AGARD-AR-341

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ADVISORY GROUP FOR AEROSPACE RESEARCH & DEVELOPMENT

7 RUE ANCELLE, 92200 NEUILLY-SUR-SEINE, FRANCE

AGARD ADVISORY REPORT NO. 341

Guide to Multimedia Storage

(le Guide des mémoires multimédia)

"This publication was prepared as part of the programme of the Technical Information Committee of AGARD"

NORTH ATLANTIC TREATY ORGANIZATION

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North Atlantic Treaty Organization
Organisation du Traité de l'Atlantique Nord

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Preface

This guide is the result of a joint effort by members of the Technical Information Committee (TIC) of NATO's Advisory Group for Aerospace Research and Development (AGARD). It is intended as a guide to multimedia for the NATO Nations' technical information centers and libraries.

Multimedia is grouped into several broad categories to include CD-ROM, magnetic tape, audio materials, and photo media. The characteristics, benefits, shortcomings, and equipment needs are noted in the discussion.

Since the guide has been compiled by a number of different authors, there may be some minor inconsistencies in presentation between the sections, but it is believed that this will not detract from its value.

Résumé

Le guide des mémoires multimédia présente un inventaire des types de mémoire actuellement disponibles pour l'accès, la restitution et la mémorisation des données. L'ouvrage présente les principaux éléments disponibles. Le guide comprend une bibliographie succincte, qui doit servir d'outil de référence.

Le type de mémoire multimédia utilisé pour la mémorisation et la restitution des données varie selon le volume de données à stocker, la demande d'informations et la capacité de restitution souhaitée. Bien que différentes méthodes de mémorisation existent, la facilité d'accès, le coût, la capacité d'écriture et de lecture et la longévité sont parmi les caractéristiques les plus importantes lorsqu'il s'agit de déterminer les besoins d'un info-centre.

Ce guide fournit des informations sur une douzaine de mémoires principales. Une description est donnée concernant leurs avantages, limitations et résistances ainsi que leurs possibilités en tant que plate-formes, comparaison, capacité de stockage, convivialité, capacité de copie, procédures de répertorisation et normes informatiques.

Le guide traite de trois grandes catégories de mémoire. La première catégorie concerne les mémoires optiques. Les mémoires CD-ROM, les disques optiques et les mémoires photo CD-ROM sont examinés. La seconde catégorie concerne les mémoires magnétiques. Ce groupe comprend la bande magnétique, la bande magnétoscopique, la cassette de bande magnétique et la cartouche de bande, les disquettes, les disques durs et les mémoires amovibles. La troisième catégorie correspond aux autres types de mémoire. Ce groupe comprend les moyens photographiques, sonores et cinématographiques.

Quelle que soit la mémoire employée, la réussite dans ce domaine passe par une gestion efficace, qui permet l'accès immédiat aux informations selon besoin.

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1. INTRODUCTION

The guide to multimedia is a review of the current storage devices available for accessing, retrieving, and storing information. The discussion addresses the principal devices available. A selected bibliography is provided as a reference tool for further inquiry.

The type of multimedia devices used in an information storage and retrieval environment will vary with the size of the collection, the demand for information, and the retrieval capability required. While there are several methods of storage available, ease of access, cost, reading and writing capabilities, and durability are a few of the issues that should be addressed in determining the needs of an information center.

This guide provides information on twelve major storage devices. A description is provided on their benefits, limitations, durability, platform capabilities, comparison, storage capacity, physical characteristics, data capacity, ease of use, copying capability, cataloguing rules and data standards.

There are three major groupings to this guide. The first is optical storage capability. CD-ROM, optical disk, and photo CD are reviewed. The second is magnetic storage. This grouping includes magnetic tape, video tape, tape cassette and cartridge, floppy disk, hard disk, and removable storage systems. The third grouping is defined as other media storage. Photo media, audio material and motion picture comprise this group.

Regardless of the storage device used, the key is effective management to enable immediate access to information when required.

2. OPTICAL STORAGE

2.1 CD-ROM

A CD-ROM disc can hold vast amounts of data, not just text, but also pictures, sound, and animation. CD-ROM can store 600-700 MB of data. When a CD-ROM contains any combination of video, sound, text, graphics and/or automation, the product is considered a multimedia. It can also be mass produced very cheaply. CD-ROM is compact, lightweight, and durable. Best of all, information contained on a CD-ROM disc is indexed and cross-referenced so that you can quickly find and display any piece of data on the disc. It is also becoming the dissemination medium of choice due to its long storage life relative to other media.

At first, its use was limited to high-tech applications and large companies and libraries with a need to distribute large amounts of information. Recently CD-ROM drives have become so affordable and CD-ROM applications have become so useful and entertaining, that many smaller companies are finding that CD-ROM is within their reach. Because of their durability, large capacity, small size, and capability of storing text, graphics, sound, and animation, CD-ROM discs are the medium of choice for multimedia applications.

Benefits of CD-ROM

CD-ROM disk drives not only meet the rapidly growing demands for storage capacity in the computer industry, but promise to revolutionize the way computers are used. As a result, CD-ROM drive will eventually be as basic a part of a personal computer as a hard disk.

