L160
Mrs.Chester

How Compact Disc Read Only Memory Works

In this report I will go into great detail on a optical storage device. The most commonly used optical storage is the CD-ROM which has revolutionized the computer world, with its enormous storage capacity, reliability, convenience, and economic cost.

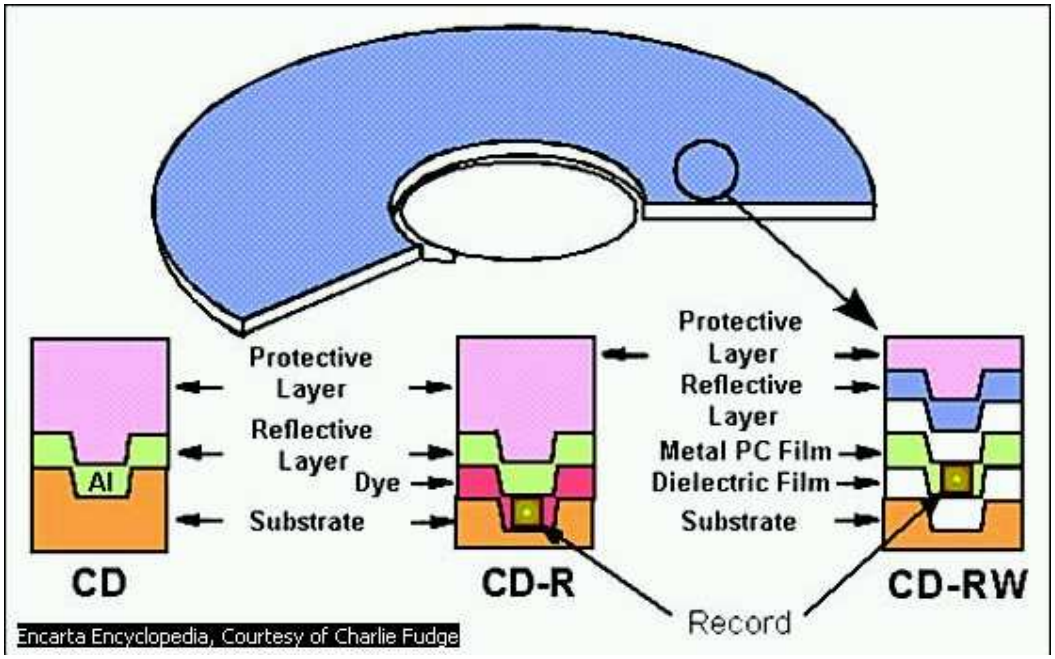
This essay examines CD-ROM operation in detail. It discusses how CD-ROMs work, the basics of CD-ROM media, and the various formats used for storing data and other information such as sound. A discussion on CD-ROM performance, reliability and interfacing is provided, along with a brief look at the newer, recordable CD formats.

History Of The CD-ROM

CD-ROM (Compact **D**isc-**R**ead **O**nly **M**emory**)** created by Sony and Philips is an optical disc that can be read thousands of times. To the normal person the CD-ROM was made only to read information. The First CDs, came to the market about 1982 and was an audio CD, (digitally stored music or sound), which played 74 minutes of audio information. The computer version (CD-ROM) came out in 1984 and was designed to store computer data in addition to audio data. This technology took a few years to catch on due to the lack of interesting content of the programs available. Once programmers and software writers realized the storage capacity they were able to create long complex programs involving video, sound, and data. It created a whole new CD-ROM software market. CDs can store up to 1 gigabyte (1 billion bytes). Common storage size is 650MB (megabytes) 650 million pieces of information. A single CD-ROM disk has the same storage capacity as a 700 floppy disk or 300,000 text pages. CDs can store a combination of computer data, VHS-quality full-motion video and audio data, photographs and other pieces of info. Today in the year 2003, CD-ROM drives are mass-produced and are faster, cheaper and easy to attach to your computer. There are internal, external, and portables drives with single or multitask reads to use with **SCSI** (**S**mall **C**omputer **S**ystem **I**nterface) or **EIDE** (**E**lectronic **D**ata **I**nterchange **E**nhanced) interface. CD-ROM drives have become a common componet on the computer, this allows a vast range of software to be delivered to the CD-ROM and can run many other programs such as databases, programs, and games. They are run directly off the CD-ROM drive. A person can find thousands of games, books or a set of encyclopedias on the CDs along with software application, presentations, and other multi-media programs. These all are available on CD-ROM.

