Chapter 15

CD-ROM Drives

This chapter explains the technology behind CD-ROM drives and their storage technology, delineates the various recording formats used on PC CD-ROMs, and examines the performance characteristics of the typical CD-ROM drive. After showing you the process of selecting a good drive for a system upgrade, the chapter guides you through the installation of the CD-ROM interface card, the drive itself, and the software that must be added to your PC for the drive to communicate with the system.

What Is CD-ROM?

Within minutes of inserting a compact disc into your computer, you have access to information that might have taken you days, or even weeks, to find a few short years ago. Science, medicine, law, business profiles, and educational materials—every conceivable form of human endeavor or pursuit of knowledge—are making their way to aluminum-coated, five-inch plastic data discs called *CD-ROMs*, or *compact disc read-only memory*.

Note

The CD-ROM (compact disc read-only memory) is a read-only optical storage medium capable of holding 660 megabytes of data (approximately 500,000 pages of text), about 70 minutes of high-fidelity audio, or some combination of the two. The CD-ROM is very similar to the familiar audio compact disc, and can, in fact, play in a normal audio player. The result is noise unless audio accompanies the data on the CD-ROM. Accessing data from a CD-ROM is somewhat faster than from a floppy disk, but considerably slower than a modern hard drive. The term CD-ROM refers to both the discs themselves and the drive that reads them.

Although only dozens of CD-ROM discs, or titles, were published for personal computer users in all of 1988, the Software Publishers Association predicts that in 1994 publishers will offer over 4,800 individual titles, containing data and programs ranging from worldwide agricultural statistics to preschool learning games. Individual businesses, local and federal government offices, and small businesses also will publish thousands of their own limited-use titles.

CD-ROM, a Brief History

In 1978, the Philips and Sony Corporations joined forces to produce the current audio CD. Philips had already developed commercial laser-disc players, whereas Sony had a decade of digital recording research under its belt. The two companies were poised for a battle—the introduction of potentially incompatible audio laser disc formats—when they came to terms on a agreement to formulate a single audio technology.

Sony pushed for a 12-inch platter. Philips wanted to investigate smaller sizes, especially when it became clear that they could pack an astonishing 12 hours of music on the 12-inch discs.

By 1982, the companies announced the standard, which included the specifications for recording, sampling, and—above all—the five-inch format we live with today. To be specific, the discs are a full 12-centimeters in diameter. This size was chosen, legend has it, because it could contain Beethoven's Ninth Symphony.

With the continued cooperation of Sony and Philips through the 1980s, additional specifications were announced concerning the use of CD technology for computer data. These recommendations evolved into the computer CD-ROM drives in use today. Where once engineers struggled to find the perfect fit between disc form factor and the greatest symphony ever recorded, software developers and publishers are cramming these little discs with the world's information.

CD Technology

Although identical in appearance to audio CDs, computer CDs store data in addition to audio. The CD drives that read the data discs when attached to PCs also bear a strong resemblance to an audio CD player. How you must handle the CDs—insert them into the CD drive and eject them when finished—are all familiar to anyone who has used an audio CD. Both forms of CD operate on the same general mechanical principles.

The disc itself, nearly five inches in diameter, is made of a polycarbonate wafer. This wafer base is coated with a metallic film, usually an aluminum alloy. The aluminum film is the portion of the disc that the CD-ROM drive reads for information. The aluminum film or strata is then covered by plastic coating that protects the underlying data.

Note

CD-ROM media should be handled with the same care afforded a photographic negative. The CD-ROM is an optical device and degrades as its optical surface becomes dirty or scratched. If your drive uses a "caddy"—a container for the disc that does not require handling the disc itself—you should purchase a sufficient supply of these to reduce disc handling.

Mass-Producing CD-ROMs

Although a laser is used to etch data onto a master disc, this technique would be impractical for the reproduction of hundreds or thousands of copies. Each production of a master disc can take over one-half hour to encode. In addition, these master discs are made of materials that aren't durable enough for continued or prolonged use. In fact, unless you are using a CD-R (CD-Recordable) or CD-WO (CD-Write Once) for mastering discs or storing data, the material used for master CD discs is made of glass. Only the CD-R and CD-WO drives use metal-coated discs for making masters or writing data.

For limited run productions of CDs, an original master is coated with metal in a process similar to electroplating. After the metal is formed and separated from the master, the metal imprint of the original can be used to stamp copies, not unlike the reproduction of vinyl records. This process works effectively for small quantities—eventually the stamp wears out.

To produce a large volume of discs, the following three-step process is employed:

1. The master is, once again, plated and a stamp is produced.
2. This stamp is used to create a duplicate master, made of a more resilient metal.
3. The duplicate master can then be used to produce numerous stamps.

This technique allows a great many production stamps to be made from the duplicate master, preserving the original integrity of the first encoding. It also allows for the mass production to be made from inexpensive materials. The CDs you buy are coated with aluminum after they are stamped into polycarbonate, and then protected with a thin layer of plastic. The thin, aluminum layer coating the etched pits, as well as the smooth surfaces, enables the reading laser to determine the presence or absence of strongly reflected light, as described below.

This mass manufacturing process is identical for both data and audio CDs.

Reading the information back is a matter of reflecting a lower-powered laser off the aluminum strata. A receiver or light receptor notes where light is strongly reflected or where it is absent or diffused. Diffused or absent light is caused by the recorded pits in the CD. Strong reflection of the light indicates no pit—this is called a “land.” The light receptors within the player collect the reflected and diffused light as it is refracted from the surface. As the light sources are collected from the refraction, they are passed along to microprocessors that translate the light patterns back into data or sound. The spiral of CD data is nearly three miles long.

When a CD—audio or data—seeks out a bit of data on the disc, it looks up the address of the data from a table of contents and positions itself near the beginning of this data across the spiral, waiting for the right string of bits to flow past the laser beam.

Inside Data CDs

The microprocessor that decodes the electrical impulses is the key difference between music and data compact players. Audio CDs can contain many differing degrees of light diffusion depending on how long a particular pit is stretched across the strata. These variations of diffusion carry important information for the reproduction of the original signal. Data encoding, however, based on the computer's native language of binary encoding, must be recorded strictly as the presence or absence of a signal.

CD-ROM drives operate in the following manner:

1. The laser diode emits a low-energy beam toward a reflecting mirror (see fig. 15.1).
2. The servo motor, on command from the microprocessor, positions the beam onto the correct track on the CD-ROM by moving the reflecting mirror.
3. When the beam hits the disc, its refracted light is gathered and focused through the first lens beneath the platter, bounced off the mirror, and sent toward the beam splitter.
4. The beam splitter directs the returning laser light toward another focusing lens.
5. The last lens directs the light beam to a photodetector that converts the light into electric impulses.
6. These incoming impulses are decoded by the microprocessor and sent along to the host computer as data.

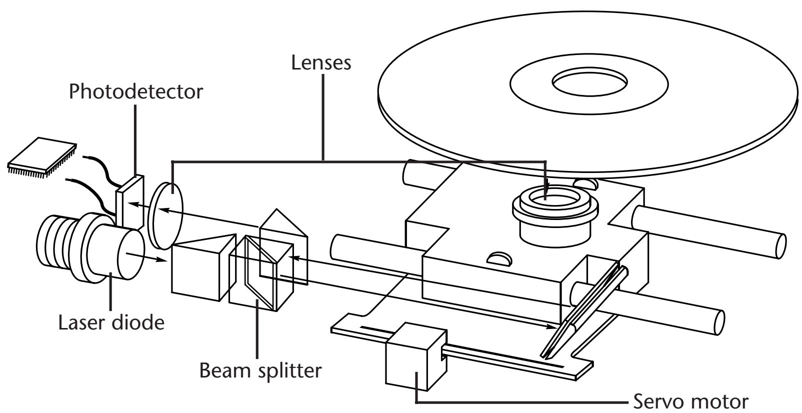

Fig. 15.1
Inside a CD-ROM drive.

Although the simplicity of data or binary language seems to imply that a data CD optical reader would need to be less sensitive to incoming signals, this is not the case. Because the encoding pits are uniform in size, the presence or absence of the pitting must be measured precisely, thereby signaling the 1 or 0 of binary code. Even one misreading of the space or pit would cause the entire data file to lose integrity, or become useless. Therefore, the tracking mechanisms—the motor that moves the laser beam across the surface and the receptors of the refracted light—must be more tightly integrated with each other and more accurate in reading the recording surface.

In the case of an audio CD, missing data can be *interpolated*—that is, the information follows a predictable pattern that allows the missing value to be guessed at. For example, if three values are stored on an audio disc, say 10, 13, and 20 appearing in a series, and the middle value is missing—due to damage or dirt on the CD's surface—you can interpolate a middle value of 15, which is midway between the 10 and 20 values. Although this is not exactly correct, in the case of audio recording it will not be noticeable to the listener. If those same three values appear on a CD-ROM in an executable program, there is no way to guess at the correct value for the middle sample. Interpolation cannot work on a CD-ROM because executable program data follows no natural law since the data is a series of values. To guess 15 in this situation is not just slightly off, it is completely wrong.