The most important benefits of the CD-ROM discs are:

<u>Capacity</u>

Many software companies find that it is more cost effective to distribute their software on CD-ROM than on floppies. For example Lotus 1-2-3 Version 1.1 with smart help for Windows environment is distributed on CD-ROM because it contains 177 MB of program, data, graphics and sound. Distributing this on 1.44 MB floppy disks would take 123 (pure coincidence) disks, and most users would not have the disk space, time, or patience to load it all. If you use the CD-ROM version you can copy only the necessary program files to the hard disk.

Durability

CD-ROM discs and drives are durable. You cannot have a head crash or you cannot accidentally delete files from a CD-ROM disc. You never get cross-linked cluster or a scrambled File Allocation Table. CD-ROM discs have a long life span. Your ability to read data from a CD-ROM is generally not impaired by minor scratches, dust, fingerprints, magnetic fields, or other common computer media hazards.

Cross-Platform Compatibility

CD-ROM drives are not restricted to use on the IBM PC. They work equally well on Macintosh, Sun, DEC, and other systems that can use a SCSI interface device. The drives work with any of these systems, and data in the CD-ROM (ISO 9660) format is accessible through any of these systems. This compatibility produces an enormous cost savings over distributing three separate databases on other media.

CD Audio Compatibility

As multimedia moves from marketing department hype to real-world applications, CD-ROM becomes even more compelling as a distribution medium. Multimedia applications are necessarily large because of the size requirements of full screen, full color graphics, sound files, animation files, and soon, 30 frame-per-second full motion video. No other medium is available that allows multimedia application to reach the personal computer user at a reasonable cost, both for the media itself, and the hardware that it takes to access it. When true CD quality audio is a feature in an application, only CD-ROM has the capability to play it.

What is a CD-ROM?

A CD-ROM disc and a CD audio disc are both made from polycarbonate, which is the same material used in the production of motorcycle helmets and bulletproof glass. Although the material is extremely durable and resistant to damage, you should handle discs carefully and keep them clean. CD-ROM is an acronym that stands for Compact Disc Read Only Memory. This name may be an unfortunate choice because Compact Disc Data more clearly describes what CD-ROM is all about. Read Only Memory (ROM) refers only to the fact that unlike floppy disks, hard disks, or tape (also known as magnetic media), you cannot write data to a CD-ROM disc. Note that CD-ROMs are called discs, whereas floppy and hard drives are called disks.

Even though audio CD discs and CD-ROM discs look exactly the same, they are different. The real differences are first that audio CDs contain only music (and sometimes graphics), and CD-ROM discs can contain text, graphics, sound, animation or video and second the different way that they store data. But some software programs, however, enable you to play audio CDs in a CD-ROM drive. As a result, some discs contain tracks of both data and digital audio. These discs usually are called mixed mode or multimedia discs. If a disc contains data tracks and music tracks, the first track always contains data, or the CD-ROM format. If the disc has a data track, it is always considered to be a CD-ROM disc, even if most of the information on the disc is an audio format.

CD-ROM Standards

The compact disc is a result of a joint venture by Sony and Philips. The CD audio specification, which describes the physical characteristics concerning the size of the pits and lands that represent data and their arrangement in a spiral, was announced in 1980. This standard, known as the Red Book standard because of the color of the binder in which it was published, was introduced as a way to ensure that any audio CD would play in any CD audio player. The CD-ROM disc is an offshoot of the CD audio disc, and the CD-ROM specification, also known as the Yellow Book, is an extension of the CD audio specification. This specification enabled the manufacturer to place different kinds of data on a CD-ROM. The standard, however, is concerned only with the physical characteristics of the disc. A standard was still needed to ensure compatibility in the way that data was organized into files.

In November of 1985, industry leaders involved in CD-ROM research and development met at High Sierra Casino and Hotel Lake Tahoe, California, and agreed to develop an industry standard. The High Sierra Group as it came to be known, consisted of people from Apple

Computer, Digital Equipment Corporation, Hitachi, LaserData, Microsoft, 3M, Philips, Reference Technology Inc., Sony Corp. , TMs Inc., Video Tools (which later became Meridian Data, Inc., and XEBEC. The High Sierra Group's goal was to create a method to organize CD-ROM sectors into logical blocks or records and then to arrange those blocks into files. The result of the High Sierra Group's collaboration is sometimes referred to as the High Sierra Standard. This standard was later adopted with a few modifications, by the International Standards Organization as ISO 9660. This standard ensured that any CD-ROM disc would be accessible in any CD-ROM drive attached to computers that use different operating system. The ISO 9660 standard is one of the advantages that CD-ROM has over WORM (Write Once Read Many) and magneto optical (erasable) technology. Although both these mediums use laser optical technology, neither has universal standards.

JPEG

The Joint Photographic Experts Group developed a data compression standard referred to as JPEG. It is an image compression format based on lossy compression. This scheme actually loses some of the data needed to reconstruct an image; however, the loss is not noticeable to the human eye. JPEG converts from RGB to make compression simpler and arranges the colors in the image to determine which are more commonly used. The less frequently used colors can be dropped.