The CD-ROM

The underside of the plastic CD-ROM disk is coated with a very thin layer of aluminum that reflects light. Data is written to the CD-ROM by burning microscopic pits into the reflective surface of the disk with a powerful laser. The data is in digital form, with pits representing a value of 1 and flat spots, called land, representing a value of 0. Once data is written to a CD-ROM, it cannot be erased or changed, and this is the reason it is termed read-only memory. Data is read from a CD-ROM with a low power laser contained in the drive that bounces light—usually infrared—off of the reflective surface of the disk and back to a photodetector. The pits in the reflective layer of the disk scatter light, while the land portions of the disk reflect the laser light efficiently to the photodetector. The photodetector then converts these light and dark spots to electrical impulses corresponding to 1s and 0s. Electronics and software convert this data and accurately access the information contained on the CD-ROM.

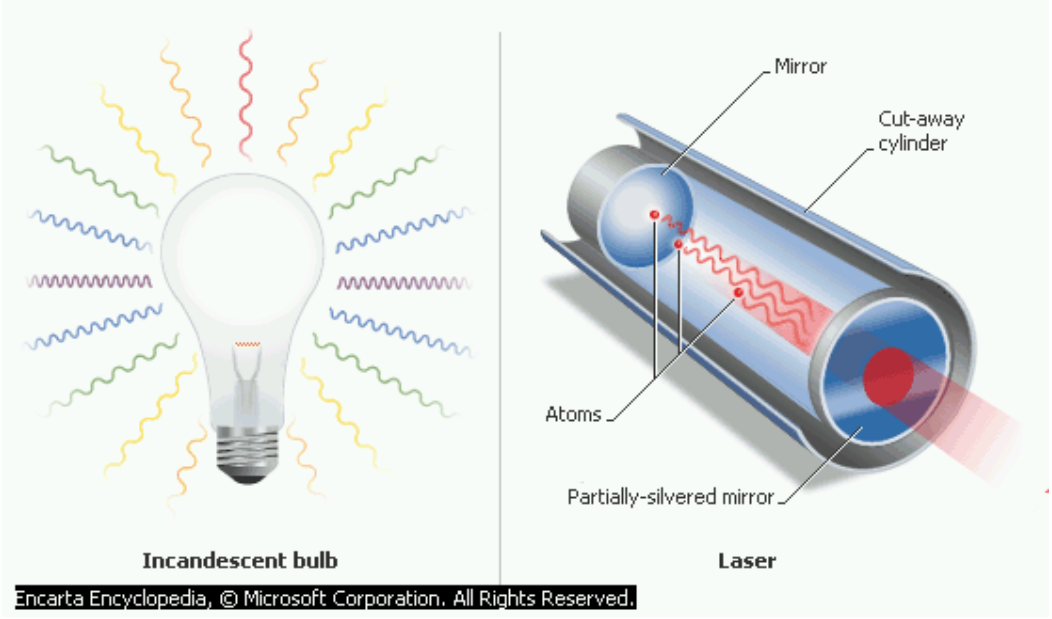


CD-ROMs can store large amounts of data and so are popular for storing databases and multimedia material. The most common format of CD-ROM holds approximately 630 megabytes.

CD-ROMs and Audio CDs are almost exactly the same in structure and data format. The difference between the two lies in the device used to read the data either a CD-ROM player or a compact disc (CD) player.

Both types of players spin the discs to access data as they read the data with a laser device.

Laser, a device that produces and amplifies light. The word laser is an acronym for Light Amplification by Stimulated Emission of Radiation. Laser light is very pure in color, can be extremely intense, and can be directed with great accuracy. Lasers are used in many modern technological devices including bar code readers, compact disc (CD) players, and laser printers. Lasers can generate light beyond the range visible to the human eye, from the infrared through the X-ray range.



Lasers are generally classified according to the material, called the medium, they use to produce the laser light. Solid-state, gas, liquid, semiconductor, and free electron are all common types of lasers.