Because of the need for such precision, CD-ROM drives for use on PCs were later to market than their audio counterparts. When first introduced, CD-ROM drives were too expensive for widespread adoption. In addition, drive manufacturers were slow in adopting standards, causing a lag time for the production of CD-ROM titles. Without a wide base of software to drive the industry, acceptance was slow.

What Types of Drives Are Available?

When purchasing a CD-ROM drive for your PC, consider three distinct sets of attributes of CD-ROM drives, as follows:

- The drive's specifications.
- The interface it requires for connection to your PC.
- The format or formats it is capable of reading.

The variance in any of these categories is enormous; in fact, single vendors offer entire lines of drives that vary in performance specifications, format reading capability, and type of adapters that can interface with your PC. For these reasons, drive prices vary widely. First-generation CD-DA (Digital Audio) drives, for example, are available for as little as $190. You'll probably be disappointed in the drive's performance and capabilities, however, and would be better off looking elsewhere. So before you buy, know the drive's characteristics.

All three drive characteristics are discussed in this section, giving you a better understanding of what type of drive you need to buy.

CD-ROM Drive Specifications

Drive specifications tell you the drive's performance capabilities. If you're shopping for a sports car, for instance, and the dealer tells you the car can accelerate from a standing stop to 60 miles per hour in six seconds, you know you've got a hot car. The car's horsepower, displacement in liters, and number of cylinders and valves are also specifications you use to determine how fast it is.

CD-ROM drive specifications tell the shopper much the same thing. Typical performance figures published by manufacturers are the data transfer rate, access time, internal buffers (if any), and the interface used.

Data Transfer Rate. The data transfer rate tells you how much data the drive can read from a data CD and transfer to the host computer when reading one large, sequential chunk of data. The standard measurement in the industry is kilobytes per second, usually abbreviated as kb/s. If a manufacturer claims a drive can transfer data at 120 kb/s, it means that a drive reading a sequential stream of data from the CD will achieve 120 kilobytes a second after it has come up to speed. Note this is a sustained and sequential read, not access across the data disc from different portions of the platter. Obviously, the data transfer specification is meant to convey the drive's peak data reading capabilities. A higher rate of transfer might be better, but a number of other factors come into play.

First, a higher transfer rate might not be useful if the software accessing the data or the PC using the data do not need the information in such high volume. In addition, the drive's host adapter, which connects it to the PC, may not be capable of fast data transfers either.

Most 16-bit adapters and today's PCs are more than up to the task, however. If you expect to run a variety of CD-based software on your system, you need a drive with a high data transfer rate. Applications that employ full-motion video, animation, and sound require high transfer rates, and you'll be disappointed with the results of a slower drive. (Recommended transfer rate minimum: 150 kb/s.)

Access Time. A CD-ROM drive's access time is measured the same way as for PC hard drives. In other words, the access time is the delay between the drive receiving the command to read and its actual first reading of a bit of data. The time is recorded in milliseconds; a typical manufacturer's rating would be listed as 350 ms. This is an average access rate; the true access rate depends entirely on where the data is located on the disc. Positioning the read mechanism to a portion of the disc near the narrower center of the disc gives you a faster access rate than positioning it at the wider outer perimeter. Access rates quoted by many manufacturers are an average taken by calculating a series of random reads from a disc.

Obviously, a faster average access rate is desirable, especially when you are relying on the drive to locate and pull up data quickly. Access times for CD-ROM drives are steadily improving, and the advancements are discussed later in this chapter. Note that these average times are significantly slower than PC hard drives, ranging from 500 to 200 milliseconds when compared to 20 milliseconds found on your typical hard disk. Most of the speed difference lies in the construction of the drive itself; hard drives have multiple read heads and range over a smaller surface area of media. CD-ROM drives have only one laser read beam, and it must be positioned over the entire range of the disc. In addition, the data on a CD is organized in a long spiral from outer edge inward. When the drive positions its head to read a "track," it must estimate the distance into the disc and skip forward or backward to the appropriate point in the spiral. Reading off the outer edge requires a longer access time than the inner segments. (Recommended access time: 350 ms or better.)

Buffers. Some drives are shipped with internal buffers or caches of memory installed on-board. These buffers are actual memory chips installed on the drive's board, and they allow data to be staged or stored in larger segments before it is sent to the PC. A typical buffer for a CD-ROM drive is 64 kilobytes or KB. Having buffer memory on the CD-ROM drive offers a number of advantages. Buffers can ensure that the PC receives data at a constant rate; when an application requests data from the CD-ROM disc, the data is probably scattered across different segments of the disc. Because the drive has a relatively slow access time, the pauses between data reads can cause a drive to send data to the PC sporadically. You might not notice this in typical text applications, but a slower access rate drive coupled with no data buffering is very noticeable, even irritating, in the display of video or some audio segments. In addition, a drive's buffer, when under control of sophisticated software, can read and have ready the disc's table of contents, making the first request for data faster to find on the disc platter. (Recommended buffer: 64 KB or better.)

Interface

A CD-ROM's interface is the physical connection of the drive to the PC's expansion bus. The interface is the pipeline of data from the drive to the computer, and its importance shouldn't be minimized. Early 8-bit adapter interfaces compounded CD-ROM drive performance problems, making access to significant blocks of data, such as graphics, painfully slow. Most drives now come with or are compatible with popular 16-bit adapters. You should be aware of differences, however.

SCSI Standard Interfaces. SCSI (pronounced SKUH-zee), or the Small Computer System Interface, is a name given to a group of adapter cards that conform to a set of common commands. They also enable computer users to string a group of devices along a chain from the one adapter, avoiding the complication of inserting a new adapter card into the PC bus slots every time a new hardware device, such as a tape unit or additional CD-ROM drive, is added to the system. These traits make SCSI interfaces preferable for connecting peripherals such as your CD-ROM to your PC.

All SCSI adapters are not created equal, however. Although they may share a common command set, they can implement these commands differently, depending on how the adapter's manufacturer designed the hardware. Furthermore, although the adapter can use SCSI commands to operate the CD-ROM drive, it might not allow the chaining of devices, defeating one of the chief purposes of implementing a SCSI interface.

SCSI-2 and ASPI. SCSI-2 was implemented throughout the PC industry and intended to create a true standard; if an adapter card or peripheral conforms to the SCSI-2 standard, the commands and the capabilities will be uniform across adapter and peripheral manufacturer's products. Such SCSI-2 products are often referred to as ASPI-compatible, a term derived from the device driver used to communicate with the adapter card. ASPI stands for Advanced SCSI Programming Interface and was developed by Adaptec, Inc., a leader in the development of SCSI controller cards and adapters. The SCSI-2 specification also allows a broader array of commands to be used with the controller card and offers other performance enhancements.

Non-Standard SCSI. Some drive manufacturers ship their own controller cards with their drives. These controllers can be called SCSI, but may not be compatible with the ASPI and/or SCSI-2 specifications. When a manufacturer claims a drive has a SCSI interface, you might be getting far less than you might need. Make certain it is a standard SCSI interface, preferably ASPI compatible.

If you don't plan on installing multiple SCSI devices, however, a proprietary controller or adapter is acceptable. Just beware of the limitations on expansion and compatibility. (Recommended interface: SCSI-2, ASPI compatible.)

CD-ROM Disc and Drive Formats

Compact discs are pitted to encode the binary bits of 0 and 1. Without a logical organization to this disc full of digits, however, the CD-ROM drive and PC would be at a loss to find any discernible data amid all those numbers. To this end, the data is encoded to conform to particular standards. When a drive encounters particular patterns, it—and the PC—can "recognize" the organization of the disc and find its way around the platter. Without standard data formats, the CD-ROM industry would be dead in the water; vendors of particular discs and disc drives would be producing incompatible software discs and drives and thereby limiting the number of units that could be sold.

Formats are also needed to advance the technology. For instance, hard rubber wheels and no suspension were just fine for the first automobiles as they cruised along at the breakneck speed of thirty miles an hour. But hitting a pothole at sixty could cause serious damage to the vehicle—and the riders. Inflatable tires and shock absorbers became necessary components of the modern car.

Similarly, the standards for disc formats evolved as well. The first compact data discs stored only text information, which was relatively easy to encode onto a disc. Graphics produced a greater challenge, and the standards evolved to incorporate them. The use of animation with synchronized sound, and then live-motion video, called for other expansions to the standards in which CDs store data.

It is extremely important to note that advanced CD-ROM standards are in the process of evolution right now. Multiple vendors are deploying a number of different techniques for expanding the capabilities of CD-ROM technology. They may be incompatible with each other or are immature in their development, and acceptance of these newer standards by software vendors is essential to the widespread use of these newer standards. It is important that you are familiar with these issues before you purchase a drive; consider the formats it is capable of reading now—and in the future.

The majority of drives available today, however, do comply with earlier CD-ROM formats, ensuring that the vast library of CD-ROM applications available today can be used on these drives.

First Data Standard: ISO 9660. Manufacturers of the first CD-ROM data discs produced their discs for one particular drive. In other words, a data disc produced for company A's drive could not be read by anyone who had purchased company B's CD-ROM drive—the disc needed to be formatted for each manufacturer's drive. Obviously, this stalled the development of the industry. Philips and Sony—the original collaborators for the standards incorporated in audio CDs, developed the “Yellow Book” specifications for data CD-ROMs.