Images are broken down into small blocks. Each block is compressed before moving on to the next. This allows for compression on the fly; however, block boundaries can become over emphasized, distorting an image at high compression rates. JPEG also has difficulty handling colors that involve high frequencies. JPEG can realize compression ratios of 20:1 without seriously distoring the image.

MPEG

An ISO committee referred to as the “Moving Pictures Expert Group” has developed a digital video compression technique which encodes video and audio streams together into a format that allows playback by a compact disc reader. This standard is formerly known as “MPEG” and addresses the critical technical issues of storage capacity and bandwidth when video is written to a CD. Efficient compression is crucial as video playback requires 30 frames per second. The net result is a minimum of 5MB storage requirement per second of video. Standard compact disc reader, however, can only transfer 154KB of data per second. There are three different audio frame types provided in MPEG. They are, intra, predicted, and bi-directionally predicted.

MPEG encoding is usually performed with a video compression card that is inserted into a CD-ROM publishing workstation. Although there are a few products that offer a complete software encoding capability, the hardware approach is more practical due to the enormous CPU processing requirements. This is particularly true if you want to encode in "real-time" so you can monitor the quality of the video as you encode it.

For MPEG video playback, software solutions are workable; however, it is recommended that MPEG video playback cards be used for better resolution. These cards are now more affordable to the typical multimedia user.

MPEG is now in its second version, MPEG-2. The second version has refined audio compression and improved video encoding of data rates from 1.65MB per second to more than 60MB per second. Also, new algorithms are being defined that will provide support for additional audio channels for surround-sound applications. The next version, MPEG-4, is expected to provide low bit-rate audio/video encoding.

Comparing CD-ROM and CD Audio

On an audio disc, music is digitized using Pulse Code Modulation (PCM) and the sound wave is sampled or broken into a series of numbers (samples). The sampling rate is 44.1 kHz. In other words. 44,100 samples are taken every second. Each sample contains 16 bits of information which means that there are 65,536 possible values. The value closest to the signal is assigned to the sample. Each sample is then converted into a series of binary numbers, zeros and ones. Error correction code (CIRC or Cross-Interleaved Reed-*Solomon* code) is added to the digitized music data. This briefly can be described as performing a series of calculations on the binary numbers and including the results on the disc itself. When the disc is later decoded by the CD audio player, these calculations are performed again, and the results compared. Any errors found can then be corrected.

Cross-Interleaved Reed-Solomon Code is a complex method of interleaving and adding parity bits to data to ensure that errors produced by scratches or dirt on the surface of the disc can be detected and corrected. Layered EDC/ECC is used on CD-ROM discs. It is an error detection and correction scheme that consists of extra error codes layered over the CIRC used in every CD audio discs. ECC for CD-ROM uses polynomials and complex Galois fields to perform checksums on the data in the header and data blocks of sector. The information generated by these calculations (a polynomial) is stored in the EDC/ECC area of each sector. When the disc is read, the calculations are performed again, and the resulting polynomial is compared with the information stored in the EDC/ECC area of the sector (EDC=Error Detection Code, ECC=Error Correction Code). If this information does not match, the error detection code can calculate the location of the error and the error correction code can generate the correct data extrapolation. In CD-ROM recordings, the process is different only up to the point of manufacturing the disc. The data, which can be text, graphics, sound, animation, or video, is encoded by a different process, which includes CIRC, CRC (Cyclic Redundancy Check), EDC (Error Detection Code), and ECC (Error Correction Code). This process is sometimes called layered ECC, because it uses the CIRC method as a basis for the extended error correction of CD-ROM. The process adds numbers to the beginning and end of pieces of data, or packets to ensure that the data is read correctly despite any foreign particles or scratches on the surface of the disc.

Very little error correction is performed on an audio disc in comparison to a CD-ROM disc because your ears are not sensitive enough to hear an error on audio disc that would be catastrophic on a data disc. CD-ROM error correction is so effective that you can expect no more than one incorrectable one-byte error in 2,000 CD-ROM discs. The purpose of using the CD-ROM complicated error correction algorithms is the need for computer data to be exact.

CD-ROM Storage Capacity

A CD-ROM disc can hold 600 to 700 MB of data, or over 1,500 floppy disks, or 300,000 single-spaced typewritten pages, or 24 volumes of an encyclopedia, or 5,000 full-color images. A person reading 1 page per minute nonstop, 12 hours a day, would take nearly 9 months to read the material contained on a single CD-ROM. At 2,400 baud, it would take 32 days to transmit the contents of a CD-ROM via a modem.

What is a CD-ROM Drive?

A CD-ROM drive is the device that can read the CD-ROM disc. It contains an optical head, a turntable for the disc, and a signal processing system. The optical head, which shines the laser on the disc surface is mounted on a sled or swing arm. The head consists of a laser diode, a lens, and a photo detector that reads the laser reflection from the disc. The photo detector also contains several photodiodes that ensure the laser beam is in focus and is following the disc track. The turntable spins the disc at a variable rate of speed. The speed will depend on where the data is being read from the disc. The speed varies from 500 rpm on the inside of the disc to 200 rpm along the outside edge.

