooks are something else again. Hard-drive-equipped PowerBooks have a small internal terminator, but if you are connecting external devices, Apple recommends adding two more terminators: One should go between the HDI-30 cable attached to your PowerBook and the first device. If only one external device is connected, the other should go on the device's unoccupied SCSI port; if there are several, the terminator should go on the last device in the chain.

If you are planning to connect a PowerBook to a desktop Mac in SCSI disk mode—setting up the PowerBook's hard disk to function as an external drive attached to your desktop machine—the termination rules are hopelessly complicated. Fortunately, they are very clearly illustrated in Apple's PowerBook manuals. Check there.



POWERBOOK

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## Backing Up

According to an ancient saying, there are two kinds of computer users: those who've had a hard disk crash and those who are about to. All computer storage devices, for now and for the foreseeable future, are inherently unreliable—they're susceptible to directory corruption, electrical glitches, and mechanical breakdown. And don't forget the risk of human error: Almost everyone who has used a computer has at one time or another inadvertently trashed some important file.

Nevertheless, most computer users don't bother to back up their data—they just don't think about it, or they decide it's not worth the hassle, or they say they'll get to it later. It's your choice, of course, but remember the bottom line: If you don't have a good—i.e., recent and complete—backup, the odds are great that sooner or later you will lose documents that are important to you.

If you do decide to make *backups*, you need to choose media, software, and a strategy.

### Backup Media

(HN/JC)

In reviewing your options for backup media, having an extra hard disk is the fastest and easiest choice—you can simply drag files and folders to it to make a backup, and back again to restore. But this approach also has clear disadvantages: doubling your disk capacity is expensive, and the second drive is as vulnerable to breakdown, fire, or theft as the first.

Floppies are the other obvious choice, and on the face of it the most economical, since you already have the drive. But you should factor in the cost of your time, since backing up to floppies requires near-constant attention over at least several hours (depending, obviously, on the size of your backup). In an era when 500MB are standard and gigabyte drives are common, floppies just won't do for full backups. They remain a good choice for quick backups of a select group of critical files—your tax return, say, or your dissertation.

The other choices are removable cartridges and tape. Using removable-media drives from Iomega or SyQuest, or magneto-optical disks offer many of the advantages of using an extra hard disk: You can back up and restore directly from the Finder, and you have the added advantages of expandability (if you run out of space, just get another cartridge) and portability (you can easily take a cartridge off site for safekeeping).

The only real disadvantage of these options is the cost of media. Buying multiple cartridges to do a complete backup of a 500MB drive can get expensive. If you want the added security of duplicate copies, or your drive is bigger than that, media costs go up proportionately. And if you want to preserve archives of files no longer on your hard disk—copies you keep in reserve in case you ever need them again for reference, recycling, or updating—along with backups of your current files, the expense can go through the roof.

That leaves tape. In many ways it's the most un-Mac-like medium, since you can't ordinarily mount tape drives on your desktop, and you have to run special software to copy or restore your files or even to see what's on a tape. And the drives aren't cheap: At this writing the least expensive *digital audio tape* (DAT) drives using the latest DDS-2 technology are about \$800.

But tape has one huge advantage: The cost per megabyte is infinitesimal. With DAT, you can store anywhere from 1 to 2GB of data (depending on tape length and whether the drive supports compression), on a tape that costs about \$9; if you buy one of the latest models you can store up to 8GB on one \$25 tape.

In addition to DAT, low-cost tape drives that have been used commonly on PCs are beginning to be made available for the Mac market. As of this writing, APS offers a tape drive that uses QIC (quarter-inch cartridge) media. The **APS HyperQic** (\$500) can store as much as 4GB of data using software compression. Tapes run about \$35.

## Backup Software

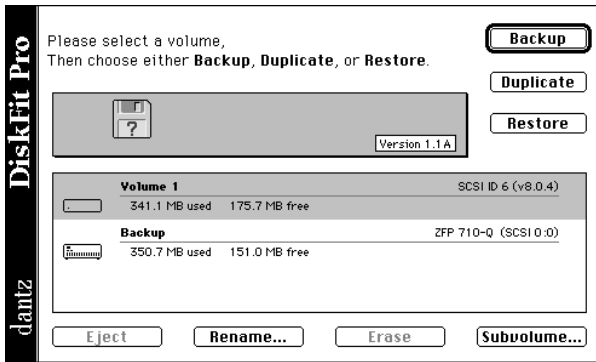
(HN)

If you are using a tape drive, you have only a couple of choices for backup software, and if you're like most other Mac tape users, you'll end up choosing Dantz Development's **Retrospect** (\$150, but often bundled free with many tape drives). It supports almost every backup medium known to humankind, it offers an amazing array of features, it's exceptionally well-supported, and though it's not exactly uncomplicated, version 3 provides an appealing interface and simplifies things enough so it's not hard to use. If you are on a network, you can get **Retrospect Remote** (\$270 for ten Macs) and have every drive on the net automatically backed up overnight.

If you are using any media you can mount on the desktop—floppies, hard disks, or cartridges—you don't need anything except the Finder to make copies. But you'll probably want to do *incremental backups*—backups that encompass only the files that have been created or modified since the last backup—between more time-consuming full backups of everything on your disk, and for that purpose (among others) a good backup utility makes life much simpler.

If you've already invested in a disk utility package like Symantec's **MacTools Pro** (\$95) or **Norton Utilities** (\$95) (covered in Chapter 7), you already own a backup utility.

These programs are good, but they may not offer the features you want. Many users, once they get serious about backup, invest in a specialized utility. In this category, too, the best-sellers come from Dantz: **DiskFit Direct** (\$50) is the easiest to use, while **DiskFit Pro** (\$125) offers more features. Also **Personal Backup** (\$50) from SunStar Publishing is extremely easy to use and currently comes bundled with Iomega's Zip drives.



You're just a few mouse clicks away from an automatic backup with Dantz Development's *DiskFit Pro*.

## Backup Strategies

(HN)

The best way to get yourself to back up is to make it a routine that demands little if any effort or attention. Many of the backup utilities have a scheduling option, so all you have to do is set up the program and make sure media is available.

I don't do that (why not? I don't know), but I do leave my DAT drive on my SCSI chain almost all the time, and I keep two tapes, Odd and Even, close at hand. When I'm winding up a serious work session, I fire up Retrospect, pop in a tape (Odd or Even depending on the date), and let her fly. With two recent backups, I'm pretty well protected even if one tape should get damaged or corrupted. (I've had several tapes go bad over the years.)



If your backup software has a verification option, as Retrospect does, turn it on. That way the software will read back every file it's backed up and check it against the original to make sure the copy is accurate. It can double the time required to complete a backup, but it's worth it. (Besides, the sensible way to do a backup is to start it at the end of your computing day or schedule it to start automatically during the night. That way, who cares if it takes a few extra hours?)

However diligent you are in making incremental backups, it's a good idea to do a new full backup from time to time. And it's plain common sense to keep a backup off site, to protect you from such threats as fire or theft.