When Sony and Philips first published the audio CD specifications, the material was released in a red binder and became known as “Red Book.” Subsequent CD-ROM specifications have been dubbed by color as well, such as “Orange Book” and “Green Book.”

An extension of the way in which audio data was stored on disc, the Yellow Book specification details how data—rather than audio—can be organized on a disc for its later retrieval. The International Standards Organization refined this specification in such a way that every vendor’s drive and disc would expect to find a table of contents for a data disc. This is known as a Volume Table of Contents (VTOC) and really is quite similar to a standard book’s table of contents in theory. ISO 9660 did not completely solve compatibility problems, however. The incorporation of additional data to aid and refine the search for data on a disc and even how to format the data blocks were still left to each separate vendor’s design.

High Sierra Format. It was in all manufacturers’ interests to resolve this issue. In a meeting in 1985 at the High Sierra Hotel and Casino in Lake Tahoe, California, leading manufacturers of CD-ROM drives and CD-ROM discs came together to resolve the differences in their implementation of the ISO 9660 format. The agreement has become known as the High Sierra format and is now a part of the ISO 9660 specification document. This expansion enabled all drives to read all ISO 9660-compliant discs, opening the way for the mass production of CD-ROM software publishing. Adoption of this standard also enabled disc publishers to provide cross-platform support for their software, easily manufacturing discs for DOS, UNIX, and other operating system formats. Without this agreement, the maturation of the CD-ROM marketplace would have taken years longer and stifled the production of available CD ROM-based information.

The exact and entire specifications for how to format the CD media are complex, strewn with jargon you may never need, and superfluous to your understanding of drive capabilities. You should know the basics, however, because doing so gives you a glimpse of the inner workings of retrieving data so quickly from such an enormous well.

To put basic High Sierra format in perspective, the disc layout is roughly analogous to a floppy disk. A floppy has a system track that not only identifies itself as a floppy and its density and operating system, but also tells the computer how it’s organized—into directories, and within the directories, files.

Basic CD-ROM formats are much the same. The initial track of a data CD identifies itself as a CD and begins synchronization between the drive and the disc. Beyond the synchronization lies a system level that details how the entire disc is structured; as a part of the system area, the disc identifies the location of the volume area—where the actual data is held. The system also contains the directories of this volume, with pointers or addresses to various named areas, as illustrated in figure 15.2. A significant difference between CD directory structures and that of DOS is that the system area also contains direct addresses of files within their subdirectories, allowing the CD to seek to a specific location on the spiral data track.

Because the CD data is all really on one long spiral track, when speaking of tracks in the context of a CD we're talking about sectors or segments of data along the spiral.

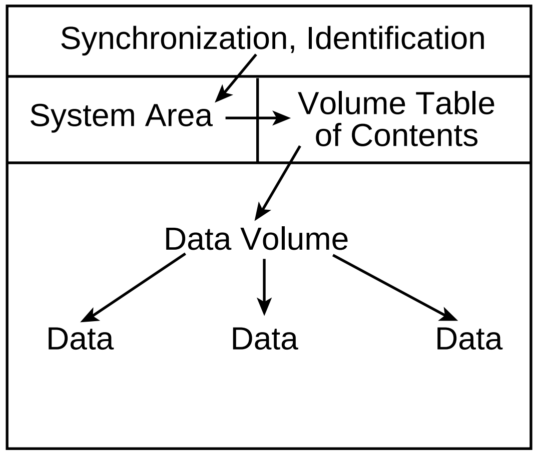

Fig. 15.2
CD-ROM basic organizational format.

CD-DA (Digital Audio). Data drives that can read data and audio are called CD-DA. Virtually any data drive now being sold reads both types of discs. When you insert a disc, the drive reads the first track of the disc to determine what type you loaded. Most drives ship with audio CD software, which enables you to play music CDs from your PC. You can use headphones, or with an installed sound card, connect speakers to the system. Some external drives ship with standard Left/Right audio plugs; just plug them into any external amplifier.

PhotoCD. First announced back in 1990, but not available until 1992, CD drives that display your own CD-ROM recorded photographs over your television are now being shipped in quantity by Kodak. You merely drop off a roll of film at a participating Kodak developer; later you take home a PhotoCD and drop it into your Kodak PhotoCD compatible disc player. But what's a PhotoCD compatible player?

The home unit is designed to play your PhotoCDs and your audio CDs as well. Because virtually all data-ready CD drives also can interpret audio, it's no mean feat for the Kodak CD players to play audio discs. The player merely reads off the first track and determines what type of disc you've fed it. The real breakthrough is in the drive's capability to determine whether one, two, or dozens of individual photo "sessions" are on the data disc.

CD Sessions. Remember from the High Sierra format discussion that each data disc holds a VTOC, or Volume Table of Contents, which tells the CD reader where—and how—the data is laid out on disc. CD data has, until this point, been single-session in its encoding. In other words, when a CD is mastered, all the data that will ever reside on the disc must be recorded in one session. The format, or the media, has no provision for returning later to append more information. The PhotoCD format—along with the XA and CD-I formats discussed later—not only allow for multiple sessions, but allow multiple sessions to be read back on a fully PhotoCD-capable CD-ROM drive. The drive must be capable of finding the multiple VTOCs associated with the appended sessions, however.

And this is where some confusion now reigns. When Kodak first released the PhotoCD, the company maintained that a drive must be CD-ROM XA-compliant to use PhotoCDs. An explanation of the XA spec follows. As of January 1992, however, Kodak has tested non-XA drives with new software drivers and approved them as single-session PhotoCD compatible. In other words, many of the drives shipping right now—in fact a majority—may be perfectly suited to reading PhotoCD discs that contain a single session of photos. The drive can recognize only the first session, and ignores any data or subsequent volume entries made after the initial session.

PC-based CD-ROM drives, if supplied with the proper device driver and Kodak-based software, can read single-session PhotoCD images. Kodak is licensing the "viewer" portion of its software so that it can be incorporated into existing software packages. Special filters—or decoders—will be added to desktop publishing, word processing, and PC paint software that allow them to import PhotoCD images into their documents.

Kodak has future plans to incorporate synchronized audio and text to the existing photo format. For these capabilities, the drive that reads these advanced discs must be XA-compatible. In addition, drives must be XA-compatible to read any disc that has multiple recordings.

PhotoCD Production

When you drop off your roll of film, the Kodak developers produce prints, just as they normally do. After prints are made, however, the process goes high-tech. Using high-speed UNIX operating system-based SUN SparcStations, the prints are scanned into the SparcStation at very high resolution using ultra-high resolution scanners. To give you an idea of the amount of information each scan carries, one color photograph can take 15–20 megabytes of storage. When the image is stored on disc, it is compressed using Kodak's own custom software. The compressed, stored images are then encoded onto special writable CD discs. The finished product is packaged in a familiar CD case and shipped back to your local developer for pickup.

Even though these scanned images occupy an enormous amount of media space, the capacity of CD technology can easily carry 100 photos, at the highest possible resolution. Because existing television, and even most home computers, cannot use these ultra-high resolutions, the typical home or PC-based PhotoCD can hold hundreds of images. See table 15.1 for more details. Because most of us rarely have that many photos developed at the same time, Kodak developed the system in conjunction with Philips so that multiple sessions can be recorded on one disc. You can have your Thanksgiving photos developed and recorded to disc in November, for example, and then bring the same disc back in late December to have your other holiday photos added to the remaining portion of the disc. Keep bringing the disc in until it fills up.

Table 15.1 PhotoCD Resolutions

Resolution	Description
256 × 384 lines	Fine for most conventional TVs
512 × 768 lines	Good for S-VHS TVs and VGA PCs
1024 × 1536 lines	Beyond current TV technology, even Super VGA can't use all
2048 × 3072 lines	Beyond TV or current PC capacities

As of this writing, Kodak PhotoCD discs run fine in single session mode in many current CD-ROM drives—in Philips CD-I home entertainment systems as well as the Kodak systems.

For multisession capabilities and the capability to use audio and text on a PhotoCD for the PC, you must have an XA-compatible CD-ROM drive.

CD-ROM XA or Extended Architecture. CD-ROM XA, or Extended Architecture, is backwards compatible with the earlier High Sierra or ISO 9660 CD-ROMs. It adds another dimension to the world of CD-ROM technology.

Interleaving. CD-ROM XA drives employ a technique known as *interleaving*. The specification calls for the capability to encode on disc whether the data that is directly following an identification mark is graphics, sound, or text. Graphics can include standard graphics pictures, animation, or full-motion video. In addition, these blocks can be interleaved, or interspersed, with each other. For example, a frame of video may start a track followed by a segment of audio, which would accompany the video, followed by yet another frame of video. The drive picks up the audio and video sequentially, buffering the information in memory, and then sending it along to the PC for synchronization.

In short, the data is read off the disc in alternating pieces, and then synchronized at playback so that the result is a simultaneous presentation of the data.