The controller is a circuit board mounted inside the drive which integrates several functions that control the focus tracking, turntable motor, rate of spin, and input from user controls. The signal processor demodulates, de-scrambles, decodes, and applies error correction to the data read from the disc. When the drive accesses a CD-ROM disc, the electronics measure the reflection from the laser beam that is focused on the disc track. The reflection from the disc surface varies, depending on whether the light is being reflected from pits in the surface of the disc or from lands. Lands are flat areas between the pits. The fluctuation in the intensity of the reflected light is converted to digital data that is decoded into programs or data by the CD-ROM drive.

CD-ROM Versus Hard Drives

It is unlikely that CD-ROM technology will replace hard drives. Although disc access is getting faster with the advent of triple and quad speed drives, access is relatively slow compared to a hard drive. CD-ROM is primarily a publishing medium, like a book. It is meant to hold static information for reference. The information contained on a hard drive can be written over, deleted, or damaged by virus, an accident, or malfunction. CD-ROM is ideal for data that does not change very often. It is unlikely that CD-ROM will ever be as fast as a hard drive based on the way in which the hard drive storage is configured.

Rewritable CD-ROM discs and drives are under development. Rewritable CD-ROM should not be confused with CD-ROM recording. The latter has been available since 1989. With the use of special equipment, CD-R (CD recordable) recorders enables you to make a single or multiple discs on the desktop. The disc can be written in multiple sessions, but the data cannot be changed. Writable CD-ROM looks and acts like a normal CD-ROM disc with the exception of the disc color. It has gold on the label side and green on the flip side.

Drive Mechanism and Data Layout

CD-ROM is slower than hard disk drives because of the way in which data is stored on a disc and the way in which the data is accessed by the CD-ROM drives. This storage method is why CD-ROM discs can hold so much more information than a hard disk or a floppy disk of the same size. A magnetic disk stores data into concentric tracks and each track contains an equal number of sectors. The files can be stored on one track or many tracks so a lot of updates can be made. If you copy a new file to a disk and the disk does not contain one empty space large enough to hold the file, then the file is copied to several different locations. The File Allocation Table (FAT) is updated with all the locations of the pieces of the file. This process of storing the pieces of the file in different locations is called file fragmentation.

The magnetic disk spins constantly at a non-varying speed during seek, read, and write operations. This process is called Constant Angular Velocity (CAV). In contrast, a CD-ROM disc contains data in one continuous spiral track, divided into sectors of equal size and density. Files are not fragmented, but reside on continuous sectors within the single track. A CD-ROM drive spins the disc at a variable rate of speed, depending on the optical head's position. The data is read from the disc data a constant rate of speed (about 1 meter per second) no matter what location on the disc it occupies. This process is called Constant Linear Velocity (CLV). The information about the location of files is stored in the path table and the directory table, which are located near the beginning of the disc. These tables are created when the disc is manufactured and cannot be changed. The path table contains the file and directory information in a tree-like format, and the directory table contains the address of each directory in an index.

When you access a file, the optical head travels to the approximate location of the data, positions itself within the spiral track, and then refocuses to read the data. The disc's rate of spin must speed up or slow down along the way, which is why a CD-ROM drive takes longer to find a data than a hard drive. When the optical head reads sequential sectors, it must move radially to stay focused within the spiral track as the data passes. The rate of disc spin must decrease gradually as the optical head moves toward the outer edge of the disc. The way in which CD-ROM drives retrieve information from a disc makes the location of files an important factor in the performance of applications. Files near the beginning of the disc can be accessed much more quickly than files at the outer edge. Related files should be placed close together to decrease seek time. Installation files, which may be used only once, should be placed at the end of the spiral track. This process is called optimization.

Physical Characteristics

CD-ROM discs are 12 centimeters (4 3/4 inch) in diameter, just a millimeter thick, and weigh about 14 g. A disc's physical composition consists of a clear polycarbonate, a very thin layer of aluminum, and a lacquer protective coating. As I mentioned, a CD-ROM disc can hold up to 680 MB of data in the form of microscopic pits arranged in a single spiral track. A pit is about a half-micron wide, about the size of 500 hydrogen atoms laid end-to-end with a single CD-ROM containing approximately 2.8 billions pits. The spiral track makes 20,000 revolutions around the disc.

Understanding the Manufacturing Process

The manufacturing processes of a CD-ROM and its popular counterpart, the CD audio disc, are identical. After the data is indexed, formatted, and encoded, a glass master is created by etching a pattern onto a glass surface. This first step creates a polished glass disc that is evenly coated with photoresist, a light-sensitive material. Then a pattern that corresponds to the encoded data is written on the disc by a laser beam. Afterward the disc is developed and the parts exposed to the laser beam are cut away, leaving bumps. The glass disc is then plated with nickel. The nickel plating is separated from the glass to form a metal master. Metal masters can be used as stampers only if a small number of CDs are made. Otherwise, metal masters, called metal fathers, are used to create multiple metal mothers. These metal mothers are used to create stampers. The CD then can be produced by the thousands using these stampers. Reproduced CDs use clear polycarbonate, not glass, as disc material.

CD-ROM Software

Three types of software are needed when you use a CD-ROM drive and an IBM PC or compatible. The first is the CD-ROM device driver software, the second is the Microsoft Extensions software, and the third is the retrieval software for the particular disc that you are using.