CD-ROM players only spin the disc to access a sector of data and copy it into main memory for use by the computer, while audio CDs spin throughout the time that the audio recording is read out, directly feeding the signal to an audio amplifier.

The most important distinguishing feature among CD-ROM players is their speed, which indicates how fast they can read data from the disc. A single-speed CD-ROM player reads 150,000 bytes of data per second. Double-speed (2X), triple-speed (3X), quadruple-speed (4X), six-times speed (6X), and eight-times speed (8x) CD-ROM players are also widely available.

Byte, in computer science, a unit of information built from bits, the smallest units of information used in computers. Bits have one of two absolute values, either 0 or 1. These bit values physically correspond to whether transistors and other electronic circuitry in a computer are on or off. A byte is usually composed of 8 bits, although bytes composed of 16 bits are also used. See Number Systems.

In a few short years, the *Compact Disk - Read Only Memory* (CD-ROM) drive has gone from luxury to inexpensive necessity on the modern PC. The CD-ROM has opened up new paths that were never possible before, due to its high capacity. In many ways, the CD-ROM has replaced the floppy disk drive, but in many ways it has allowed us to use our computers in ways that we never used them before. In fact, the "multimedia revolution" was largely a result of the availability of cheap CD-ROM drives.

CD-ROMs use compact disks, in fact, the same physical disk format as the ones we use for music. Special formatting is used to allow these disks to hold data. As CD-ROMs have come down in price they have become almost as common in a new PC as the hard disk or floppy disk, and they are now the method of choice for the distribution of software and data due to their combination of high capacity and cheap and easy manufacturing.

CD-ROM drives play a significant role in the following essential aspects of your computer system:

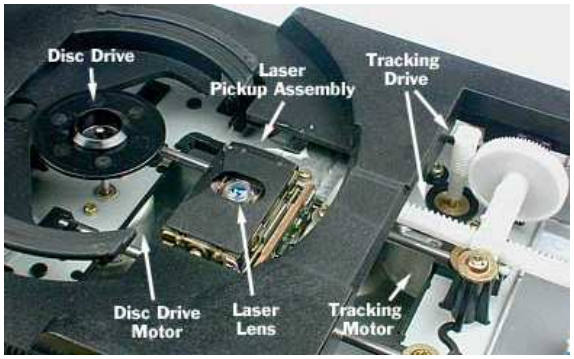
- **Software Support:** The number one reason why a PC today basically *must* have a CD-ROM drive is the large number of software titles that are only available on CD-ROM. At one time there were a few titles that came on CD-ROM, and they generally came on floppy disks as well. Today, not having a CD-ROM means losing out on a large part of the PC market. Also, some CD-ROMs require a drive that meets certain minimum performance requirements.
- **Performance:** Since so much software uses the CD-ROM drive today, the performance level of the drive is important. It usually isn't as important as the performance of the hard drive or system components such as the processor or system memory, but it is still important, depending on what you use the drive for. Obviously, the more you use the CD-ROM, the more essential it is that it perform well.

There are many types of CDs out on the market with different formats that will work in certain CD players. Each type of CD had been assigned a color and a book that clearly itemizes and identifies different formats. All audio CDs are listed in the Red Book. All CD-ROM discs are listed in the Yellow Book, and are Red Book compatible.
Here is a list of different types of CD's with their formats.

- **Red Book-** most common CD standard specialized in audio information
- **Yellow Book-** CD-ROM standard for computer data storage.
- **CD-ROM XA**-separate extension to Yellow Book
- **Green Book** -CD-i interactive disc
- **Orange Book-** defines recordable CDs and multisession capability
- **White Book** - defines VideoCD specification
- **Blue Book -** Enhance music CD specification Higher standard then Red Book
- **CD-I Bridge**-Philips/Sony specification for CDs to play on CD-i players.
- **Photo CD -** specified by Kodak and Philips specialized in photo formats based on

CD-ROM Drive Construction and Operation

In terms of construction and basic components, CD-ROMs are similar to other storage devices that use circular and spinning media. The big difference of course is the way the information is recorded on the media, and the way that it is read from the media as well. This section takes a look at the basics of how CD-ROM drives are constructed and how they work.



Here's how the CD-ROM works.