Mode 1 and Mode 2, Form 1 and Form 2. To achieve this level of sophistication, the CD format is broken up so that the data types are layered. Mode 1 is CD data with error correction. Mode 2 is CD data without error correction. The Mode 2 track, however, allows what are called Form 1 and Form 2 tracks to exist one after the other on the Mode 2 track, thereby allowing the interleaving. These interleaved tracks may include their own error correction and can be any type of data. Figure 15.3 shows a visual representation of the breakdowns of Mode and Form structure.

For a drive to be truly XA-compatible, the Form 2 data encoded on the disc as audio must be ADPCM (Adaptive Differential Pulse Code Modulation) audio—specially compressed and encoded audio. This requires that the drive or the SCSI controller have a signal processor chip that can decompress the audio during the synchronization process.

What all this translates into is that drives currently available may be partially XA-compliant. They might be capable of the interleaving of data and reading of multisession discs, but may not have the ADPCM audio component on the disc or its controller.

Presently, the only drives with full XA compliance are produced by Sony and IBM. The Sony drive incorporates the ADPCM chip on its drive. The IBM XA drive is for IBM's proprietary micro channel bus and is designed for its high-end PS/2 Model computers.

Manufacturers may claim that their drives are "XA-ready," which means that they are capable of multiple sessions and Mode 1 and Mode 2, Form 1 and Form 2 reading, but they do not incorporate the ADPCM chip. Software developers, including Kodak, have yet to produce many XA software titles. IBM has a few under its Ultimedia program, but others have not yet hit the market.

If you get a drive that is fully mode and form compatible and is capable of reading multiple sessions, you may have the best available at this time. XA is a specification waiting for acceptance right now. Audio and video interleaving is possible without full XA compliance, as MPC applications under Microsoft Windows demonstrate.

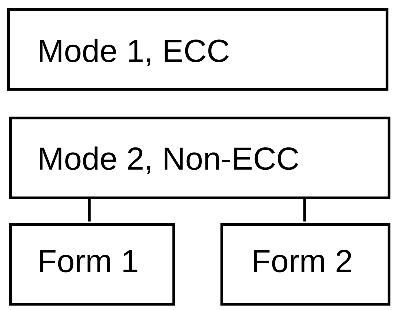

Fig. 15.3
Mode and Form format for CD-ROM XA.

CD-R. Sometimes known as CD-WORM and CD-WO, CD-R (CD-Recordable) enables you to write your own CDs.

As with mastering any CD, your data must be laid out or formatted before recording it to the CD-R unit. Often this layout is performed on a PC with large hard disks or other magnetic and removable media.

The CD-R is not quite the CD you might expect, however. Instead of the recording beam burning pits into a metallic or glass strata, the CD-R media is coated with a dye that has the same reflective properties as a "virgin" CD disc—in other words, a CD reader would see an unrecorded CD-R disc as one long land. When the recording laser begins to burn data into the CD-R media, it heats the gold layer and the dye layer beneath. The result of heating these areas causes the dye and gold areas to diffuse light in exactly the same way that a pit would on a glass master disc or a mass-produced CD. The reader is fooled into thinking a pit exists; there is no actual pit, however—just a spot of less-reflective disc caused by the chemical reaction of heating the dye and gold.

Many of the newer models support all the formats discussed—ISO 9660 all the way through CD-ROM XA. In addition, these drives read the formats as well, serving as a

ROM reader. Prices have fallen, but they're still around $5,000. A number of models may cost less than this by early 1995.

Multimedia CD-ROM

Multimedia is not a specific standard but a descriptive term. Any CD that incorporates text with graphics, sound, or video is by definition multimedia. Multimedia CDs exist for DOS, Macintosh System 7, AmigaDOS, Windows, OS/2, and UNIX operating systems and can be in many different formats.

MPC CD-ROMs. A consortium of hardware and software manufacturers led by Microsoft Corporation announced the formation of the Multimedia PC Marketing Council at Fall COMDEX in 1991. This council described the recommended platform for implementing multimedia on PC systems, and as more manufacturers joined the council, applications and hardware conformed to the prescribed specifications.

The MPC Council recommends minimum performance requirements for MPC-compatible CD-ROM drives, however. They are as follows:

- CD-DA drive with external audio output. (This can be as simple as a headphone jack. Most drives have headphone jacks and a 4-pin audio edge connector or standard RCS audio plugs.)
- 150 kb/s transfer rate, required for animation or video.
- 500ms access speed; this rate is unrealistically low, however. Most drives have much better access rates, and particularly with graphics and video, you'll want a drive with better performance than this.

Far from being an exact specification or format for data, MPC CD-ROM is a convention for storing audio, animation, video, and text for synchronization under the Microsoft Windows operating system from data received from an MPC-compliant CD-ROM. Microsoft has developed Windows Application Programmer's Interface software, which allows CD-ROM software manufacturers to organize the data on their CDs in such a way that information can be passed to Windows for processing.

Note that discs labeled as MPC only run under Microsoft Windows 3.0 or higher with the Microsoft Multimedia Extensions, or under OS/2 with MMPM. If a drive meets the minimum MPC Council recommendation for performance, it will run MPC CD-ROMs under Windows.

MultiSpin and High-Speed Drives. Audio drives deliver sound at a preset transfer rate to the amplifiers. MultiSpin drives, a term coined and patented by NEC, Inc., allow the drive to spin faster and deliver data at rates far higher than the audio equivalent. There is no reason why the computer must restrict itself to receiving data at this slower rate if the CPU, memory, and application software are capable of handling faster data rates.

NEC's line of high-speed drives was the first on the market in 1992 and delivers data to the PC at roughly twice the speed of previous CD-ROMs. Particular applications, such as live-motion video, especially benefit from this technology. Data is delivered in a constant stream, allowing the PC to process the video frames at a smoother rate. Some drives without high-speed technology, especially those that have no buffering capabilities, deliver video in a jerky and uneven manner.

A number of vendors are now supplying high-speed versions of their drives, including NEC, Texel, Toshiba, and Chinon.

The Pioneer mini-changer offers what the company calls QuadSpin—speeds up to four times the base delivery rate of data.

Other Drive Features

Although drive specifications are of the utmost importance, other factors and features should be taken into consideration as well. Besides quality of construction, the following criteria bear scrutiny when making a purchase decision:

- Drive sealing
- Caddy type
- Self-cleaning lenses
- Internal versus external drive

Drive Sealing. Dirt is your CD-ROM's biggest enemy. Dust or dirt, when it collects on the lens portion of the mechanism, can cause read errors or severe performance loss. Many manufacturers "seal" the lens and internal components in airtight enclosures from the drive bay. Other drives, although not sealed, have double dust doors—one external and one internal—to keep dust from the inside of the drive. All these features help prolong the life of your drive.

Caddy Type. Most CD-ROM drives require that you first insert the CD disc into a caddy, and then insert the caddy into the drive. Some drive manufacturers, however, have built-in caddies—drawers that slide out when the eject button is pushed. The disc is merely inserted into the drawer.

Both methods have pros and cons:

- *Caddiless*. Because these drive mechanisms don't require caddies, you spend much less time fumbling around with your CDs. There are two slight hitches here, though. First, you must make certain the CD drawer is kept very clean—the easiest way to foul the reading of a disc and potentially damage a drive is to introduce dirt into the mechanism. Second, if the drawer hinge fails, you must send the entire drive in for repair.
- *Caddy*. You need a phone number for a business in Los Angeles. You open the CD case for your American Business Phone Book CD. You eject the CD already in the drive, remove it, and replace it in its case. You take out the Phone Book CD and insert it into the caddy, and then...you get the picture. Using caddies is a time-consuming bother if you deal with a number of different CDs. This is the only drawback to using them, however. The individual caddies are easy to clean, and

when they show signs of wear, throw them away. You can pick up caddies for around five or six dollars apiece, and it's worth the small investment to buy each of your most-used CDs its own caddy.

Self-Cleaning Lenses. If the laser lens gets dirty, so does your data. The drive will spend a great deal of time seeking and reseeking—or finally giving up. Lens cleaning discs are available, but built-in cleaning mechanisms are now included on some model drives. This may be a feature you'll want to consider, particularly if you work in a less than pristine work environment, or if you have trouble keeping your desk clean, let alone your CD-ROM drive lens.

Internal versus External Drives. When deciding whether you want an internal or external drive, think about where and how you're going to use your CD-ROM drive. What about the future expansion of your system? Both types of drives have pluses and minuses. The following lists some of the issues:

- *External Enclosures*. These tend to be rugged, portable, and *large*—in comparison to their internal versions. Buy an external if you have the space and are considering or already own other external SCSI peripherals that you can chain to the same adapter. You might also consider an external if you want to move the drive from one PC to another easily. If each PC has its own SCSI adapter, all you need to do is unplug the drive from one adapter and plug it into the other.
- *Internal Enclosures*. Internal drives will clear off a portion of your desk. Buy an internal if you already have internal SCSI devices you can chain to your adapter, have ample drive bay space, or plan on keeping the CD-ROM drive exclusively on one machine.

Installing Your Drive

You decided on the drive you want. You ordered it. Now it's arrived at your doorstep. What next?