Device Drivers

A device driver is a program that contains the information necessary for the computer to control and/or access a peripheral device such as a CD-ROM drive, a scanner, or a mouse. As a result CD-ROM drives also come with a device driver software that tells the computer how to interact with the CD-ROM drive.

Microsoft Extensions for CD-ROM

Microsoft Extensions for CD-ROM refer to a particular program written by Microsoft called MSCDEX.EXE. This program allows the MS-DOS operating system commands to access a CD-ROM drive. Because the capacity of a CD-ROM drive is greater than MS-DOS is used to dealing with and CD-ROMs use ISO 9660 or High Sierra instead of MS-DOS format to store files, this program is required. For MS.DOS version 6.0 and higher, Microsoft extensions are integrated within the Operating System Software.

Retrieval Software

Retrieval software (sometimes referred to as a search engine or interface) is the software that enables you to access the data placed in indexed form on the CD-ROM discs. A common complaint in the CD-ROM world is that no standards exist for retrieval software. For example, for 10 discs the user may have to use different types of retrieval software.

CD-ROM Cost

The cost to produce a CD-ROM master is approximately $800, and $1.35 for replicating additional copies at a CD-ROM mastering facility.

There are additional charges for data preparation, use of data, and software fees. The price will vary depending on the number of copies ordered and the cost recovery policy. With the advent of CD-WORM (Compact Disk-Write Once Read Many), also called CD-R (CD-Recordable), data originators can replicate individual discs in-house at a lower cost than CD-ROM for limited production runs. CD-R desktop recoding can be replicated for about $10 to $12 per copy.

Glossary of Terms

Access Time — The time required to deliver data from a CD-ROM disc. Access time consists of the time it takes for the optical head to travel to the desired location on the disc (seek time), plus the time it takes to focus the laser on the spiral track, plus the time it takes to transfer the data from disc to the screen or printer.

Algorithm — A mathematical formula to the instructions of a computer program. It is the orderly steps to be taken to solve the problem.

Bit — Binary digit; either a zero or a one. The smallest unit in computer information handling.

Bus interface — An electronic pathway between CPUs and input/output devices. A bus interface for a CD-ROM drive consists of a controller card and cable.

CAV — Constant Angular Velocity is the process by which a disc rotates at a constant rate speed. Examples are hard drives, floppy disks, magneto optical discs, and some video discs.

CD audio — A laser-encoded optical disc that contains digitally encoded information, usually music, defined by the Red book standard. Also called CD-DA (Compact Disc Digital Audio).

CD-ROM — Compact Disc Read Only Memory. A laser encoded optical memory storage medium, defined by the Yellow Book standard.

CIRC — Cross-Interleaved Reed-Solomon Code. A method of error detection and correction used on CD audio discs and as basis for layered ECC on CD-ROM discs. Reed-Solomon codes are especially effective when errors occur in bursts, as on a scratched compact disc. Cross-coding and interleaving break long bursts of errors into smaller error bursts.

CLV — Constant Linear Velocity. A disc that rotates at a varying rate of speed. Examples are CD Audio, CD-ROM and some video discs.

Controller — Specialized processor that controls the flow of data between a computer and one or more peripheral devices.

CRC — Cyclic Redundancy Check. A checksum calculated from data in a CD-ROM packet. It is used to generate EDC (Error Detection Code).

Database — A collection of data, stored in electronic form.

Directory Table — One of two tables contained in the volume descriptor of a CD-ROM. The directory table comprises the file management system for the disc. The directory table is a hierarchical tree structure. Using the directory table is the fastest way to access directories closest to the root.

Directory Tree — A hierarchical database of files. Files are grouped together so that users have access to subsets of files. A directory tree is useful for organizing large numbers of files. On CD-ROM discs, a directory tree and a path table comprise the file management system for the disc.

Disc	Used in reference to optical storage media, such as CD audio, CD-ROM, video, and WORM.
Disk	Used in reference to magnetic media, such as floppy and hard disks.
EDC/ECC	Error Detection Code and Error Correction Code. A special, highly complex and very efficient method of error detection and correction for CD-ROM discs, which is defined in the yellow book specification.
Encode	To convert information into machine or computer-readable format.
FAT	File Allocation Table. Part of the MS-DOS operating system that keeps track of the location of files on disk.
Format	An established system standard in which data is stored.
Fragmentation	Storing parts of a file in disparate, available space on a disk, rather than contiguously.
Glass Master	A highly polished glass disc, coated with photoresist and etched by laser beam that is used at the start of the compact disc manufacturing process.
Indexing	The act of creating a file or files that contain information about the location of specific pieces of data in the files being indexed.
Interface	The link between two pieces of disparate equipment, such as a CPU and a peripheral device. It is also a method of translating data from computer to user.
Interleave	A method of storing information in an alternating sequence of frames.

<u>ISO 9660</u> The international standard CD-ROM file format.

<u>Lands</u> Microscopic flat areas on a compact disc that separate the pits.