The **CD-ROM drive** is a device that reads information from a CD-ROM disk. CD-ROM players can be placed either internally or externally, and can be connected to the computers SCSI interface or parallel port.

A player reads information from the CD's spiral track of pits and **lands**, (areas around the pits) from the center moving outward.

It uses a low powered infrared laser beam, 780 nanometres wide, generated by a small gallium arsenate semiconductor, it then fires it through a clear optical grade polycarbonate plastic layer (bottom portion of disk), onto the metallic sheet.

As the disc rotates, the light bounces off the pits and lands, these change the frequency of the light.

The reflected light passes through a prism and onto a photo sensor, the output of which is proportional to the amount of light it receives. Light reflected from a pit is 180 degrees out of phase with the light from the lands.

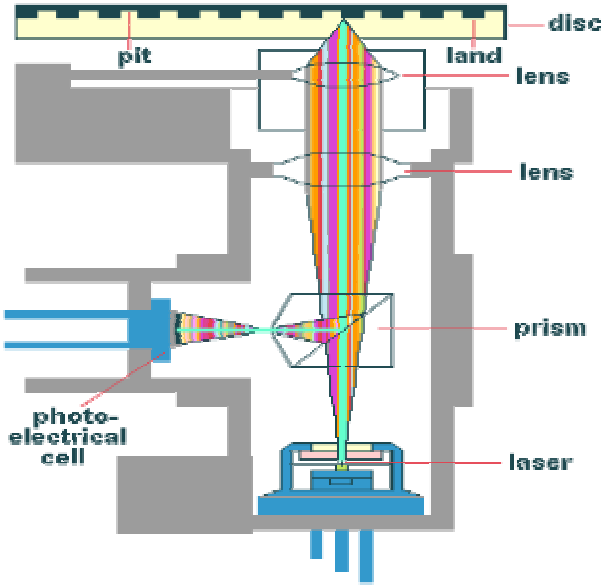
The differences in the intensity of the lights are measured by the photoelectric cells and converted into electrical pulses.

The results are that the series of pits and lands of varying lengths stamped into the surface of the disc are seen as a series of corresponding 0s and 1s from which the data or via a digital-to analogue converter (DAC), the audio stored on the disc is recreated.

Optical "Head" Assembly

The middle two letters in "CD-ROM" stand for "read only", so it shouldn't be any surprise that standard CD-ROM drives are read only devices, and cannot be written to. Most people know this anyway because CD-ROMs use the same basic technologies that CD audio players have for many years, and everyone knows that these devices can only play back, not record.

The reason that the word "head" say that CD-ROM drives do not use a read head in the conventional sense the way a floppy disk or hard disk does. It isn't just that the head cannot record, it really isn't a single solid head that moves over the surface of CD-ROM media, reading it. The head is a lens sometimes called a *pickup* that moves from the inside to the outside of the surface of the CD-ROM disk, accessing different parts of the disk as it spins. This is just like how a hard disk or floppy disk head works, but the CD-ROM lens is only one part of an assembly of components that together, read the information off the surface of the disk.



Most of these components are fixed in place; only the head assembly containing the mirror and read lens moves. CD-ROMs are of course single-sided media, and the drive therefore has only one "head" to go with this single data surface.

Since the read head on a CD-ROM is optical, it avoids many of the problems associated with magnetic heads. There is no contact with the media as with floppy disks so there is no wear or dirt buildup problem. Dirt on the media can cause problems for CD-ROMs, and over time dust can also form on the focus lens of the read head, causing errors as well.

Head Actuator Mechanism

Most people don't think of a CD-ROM drive as having a head actuator, in the sense that a hard disk or floppy disk drive does. In fact, however, the lens assembly does move across the CD-ROM media in a similar way to how the heads on a hard disk or floppy disk drive do.

As described in the section on the read head, only part of the whole mechanism used to read the CD-ROM actually moves. This is the lens and mirror assembly that focuses the laser energy onto the surface of the disk. The technology used to move the read head on a CD-ROM drive is in some ways a combination of those used for floppy disk drives and for hard disk drives.