Installation of a CD-ROM drive is as difficult—or easy—as you make it. If you know a little about SCSI interface devices, such as your CD drive, and plan ahead, the installation should go smoothly.

This section walks you through the installation of typical internal and external CD-ROM drives with tips that often aren't included in your manufacturer's installation manuals. Even after you install the hardware, it isn't enough to just turn on the drive and toss in a CD, though. Special software must be loaded onto your PC first.

Avoiding Conflict: Get Your Cards in Order

Regardless of your type of installation—internal or external drive—you need to check your CD-ROM drive's SCSI host adapter before installation.

Carefully remove the adapter card from its protective, antistatic bag.

Note

Never handle the SCSI adapter card by its gold, edge connector contacts—a simple spark of static electricity sent to the card is enough to do potential damage.

Lay the card out on the antistatic bag with the IC chips, transistors, and processors face up and the external connector to your right. Virtually all documentation for adapter cards assumes that cards are oriented this way when you configure them.

The single most important step in installing any SCSI device, including this new CD-ROM drive, is the proper configuration, or settings, for the adapter card in front of you. If you pay special attention to this part of the installation, you avoid 90 percent of the problems with installing SCSI devices.

Check the adapter's documentation or pamphlet for the default settings for the card. These should be indicated by a list near the front, or by notation throughout the manual. DO NOT worry about pin settings, jumpers, or anything else other than copying the default settings to a piece of paper. Look for the following default settings:

- IRQ
- DMA channel
- I/O address or memory address
- Adapter SCSI ID

The following is a typical list of default settings for a SCSI adapter:

- IRQ 11
- DMA channel 5
- I/O address 330
- SCSI ID 7

Don't worry if your settings are different; each setting is discussed later in the chapter.

Note

Some proprietary SCSI host adapters may have some, all, or just a few of these settings available to you. In any case, jot down the defaults they list in the manual.

If you want to avoid hair-pulling, teeth-gnashing, and general frustration, check these default settings for your SCSI card for possible conflicts with other cards already installed in your PC. You CANNOT have two cards set for the same IRQ, DMA, or I/O address or the drive—and possibly your PC—will lock up or operate erratically.

The following are some typical cards you should check for IRQ, DMA, and I/O port address settings:

- Network interface cards (Ethernet, ARCNet, and so on)
- Sound cards
- Scanner interfaces
- Internal modems and fax-modems
- Other SCSI cards for hard drives, Bernoulli drives, or other added peripherals such as tape backup units

If you value your time and your sanity, it's a good idea to keep a record of these important settings for all your adapter cards handy. Write down the current settings on a piece of paper and tape it into your PC's owner manual, for example. Any time you add a new adapter card or must reconfigure one already installed, you'll have a reference. Otherwise, you might find yourself pulling out every peripheral adapter in your machine to check its settings. Obviously, any time you add a new card or change the settings of one installed, change your note card.

Make a note of any conflicts. It probably is easier to reset the defaults on your CD-ROM SCSI card—it's already out of the PC and sitting in front of you. Don't make changes yet. Just take notes.

The next step is to make sure that the defaults listed in the manual are, in fact, the defaults actually set on the board. Everyone makes mistakes, and your manufacturer is included. Although this is relatively uncommon, it's best to double-check things now, before you go too far into the installation.

Jumpers. Adapter card configurations are set with jumpers—tiny plastic-covered shunts that fit over pin-pairs on the adapter card (see fig. 15.4). These rows of jumper pins may run left to right or up and down across the card. Configuration is a matter of having the jumpers on or off a pair of pins.

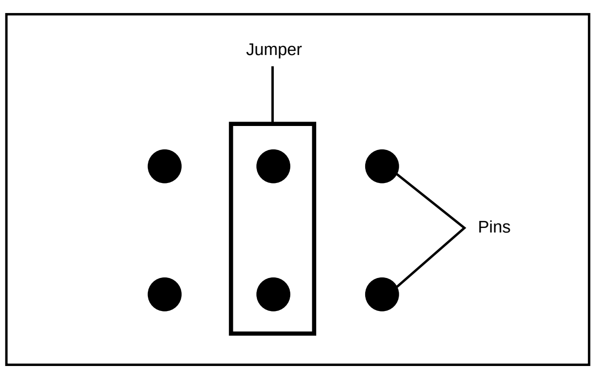

Fig. 15.4
A SCSI card with jumper banks.

These rows of jumper pins are labeled on the card as J5 or W1, for example. Your adapter card manual or pamphlet has a diagram of these jumper rows, or *blocks*, as they're called. Carefully check the pin settings against your manual. Make sure that pins are jumpered where they should be, and just as important, that no extra jumpers are on any of the pins.

Note

Some SCSI adapters, such as the Trantor 130, use rocker switches rather than jumpers to configure the cards.

If you believe you've found an error, double-check. You might have multiple jumper blocks on your card—make sure that you're checking the right ones.

After you make sure that you have the pins set to the correct defaults, you're ready to resolve any possible conflicts.

IRQ Conflicts. The most common cause of a system lock-up after an installation is an IRQ conflict. Avoid problems up front by making sure that you have no conflicts now. Table 15.2 lists common IRQ numbers and which ones are typically open. Remember, you may already have an installed card occupying one of the interrupt request lines.

Table 15.2 Common IRQ Assignments

IRQ 0	Use
IRQ 0	Timer Interrupt
IRQ 1	Keyboard Interrupt
IRQ 2	Cascade to IRQ 9
IRQ 3	COM 2 and COM 4
IRQ 4	COM 1 and COM 3
IRQ 5	LPT 2 (parallel printer port)
IRQ 6	Floppy Disk
IRQ 7	LPT 1 (parallel printer port)
IRQ 8	Real Time Clock
IRQ 9	Cascade to IRQ 2
IRQ 10	Available to user
IRQ 11	Available to user
IRQ 12	Mouse Port on PS/2
IRQ 13	80X87 Math Coprocessor
IRQ 14	Hard Disk
IRQ 15	Available to user

If you find a conflict, consult your adapter card manual for selecting a different IRQ. At this point, remove or move a jumper from one pin pair to another. Although jumper blocks can be removed with your fingers, you risk handling chips that may be near the jumpers. It's better to use a pair of tweezers, especially those sold in a computer tool kit, to carefully remove the jumper. Reset the jumper blocks according to the manual's diagrams for the new IRQ.

DMA Conflicts. DMA, or Direct Memory Address, settings have less serious consequences when in conflict. A typical symptom of a DMA conflict is no response from one of the cards in conflict. For example, if you have a sound card and your CD-ROM SCSI card set for the same DMA channels, one—or both—of the cards might not function. Check DMA settings on the card, but be aware that the card may require that the DMA channel be set on a number of jumper blocks. The Adaptec 1540 SCSI card, for example, has a default DMA of 5, but jumpers pertaining to the DMA selection are on jumper block 5 as well as jumper block 9. For all DMA jumpers to be set, the Adaptec must have DMA Channel Select, DMA Request, DMA ACKnowledge, and DMA INTerrupt Request set on these two separate blocks.

Note

Direct Memory Access (DMA) is a technique that speeds up access to memory for expansion cards. Because it avoids the intervention of the CPU, this technique is "direct." Seven DMA channels are in an IBM-AT compatible machine.

Most SCSI cards come with a default of DMA channel 5 set. This should be fine for most PCs because few other adapter cards occupy these channels. Some of the newer, 16-bit sound cards have DMA channel 5 set as default, however, so they are likely culprits in any conflict.

Memory I/O Addresses. No two cards can live at the same memory address. More important, these I/O addresses are really base addresses—they describe the address start that the card occupies. The full range of the memory address must be taken into consideration when resolving conflict with other cards. For example, if a sound card occupies memory address 220, you might assume that the SCSI card could exist at 230. This is not necessarily so. If the sound card's memory range is 220–235, you've just introduced a conflict.

We've noticed some typical conflicts of late in the way types of adapter cards are shipped in their default state. Most SCSI cards ship with base memory I/O addresses of 300, 330, or 220. Many sound boards and internal fax modem cards may also occupy these addresses in their default configurations. Network interface cards are often set in the 300–360 range by default too. If you need to change your I/O address due to a conflict, make sure that you know the range of the possible conflict.

Typical symptoms of I/O conflict are similar to those with DMA—one or both of the cards in conflict will not respond. Another symptom of memory conflict is disconcerting, but harmless. Your machine may go through the boot process of checking memory, loading drivers, and so on, get to the end of the boot, and then reboot all over again. If this happens, you can be certain you have a memory conflict.

Selecting a Slot. After you configure your card correctly, resolve all potential conflicts, and are thoroughly tired of looking at the manual's hazy diagrams for jumper blocks, you're ready to insert the SCSI card into the PC.

Turn off the power. Unscrew the case cover and remove it. Look at the available or unoccupied slots in your PC bus. These card slots may come in 8-, 16-, or 32-bit lengths—with 8-bit being the shortest and the 32-bit slots the longest and usually the last slots in the case. If your CD SCSI adapter is an 8-bit adapter, it will have one set of gold edge connectors; the 16-bit cards have two sets—one short and one long. Make the most of the real estate inside your PC case. Don't put an 8-bit card in a 16-bit slot unless you have no other choice—you may want that 16-bit slot later on for a true 16-bit card. The main point is simple, though—you can put the SCSI card in any of the available slots in the case. Unscrew the slot cover for the bus slot you've selected from the back of the PC. Hang onto this screw.