<u>Laser</u> Light amplification by stimulated emission of radiation. Amplifies and generates coherent energy in the light region of the spectrum. Laser light contains waves that have the same phase, as opposed to conventional light, whose individual wave phases are unrelated to the phases of the others.

<u>Magnetic Media</u> Any medium on which data is stored as variations in magnetic polarity; usually floppy disks, hard disks, and tape.

<u>Magneto Optical</u> An information storage medium that is magnetically sensitive only at high temperatures. A laser heats a small spot, which allows a magnet to change its polarity. The medium is stable at normal temperatures. Magneto optical discs can be erased and rerecorded.

<u>Megabyte</u> One million bytes or 1,048,576 bytes.

<u>Multimedia</u> Any application that combines text, graphic, audio, and video files.

<u>Operating System</u> A computer program that runs the computer and handles data traffic between the disks and memory.

<u>Path Table</u> One of two tables contained in the volume descriptor of a CD-ROM and which comprises the file management system for the disc. The path table contains the names of all directories on the disc and is the fastest way to access a directory that is not close to the root directory.

Pits — Bumps which represent data, contained in the track of a compact disc.

Polycarbonate — Material from which compact discs are made.

Red Book — The specification standards for Compact Disc Digital Audio.

Retrieval Engine — A program that finds and presents data.

Sampling Rate — Sampling frequency. The number of samples taken per second of an analog signal, expressed in Hertz. A 44.1 kHz sampling rate, used for C3 audio sound that represents 44,100 samples per second.

WORM — Write Once Read Many. A type of permanent optical storage that enables the user to record information on a blank disc. Information can be added until the disc is full, but not erased and changed.

Yellow Book — The physical specification for CD-ROM discs.

2.2 OPTICAL DISK

An optical disk consists of information impressed as a series of pits in a flat surface and is read by optical means, such as a laser. Optical disks are available in many formats such as read only memory, write once and read many and rewritable disks, all utilizing binary digital techniques for storage.

Present Development

Optical storage products are becoming widely available and can be integrated with other kinds of storage media. There is software technology available which allows users to write data to an optical disk without requiring a dedicated application. The optical mediums are transportable and space-efficient. Access speeds are increasing and software that perform tasks on tapes and disks are appearing in optical storage technology.

Data Capacity

Optical disks are available in 14 inch, 12 inch, 5.25 inch, 4 3/4 inch, and 3.5 inch formats. Read only memory stores approximately 650 MB per 4 3/4" disk, rewritable optical disks store between 256 MB and 650 MB per side on a 5.25" disk, and between 128 MB and 256 MB on a 3.5" disk. Write once, read many disks store 256 MB on 3.5" disks, 940 MB on 5.25" disks, 9,000 MB on 12" disks and 10,200 MB on 14" disks.

Copyright Issues

All commercially produced optical disks are protected by copyright laws. Disks personally produced belong to the author.

Storage

Optical disks are space efficient and only require vertical space for the disk and case. They are unaffected by stray magnetic fields, head crashes, shock and humidity. Only excessive cold and heat can warp the disk. The Consultative Committee for International Telephone and Telegraph (CCITT) developed two standard algorithms for compression (ratios range from 7:1 to 30:1) to enable more storage of data.

Ease of Copying

Manufacturing processes involve burning pits in recording surfaces, utilizing bubble forming techniques at about 2000 degrees centigrade, or optically assisted magnetic recording using a laser beam to change the disks' magnetic field. Copying disks is costly, essentially a new disk is created each time.

Ease of End Use

Disks are portable, they contain an immense amount of information per side, and are resistant to mechanical damage. Most disks are designed with menu driven software making their use simple.

Ease of Amendment or Updating

As a read only medium, optical disks are inexpensive. They are, however, expensive to master and duplicate. Costs range from $3,000-$10,000. Disks cannot be updated. Manufacturing master disks is time consuming. Rewritable disks can be easily amended.

Typical Cost

Storage cost run approximately 1 cent per MB. Drives cost from $600-$5,000. Drives for write once disks begin at $2,800 and rewritable drives begin at $2,000. Disks run from $80.00 to $150.00 to thousands for commercially produced CD-ROMs. Disks and drives require a host computer. Costs for purchasing of one, ranges from $1,000-$6,000.

Durability

Optical disks are very durable, and resistant to electromagnetic and mechanical damage. They have an extended life span.

Summary

Optical disks are used for anchoring on-line or near-line storage of large data, intensive images, and for backup of magnetic disks. Distribution of disks is easy due to the size of the packages. CD-ROM technology follows standard ISO 9660. Write once technology follows a split between ANSI XB311 and ISO 9660 standards. CD-ROM drives are slow in the retrieval process of data. They can store more information than write once or rewritable drives. Optical disks are excellent for both temporary and archival storage. They guarantee data integrity due to error protection techniques and durability.

2.3 PHOTO CD

Photo CDs consist of digitized 35mm photographs at a resolution of 2048 x 3072 pixels stored on recordable (optical) compact disks. Images displayed on a TV or photo CD player, can be manipulated from a PC or Macintosh system, across a suitable network.

Present Development Status

Photo CD disks adhere to ISO 9660 standard. Currently no sound, text graphics are available. New software is under development to incorporate these elements.