Mechanically, the head moves in and out on a set of rails, much as the head of a floppy disk drive does. At one end of its travel the head is positioned on the outermost edge of the disk, and on the other end it is near the hub of the CD. However, due to the dense way the information is recorded on the CD, CD-ROM drives cannot use the simple stepper motor positioning of a floppy disk

Instead, the positioning of the head is controlled by an small microcontroller and servo system. This means that the alignment problems found on floppy drives are not generally a concern for CD-ROM drives, and there is some tolerance for a CD that is slightly off center (but not a lot).

Spindle Motor, Constant Linear Velocity (CLV) and Constant Angular Velocity (CAV)

Like all spinning-disk media, the CD-ROM drive includes a spindle motor that turns the media containing the data to be read. The spindle motor of a standard CD-ROM is very different from that of a hard disk or floppy drive in one very important way: it does not spin at a constant speed.

Standard hard disks and floppy disks spin the disk at a constant speed. Regardless of where the heads are, the same speed is used to turn the media. This is called *constant angular velocity* (*CAV*) because it takes the same amount of time for a turn of the 360 degrees of the disk at all times. Since the tracks on the inside of the disk are much smaller than those on the outside of the disk, this constant speed means that when the heads are on the outside of the disk they will traverse a much longer linear path than they do when on the inside. Hence, the linear velocity is not constant. Newer hard disks take advantage of this fact by storing more information on the outer tracks of the disk than they do on the inner tracks, a process called zoned bit recording. They also have higher transfer rates when reading data on the outside of the disk, since more of it spins past the head in each unit of time.

CD-ROMs take a different approach. They adjust the speed of the motor so that the linear velocity of the disk is always constant. When the head is on the outside of the disk, the motor runs slower, and when it is on the inside, it runs faster. This is done to ensure that the same amount of data always goes past the read head in a given period of time. This is called *constant linear velocity* or *CLV*.

Early CD players did not have the necessary smarts or buffer memory to allow them to deal with bits arriving at a different rate depending on what part of the disk they were using. Therefore, the CD standard was designed around CLV to make sure that the same amount of data would be read from the disk each second no matter what part of it was being accessed. CD-ROMs were designed to follow this way.

The speed of the spindle motor is controlled by the microcontroller, tied to the positioning of the head actuator. The data signals coming from the disk are used to synchronize the speed of the motor and make sure that the disk is turning at the correct rate.

The first CD-ROMs operated at the same speed as standard audio CD players: roughly 210 to 539 RPM, depending on the location of the heads. This results in a standard transfer rate of 150 KB/s. It was realized fairly quickly that by increasing the speed of the spindle motor, and using sufficiently powerful electronics, it would be possible to increase the transfer rate. There's no advantage to reading a music CD at double the normal speed, but there definitely is for data CDs. So the double-speed, or 2X CD-ROM was born. It followed in short order with 3X, 4X and even faster drives. This is discussed more in the performance section.

All of these drives up to about 12X or so still vary the motor speed to maintain constant linear velocity. As the speed of the drives has increased, many newer drives have come out that actually revert back to the CAV method used for hard disks. In this case, their transfer rate will vary depending on where on the disk they are working, again, just like it does for a hard disk. Some drives actually use a partial CLV or mixed CLV/CAV implementation where the speed of the disk is varied but not as much as in a true CLV drive.

The change back to CAV as the drives get faster and faster is being done due to the difficulty in changing the speed of the motor when it is going so fast. It is one thing to change a disk spinning at 210 RPM to 539 and back again, but quite another to change it from 5,040 to 12,936 and then back to 5,040! This spin-up and spin-down action is actually one factor contributing to the slow performance of CD-ROMs especially on random accesses.

This table shows the differences between CLV and CAV:

Characteristic	Constant Linear Velocity (CLV)	Constant Angular Velocity (CAV)
Drive Speed	Variable	Fixed
Transfer Rate	Fixed	Variable
Application	Conventional CD-ROM drives	Faster and newer CD-ROM drives, hard disk drives, floppy disk drives

There are in fact some drives that use a mixture of CLV and CAV. This is a compromise design that uses CAV when reading the outside of the disk, but then speeds up the spin rate of the disk while reading the inside of the disk. This is done to improve the transfer rates at the inside edge of the disk, which can be 60% lower than the rates at the outside of the disk in a regular CAV drive.

CD-ROMs are getting more advanced all the time, and I doubt that the evolution of the CD-ROM will stop.

By Amit Valand

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