Holding the card by its top edges, slide it firmly into the expansion bus, with the connector edge facing through the open slot in the back of the PC chassis. Press down firmly. You'll feel the card seat itself and pop into the connector. Be careful not to press down too hard—you might damage the motherboard below. Make sure that the card is evenly seated, front to back. Most SCSI cards have cable hooks on either side of the outside connector. These can get in the way when you put the card into the bus.

If one of these hooks gets caught between the chassis and the card, you'll have a difficult time seating the card properly (see fig. 15.5). Move the hooks straight up, parallel with the connector so that they'll slide easily through the slot in the back of the PC.

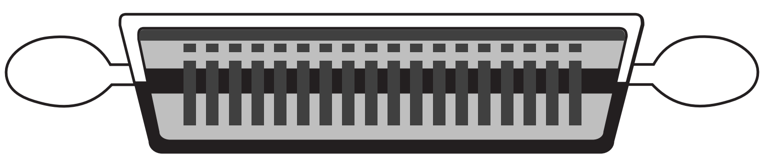

Fig. 15.5
A SCSI connector, showing hooks that can get in the way of installation.

Gently move the adapter flange with its slotted top away from the screw hole of the PC chassis. Put the screw from the slot plate into the hole and give it a few turns, enough to start it solidly. Slide the card flange under the screw head and secure it firmly. By starting the screw into the chassis first, and then sliding the card into place beneath it, you can avoid the problems of trying—often without luck—to align the adapter bracket flange and PC chassis hole with the screw. A common hassle here is dropping the screw into your PC case while attempting to secure the card. It's a good idea to have a flashlight around to peer between the cards to find dropped screws; those tweezers you used for changing jumpers might come in handy here to carefully remove the misplaced screws. If you've grounded yourself, you won't do any damage if you're careful in removing a dropped screw.

Never, under any circumstances, leave a loose or dropped screw in the case. It will inevitably short something out, doing severe damage to your main PC board and any cards in the expansion bus.

The worst part is over.

DO NOT replace the cover of the PC yet. If some lingering conflicts exist or the card is not fully seated in the slot, you might need to do more inside work. You can replace the PC case after you install the drive, reboot your system, install the driver software, and (whew!) test the drive—not before.

External CD-ROM Hook-Up

Unpack the CD-ROM carefully. With the purchase of an external drive, you should receive the following items:

- CD-ROM drive
- SCSI adapter cable
- SCSI adapter card

This is the bare minimum to get the drive up and running. You'll probably also find a CD caddy, a manual or pamphlet for the adapter card, and possibly a sampling of CDs to get you started.

Take a look at your work area and the SCSI cable that came with the drive. Where will the drive find a new home? You're limited by the length of the cable. Find a spot for the drive, and insert the power cable into the back of the unit; make sure that you have an outlet, or preferably, a free socket in a surge-suppressing power strip to plug in the new drive.

Plug one end of the supplied cable into the connector socket of the drive, and one into the SCSI connector on the adapter card. Most external drives have two connectors on the back—either connector can be hooked to the PC (see fig. 15.6). The following sections discuss the extra connector. Secure the cable with the guide hooks on both the drive and adapter connector, if provided. Some SCSI cables supplied with Future Domain 16-bit controllers have a micro-connector for the adapter end, and simply clip into place.

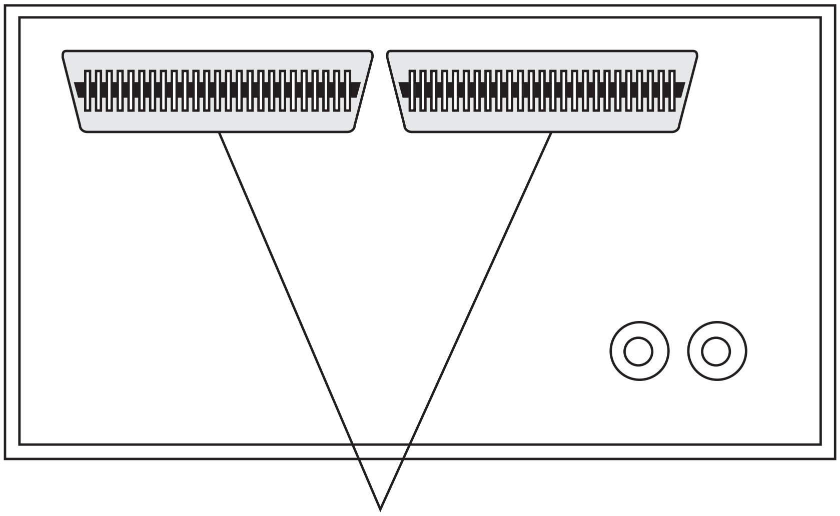

Fig. 15.6
External CD-ROM drive SCSI connectors.

Finally, your external CD-ROM drive should have a SCSI ID select switch on the back. This switch sets the identification number for the drive when hooked to a host adapter. The adapter, by most manufacturer's defaults, should be set for SCSI ID 7. Make sure that you set the SCSI ID for the CD-ROM drive to any other number—6, 5, or 4, for example. The only rule to follow is to make sure that you do not set the drive for an ID that is already occupied—by either the card or any other SCSI peripheral on the chain.

Internal Drive Installation

Unpack your internal drive kit. You should have the following pieces:

- The drive
- Power cord
- SCSI interface board
- Internal SCSI ribbon cable
- Floppy disks with device driver software and manual
- Drive rails and/or mounting screws

Your manufacturer also may have provided a power cable splitter—a bundle of wires with plastic connectors on each of three ends. A disc caddy and owner's manual may also be included.

Make sure that the PC is off and leave the cover off the PC for now. Before installing the card into the PC bus, however, connect the SCSI ribbon cable onto the adapter card (see fig. 15.7).

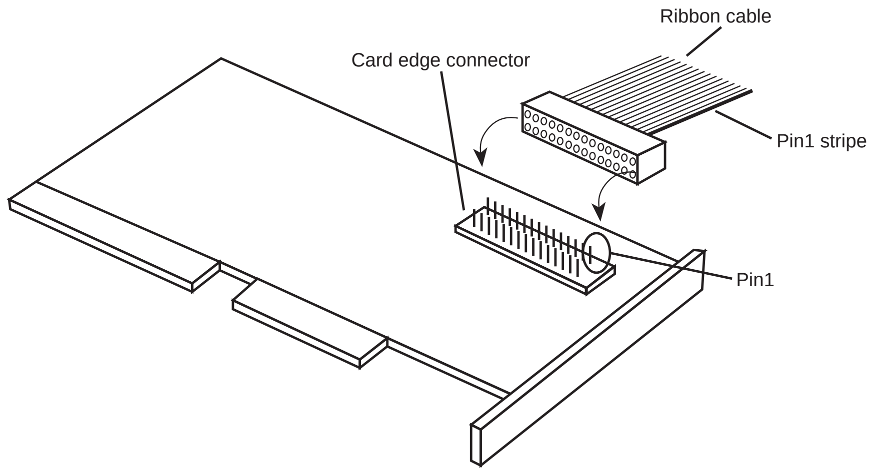

Fig. 15.7
Ribbon cable connection to SCSI adapter.

Ribbon Cable and Card Edge Connector. The ribbon cable should be identical on both ends. You'll find a red stripe of dotted line down one side of the outermost edge of the cable. This stripe indicates a pin 1 designation, and ensures that the SCSI cable is connected properly into the card and into the drive. If you're lucky, the manufacturer supplied a cable with notches or keys along one edge of the connector. With such a key, you can insert the cable into the card and drive in only one way.

Unkeyed cable must be hooked up according to the pin 1 designation.

Along one edge of your SCSI adapter, you'll find a double row of fifty brass-colored pins. This is the card edge connector. In small print along the base of this row of pins you should find at least two numbers next to the pins—"1" and "50." Align the ribbon cable's marked edge over pin 1, and then carefully and evenly insert the ribbon cable connector.

Now insert the adapter card, leaving the drive end of the cable loose for the time being.

Choose a slot in the front bay for your internal drive. Make sure that it's easily accessible and not blocked by other items on your desk. You'll be inserting the CDs here, and you'll need the elbow room.

Remove the drive bay cover. Inside the drive bay you should find a metal enclosure with screw holes for mounting the drive. If the drive has mounting holes along its side and fits snugly into the enclosure, you won't need mounting rails. If it's a loose fit, however, mount the rails along the sides of the drive with the rail screws, and then slide the drive into the bay. Secure the drive into the bay with four screws—two on each side. If the rails or drive don't line up evenly with four mounting holes, make sure that you use at least two—one mounting screw on each side. Because you'll be inserting and ejecting many CDs over the years, mounting the drive securely is a must.

Once again, find the striped side of the ribbon cable and align it with pin 1 on the drive's edge connector. Either a diagram in your owner's manual or designation on the connector itself tells you which is pin 1.