Data Capacity

Each photo CD disk, (5" compact) holds over 100 35mm photographs with approximately 100 MB of index data and 600 MB of image information.

Copyright Issues

Copyright belongs to the author or photographer of the photographs. Portions of the photo CD system are covered by one or more patents and subject to copyright restrictions.

Storage

The amount of storage required for a 35 mm photograph image will vary according to the color and composition of the photograph.

Ease of Copying

Photo CDs are write once compact disks. New disks from scanned photographs can be created as many times as necessary. Each disk is permanent.

Ease of End Use

The photo CD can be viewed on a television using a photo CD player. Images can be viewed in the order that they are on the disk or can be specifically selected.

Ease of Amendment or Updating

Images can be added to a photo CD disk as desired until it is full. Once a disk is full it cannot be amended or changed.

Typical Cost

Costs include a scanner to digitize film images. There is also photo CD disks, a photo CD player, access software, a computer workstation, a printer, and a photo CD writer to write the images on the CD disk. A photo-finisher can develop 24 photographs and transfer them to photo CD for approximately $20.00.

Format

Picture files are written to the photo CD disk using a Kodak proprietary compression algorithm. Each picture is recorded in 5 different resolutions.

Durability

Digitized data does not deteriorate and has a projected life span of 100 years.

Summary

Photo CD allows display of photographs on television using a photo CD player or multisessional audio CD player. The disk is small, durable, and can be easily mailed. Technology allows manipulating images from any PC or Macintosh system and enables images to be transferred across a network.

3. MAGNETIC STORAGE

3.1 MAGNETIC TAPE - GENERAL PROPERTIES

During the past 25 years the storage and retrieval of information has undergone a tremendous evolution. In the 1960s, off-line (batch) processing of magnetic tapes allowed complex searches of large files. The 1970s were known for the growing importance of on-line services (time sharing). On-line services became widespread and DIALOG in the USA as well as ESA-IRS in Europe built a new industry. In the 1980s millions of microcomputers were widespread in business and professional settings and the idea to use databases on a local PC where data are stored on floppy and hard disks became reality. Companies such as Knowledge Access, Inc., published databases (1985) on floppies and as soon as 1986 planned to start with databases on CD-ROM. CD-ROMs are now used in every library. Floppies as storage media are only used for small databases, such as computer programs or delivery of SDI results, as was proposed by the National Agricultural Library's Current Awareness Literature Service (CALS).

Mass storage is the main problem in the computer industry.
The most popular form of magnetic technology is still the disk, both floppy (flexible) disk and hard disk. The characteristics of both types improved over time. Speed and capacity increased. Also, materials and recording capabilities improved.

In fact, data storage capacity is only limited by physical storage facilities. An important feature is the tradeoff between technology capabilities, access time, and cost per bit. Masses of data need to be stored at the lowest cost per bit. New disk technologies and new recording technologies such as perpendicular recording will make this possible. Those new technologies will, of course, affect future drives and disk formats.

3.1.1 OPERATIONS AND USES OF MAGNETIC TAPE

Magnetic tape is one of the most used medium for storing very large quantities of information. It has a long access time. This makes it a less desirable medium for storage on a high speed computer. Modern mass-production techniques have made the cost of tape very low. This has allowed us to store vast quantities of information inexpensively. Another advantage of magnetic tape is the ability to erase and rewrite information on tape. Magnetic tapes are used mainly as a medium for storage of large amounts of data in backup operations. It has very good storage properties.

The main drawback of magnetic tape is the length of time needed to access stored information. It allows only sequential access to information. This is a very slow process in finding stored records. In contrast, a magnetic disc file allows direct access to a record by using an index key.

In summary, the principal advantage of magnetic tape is its large storage capacity at relatively low cost. It also has good storage characteristics, and its standard is accepted by the data processing community. Its main disadvantage is the accessibility of data on a serial basis only. This is a lot slower than that of disks or computer memory.

3.1.2 SIZES AND TYPES OF TAPES

Tapes are available in 2,400, 1,200, 600, 400, and 200 feet lengths for convenience of use. At a density of 800 bpi, a 2,400 feet reel tape could theoretically hold 23 million characters. Tapes vary from 1/4 to 3 inch in width; however, most tapes are 1/2 inch in width and 1.5 mil thick. A 10.5 inch reel typically has 2400 or 3600 feet of tape. Generally about nine channels or tracks are used for 1/2 in. of width. The surface of the tape is usually in contact with the read-write head. Output signals from the read head are generally in the 0.1 to 0.5 V range.

The medium is reusable and can be erased and remagnetized as many as 10,000 times. Data stored on the tape will remain indefinite unless exposed to excessive heat or fluctuation in magnetic fields, which can erase the data.

Another advantage of using magnetic tape for storing large quantities of data is that the reel of a tape may be changed. In this way the same magnetic tape handling mechanism and its associate circuitry may be used with many different reels of tape, each reel containing different data.

The recording material is a combination of a magnetic iron oxide substance and a binder about 1/2 mil in thickness. Each manufacturer attempts to achieve the most desirable combination of high permeability (ease of recording), high retentivity (retention of recorded data) and high coercivity (resistance to stray fields). There are tradeoffs among these characteristics, influenced by both the oxide layer and the binding agent.