The back of the CD drive has a power connector outlet. Inside the case of your PC, at the back of your floppy or hard disk, are power cords—bundled red and yellow wires with plastic connectors on them. You may already have a power connector lying open in the case. Take the open connector and plug it into the back of the power socket on the CD-ROM drive. These connectors only go in one way. If you do not have an open connector, use the splitter (see fig. 15.8). Disconnect a floppy drive power cord. Attach the splitter to the detached power cord. Plug one of the free ends into the floppy drive, the other into the CD-ROM drive.

Note

It's best to "borrow" juice from the floppy drive connector in this way. Your hard drive may require more power or be more sensitive to sharing this line than the floppy is. If you have no choice—the splitter and ribbon cable won't reach, for example—you can split off any power cord that hasn't already been split. Check the entire length of the power cord—power supply to drives—to ensure that you have a line not already overloaded with a split.

Again, DO NOT replace the PC cover yet—you need to make sure that everything is running perfectly before you seal the case. You're now ready to turn on the computer. For the drive to work, however, you need to install the software drivers.

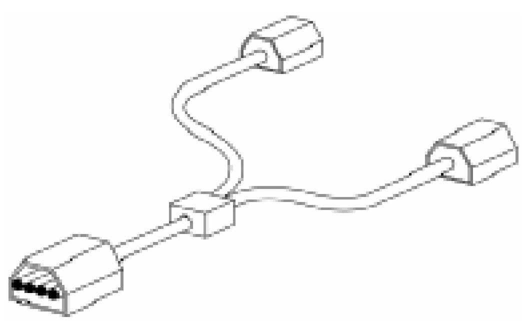

Fig. 15.8
Power cord splitter and connector.

SCSI Chains: Internal, External, a Little of Both

Remember, one of the primary reasons for using a SCSI controller for your CD-ROM drive is the capability to chain a string of peripherals from one adapter card—saving you card slots inside the PC, and limiting the nightmare of tracking IRQs, DMAs, and I/O memory addresses.

You can add scanners, tape backup units, and other SCSI peripherals to this chain (see fig. 15.9). You must keep a few things in mind; chief among them is SCSI termination.

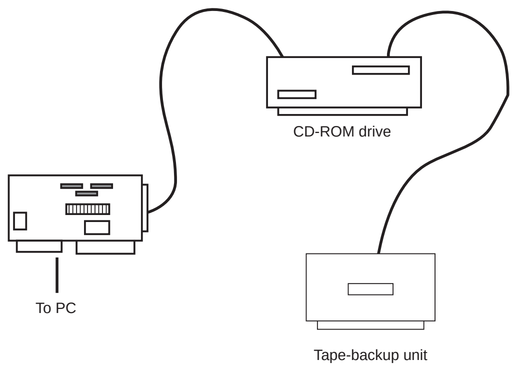

Fig. 15.9
A SCSI chain of devices on one adapter card.

Identify and Terminate with Care. The first rule of SCSI device chaining is simple: each end of the SCSI chain must be terminated. The first device must contain a termination resistor, and the last must also have a terminator attached. All devices between the first and last should be free of any terminator.

The second SCSI rule you must follow is that all SCSI devices must be set to a unique ID number. In the external drive installed earlier, the SCSI adapter is set for ID 7, and the CD-ROM drive is set for ID 6. Any additional SCSI devices added must then take IDs 1, 2, 3, 4, or 5. REMEMBER: the SCSI adapter takes an ID, and its default is usually ID 7.

Example One: All External SCSI Devices. Say that you installed your CD-ROM drive and added a tape device to the chain with the extra connector on the back of the CD-ROM drive. The first device in this SCSI chain is the adapter card itself. On all SCSI cards you find a series of long, reddish, ceramic-tipped components plugged into the board in a group of three. These are the terminating resistors for the card (see fig. 15.10). From the card, you ran an external cable to the CD-ROM drive, and from the CD-ROM drive, you added another cable to the back of the tape unit. The tape unit must then be terminated as well. Most external units are terminated with a SCSI cap—a small connector that plugs into the unused external SCSI connector. These external drive connectors come in two varieties: a SCSI cap and a pass-through terminator. The cap is just that; it plugs over the open connector and covers it. The pass-through terminator, however, plugs into the connector and has an open end that you can use to plug the SCSI cable into. This type of connector is essential if your external drive has only one SCSI connector; you can plug the drive in and make sure that it's terminated—all with one connector.

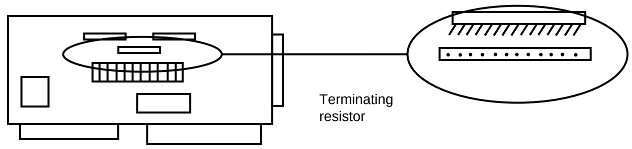

Fig. 15.10
SCSI adapter card terminating resistors.

Note

Some external drives have internal termination. In other words, the manufacturer installed terminating resistors, much like the ones installed on the adapter card, onto the drive's IC board inside the drive case. If your drive has internal termination, you must not put a terminator cap on the external connector.

Example Two: Internal Chain and Termination. The same rules apply—all the internal devices must have unique SCSI ID numbers, and the first and last devices must be terminated. In the case of internal devices, however, you must check for termination. Internal devices have terminator packs or resistors similar to the ones installed on your adapter card. If you install a tape unit as the last device on the chain, it must have resistors on its circuit board. If you place your CD-ROM drive in the middle of this chain, its resistors must be removed. The adapter card, at the end of the chain, keeps its resistors intact.

Note

Most internal SCSI devices ship with terminating resistors on board. Check your user's manuals for their locations. Any given device may have one, two, or even three such resistors.

Example Three: Internal and External SCSI Devices. If you mix and match external as well as internal devices, follow the rules. The example shown in figure 15.11 has an internal CD-ROM drive, terminated and set for SCSI ID 6; the external tape unit also is terminated, and is assigned SCSI ID 5. The SCSI adapter itself is set for ID 7, and—most importantly—its terminating resistor packs have been removed.

Note

As with any adapter card, be careful when handling the card itself. Make sure that you ground yourself first. Chip pullers—specially made tweezers found in most computer tool kits—are especially useful in removing resistor packs from adapter cards and internal peripherals such as CD-ROM drives. The resistor packs have very thin teeth that are easily bent. Once bent, they're tough to straighten out and reinsert, so be careful when removing the packs.

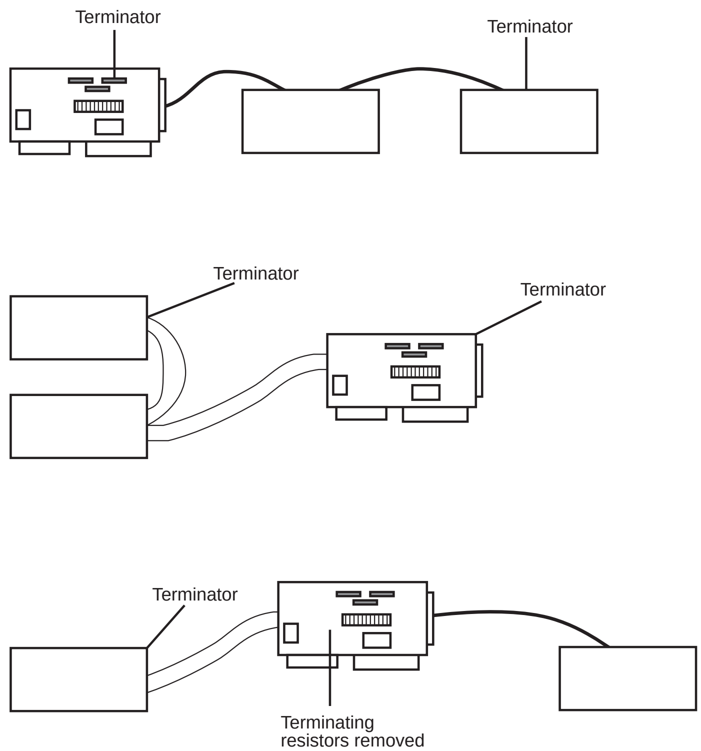

Fig. 15.11
Examples of SCSI termination.

CD-ROM Software on Your PC

After you configure the adapter card correctly, insert it into the PC, and make sure that the drives are connected and terminated properly, you're ready for the last step—installation of the CD-ROM software. The CD-ROM needs the following three software components for it to operate on a PC:

- A SCSI adapter driver
- A SCSI driver for the specific CD-ROM drive you've installed
- MSCDEX—Microsoft CD Extensions for DOS

You can have the first two drivers—the SCSI adapter driver and CD-ROM driver—load into your system at startup by placing command lines in your CONFIG.SYS file. The MSCDEX, or DOS extension, is an executable file added into your system through your AUTOEXEC.BAT file.

SCSI Adapter Driver. Each SCSI adapter model has a specific driver that allows communications between the PC and the SCSI interface. This driver should have been provided with your SCSI drive and adapter kit. Documentation should also have been included that walks you through the installation of the software. You can manually add the SCSI device driver to your CONFIG.SYS file as follows:

At the front of the CONFIG.SYS file, add the name and path of the driver with the DEVICE= command:

```
DEVICE=C:\DRIVERS\MYSCSI.SYS
```

C:\DRIVERS is the subdirectory in which you copied the SCSI device driver. Some drivers have option switches or added commands that, for example, enable you to view the progress of the driver being loaded.

CD-ROM Device Driver. This driver, as well, should be a part of your basic installation kit. If not, contact the drive's manufacturer for the proper device driver for your SCSI card.

The device driver should come with an installation program that prompts you for the memory I/O address for the SCSI adapter on which you installed your CD-ROM drive. This device driver allows communication with the drive through the SCSI bus to your PC. Installation programs add a line similar to the following to your CONFIG.SYS file:

```
DEVICE=C:\DRIVERS\MYCDROM.SYS /D:mscd001
```

C:\DRIVERS is the subdirectory that contains the driver MYCDROM.SYS, the CD-ROM driver for your specific CD-ROM drive.

Note the /D:mscd001 option after the preceding statement. This designates this CD-ROM driver as controlling the first (001), and only, CD-ROM drive on the system. This portion of the device driver statement is for the Microsoft DOS Extension driver, which designates CD-ROM drives in this fashion.

MSCDEX: Adding CDs to DOS. The Microsoft CD Extensions for DOS allow the DOS operating system to identify and use data from CD-ROMs attached to the system. The original DOS operating system had no provisions for this technology, so "hooks" or handling of this unique media are not a part of the basic operating environment. Using these extensions is convenient for all involved, however. As CD-ROM technology changes, the MSCDEX can be changed, independent of the DOS system. For example, most PhotoCD, multiple session CD-ROM drives require MSCDEX.EXE version 2.21, which has been modified from earlier versions to accommodate the newer CD format.

MSCDEX.EXE should be in your software kit with your drive. If not, you can obtain the latest copy from Microsoft directly. The latest version of the DOS extension also is available on CompuServe in the Microsoft forum. If you are a registered user of the DOS operating system, the MSCDEX is free. Read the licensing agreement that appears on the disk or in your manual concerning the proper licensing of your MSCDEX files.

Your installation software should add a line similar to the following to your AUTOEXEC.BAT file:

```
C:\WINDOWS\MSCDEX.EXE /d:mscd001
```

C:\WINDOWS is the directory in which you copied the MSCDEX.EXE file. The /d:mscd001 portion of the command line tells the MSCDEX extension the DOS name of the device defined in the CD-ROM device driver of your CONFIG.SYS file.

Note

The MSCDEX and CD-ROM device driver names must match. The defaults that most installations provide are used in this example. As long as the two names are the same, the drivers can "find" one another.

Sounds complicated? Don't worry. As long as you have these three drivers—the SCSI adapter driver, the CD-ROM driver, and the DOS CD extensions—loaded properly in your system, the CD-ROM drive will operate as transparently as any other drive in your system.

MSCDEX.EXE has a variety of options or switches that you can add to its command line (see table 15.3).

Table 15.3 MSCDEX Command Line Options

Switch	Function
/V	Lists information about memory allocation, buffers, drive letter assignments, and device driver names on your screen at boot up when this option is added to the command line. This option is called Verbose.
/L: <letter>	Designates which DOS drive letter you will assign the drive. For instance, /L:G assigns the drive letter G: to your CD-ROM drive. Two conditions apply: first, you must not have another drive assigned to that letter; and second, your lastdrive= statement in your CONFIG.SYS file must be equal to or greater than the drive letter you're assigning. LASTDRIVE=G would be fine. LASTDRIVE=F would cause an error if you attempt to assign the CD-ROM drive to the G: drive through the /L: switch.
/M: <buffers>	Enables you to buffer the data from the CD-ROM drive. This is useful if you want faster initial access to the drive's directory. Buffers of 10 to 15 are more than enough for most uses. Any more is overkill. Each buffer, however, is equal to 2K of memory. So a /M:10 buffer argument, for instance, would take 20K of memory. Note that this does not significantly increase the overall performance of the drive, just DOS's initial access to the drive and the access of large data blocks when the drive is gulping down live-motion video, for example. You can't turn a 400 millisecond drive into a speed demon by adding a 200K buffer. With no /M: argument added, MSCDEX will add, as a default, 6 buffers anyway. That may be fine for most PCs and CD-ROM drives.
/E	Loads the aforementioned buffers into DOS high memory, freeing up space in the conventional 640K. Early versions of MSCDEX—anything below version 2.1—do not load into extended memory. You must have DOS 5.0 for this option to load.
/K	Kanji support.
/S	Enables you to share your CD-ROM drive on a peer-to-peer network, such as Windows for Workgroups.

Software Loaded, Ready to Run

As mentioned earlier, your drive should come with installation software that copies the device driver files to your hard drive and adds the necessary command lines to your CONFIG.SYS and AUTOEXEC.BAT files.

When this is accomplished, you can reboot your machine and look for signs that all went smoothly in the software installation.

Following is a series of sample portions of your boot up screens to give you an idea of what messages you'll receive when a given driver is properly loaded into the system.

When you're sure that the software is loaded correctly, try out the drive by inserting a CD into the disc caddy and loading it into the CD-ROM drive. Then get a directory of the disc from the DOS prompt by issuing the following command:

```
DIR/w G:
```

This command gives you a directory of the CD you've inserted, if your CD has been assigned the drive letter G (see fig. 15.12).

Fig. 15.12
The directory of a CD after installing the drive.

You can log in to the CD-ROM drive, just as you would any DOS drive. The only DOS commands not possible on a CD-ROM drive are those that write to the drive. CDs, remember, are media that cannot be overwritten, erased, or formatted.

If you logged in to the CD-ROM and received a directory of a sample CD, you're all set.

NOW you can power down the PC and replace the cover.

CD-ROM in Microsoft Windows. When your drive is added to your system, Windows already knows about it through DOS. Suddenly you'll find a few changes in your Windows environment. Open up your File Manager by double-clicking its file cabinet icon (see fig. 15.13). You see your CD-ROM drive among the old, familiar drive icons across the top. Notice that the CD-ROM drive icon is highlighted with a miniature CD disc, and the drive carries the title CD_ROM. Windows knows the media type your new drive is through the DOS extension discussed earlier.

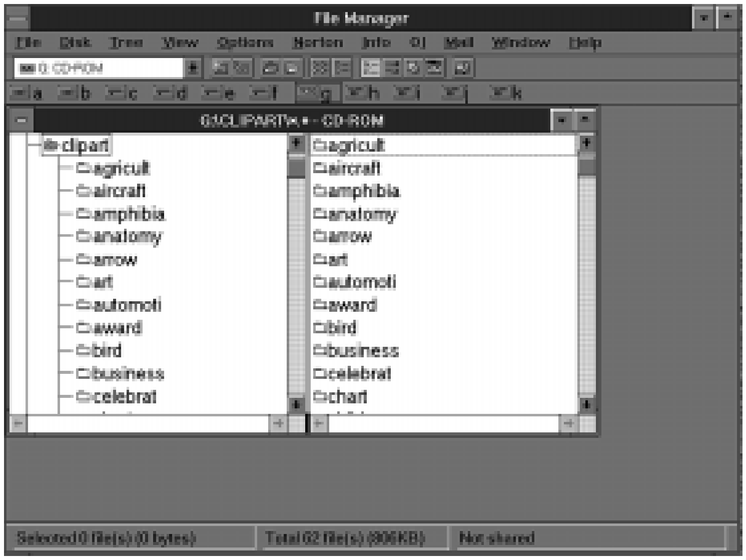

Fig. 15.13
The CD-ROM icon is automatically added to the Windows File Manager window.

Media Player

You can set your CD-ROM player to play audio CDs while you are working in Windows. You need to hook up your drive to a sound card and speakers or connect the CD's audio ports to a stereo first. Go to Window's Control Panel and select Drivers. If you do not see [MCI] CD Audio among the files in the driver's list, choose Add. Insert the Windows installation disk that contains the CDAUDIO driver. When the driver appears on the list, exit the Drivers and Control Panel windows.

Double-click on the Media Player icon. Under Devices, select CD. A listing of the track numbers on your audio CD appears along the bottom edge of the Media Player. The controls on Media Player are similar to those of an audio CD player, including track select, continuous play, and pause (see fig. 15.14).

Fig. 15.14
The Media Player with an audio CD loaded.

Many drive manufacturers supply DOS-based CD audio players with their systems. Check your installation manual and software disks for these utilities.

Summary

This chapter should aid you in selecting, installing, and configuring a typical CD-ROM drive in a DOS- or Windows-based PC. When selecting a drive, remember to pay careful attention to drive specifications, drive quality, and other drive features such as self-cleaning lenses and tray versus caddy operations.

When installing your drive, make sure you follow the manufacturer's recommendations and instructions. What this chapter offers is a generic or basic guide for installation and tips on avoiding trouble spots and misconfiguration.

Finally, whenever possible update your SCSI, CD-ROM, and MSCDEX drivers to the latest revisions; these latest versions may increase performance and compatibility with other PC components and software.