The better quality magnetic tapes have a layer of conductive material on the back of the tape. This coating reduces the buildup of static charges when the tape is being used in a very dry environment. The most common problem with tapes is that the magnetic oxide material becomes relocated from one area of the tape to another. This can cause microscopic bumps which alter signal strength significantly as the tape passes under the read head. Other problem sources are contamination by dirt and loss of dimensional stability because of humidity and high temperature. Often the electronics of the tape drive are less susceptible to malfunction owing to a wide variation of temperature and humidity, than is the tape itself.

After a tape is manufactured, it is tested for a number of characteristics. Normally the manufacturer certifies it for zero permanent errors at a given density if it meets that specification. This mean that data has been successfully recorded and recaptured throughout the length of tape without the discovery of any permanent errors. If the tape fails to pass the later test, the tape is rejected as unsuitable for recording digital data.

3.1.3 RECORDING OF TAPES

The recording technique for magnetic tape is similar in principle to that for other forms of magnetic storage, i.e., disks or drums. The write head is a form of electromagnet wherein a current is manipulated to generate a series of magnetized spots on the tape which correspond to the presence or absence of data. In the read process, as the tape passes the read/write head, the changing flux on the tape induces a voltage in the coil winding. The voltage so induced is amplified and converted back into its original digital form.

A recording head functions as a small transformer with one winding. The recording head is constructed of two pieces which are wound separately and bonded together with some gap material in between. When a current flows through the C-shaped portion of the recording head, a magnetic flux is generated and flows preferably through the tape to the pole piece of the read/write head, instead of flowing through the gap material. Most tape drives record nine tracks in parallel so that a read/write head consists of nine individual recording stations. Eight of the nine tracks records 8 bit, or 1 byte, and the remaining track is used to record parity bits.

Recording densities use the terminology of bits per inch along the longitudinal track. In reality, this means that the actual density is that number of bytes, or frames, per inch, bpi. The recording density varies; however 200, 556, 800, 1600, 6250 and even 12,500 bits/in per channel are fairly standard. Currently, the most commonly used densities are 800, 1,600 and 6250 bpi.

3.1.4 PARTS OF A MAGNETIC TAPE SYSTEM

There are four basic parts to a digital magnetic tape system, they are:

The magnetic tape

This is generally a flexible plastic tape with a thin coating of some ferromagnetic material along the surface.

The tape transport

This consists of a mechanism designed to move the tape past the recording heads at the command of the computer. Included are the heads themselves and the storage facilities for the tape being used, such as the reels on which the tape is wound.

The reading and writing system

This part of the system includes the reading and writing amplifiers and the translators which convert the signals from the tape to digital signals which may be used in the central computing system.

The switching and buffering equipment

This section consists of the equipment necessary to select the correct tape recording formats. If there are several recording formats supported, then one would select the proper format to store information on the tape, and also information to be read from the tape.

The tape transports used in digital systems have two unique characteristics: (l) the ability to start and stop very quickly and, (2) a high tape speed. The ability to start and stop the tape very quickly is important for two reasons. First, since the writing or reading process cannot begin until the tape is moving at a sufficient speed, a delay is introduced until the tape gains speed, slowing down operation. Second, information is generally recorded on magnetic tape in "blocks" or "records." Since the tape may be stopped between blocks of information, the tape which passes under the heads during stopping and starting processes is wasted. This is called the interblock or interrecord gap. Fast starting and stopping conserves tape.

To accelerate or decelerate the tape very quickly, an effort is made to isolate the tape reels, which have a high inertia, from the mechanism that moves the tape past the recording heads. There is a high speed start-stop tape mechanism which uses a set of tension arms around which the tape is laced. The upper and lower tension arms are movable, and when the tape is suddenly driven past the heads by the capstan, the mechanism provides a buffering supply of tape. A servomechanism is used to drive the upper and lower reels, maintaining enough tape between the capstan and the tape reels to keep the supply of tape around the tension arms constant.

At the read/write station, the movement of the tape is controlled by one or more capstans and pinch rollers. The capstans are low inertia so that they may be quickly brought up to the design speed of the tape drive. With the single capstan, direction of motion is provided by the movement of the capstan and the fact that the tape is mounted, with slight tension, around 180 degrees of its circumference. The dual capstan mechanism depends on pinch rollers to provide a sufficient grip on the tape to move it back and forth across the read/write station.

Ideally spring loaded ceramic washers are provided at the tape guide stations because of their resistance to wear from many passes of the tape medium. The tape will more easily scratch and score a metal surface. The normal course of the tape is to pass over a tape cleaner, an erase head, a write head, and finally a read head.

Because the inertia of the entire reel of tape is too great to be accelerated quickly for each read or write function, slack is maintained between the tape reel and the read/write station. The capstans are at the read/write station then need only to pull the slack tape as it is needed. Two types of mechanisms are used to take up the slack, or feed it, as required. One mechanism is the above mentioned, using tension arms; the other uses vacuum columns.

Historically, the tension arm design depends on the capability of the system to sense the need for more tape and release it by moving the tension arm to reduce the tape tension. As the slack is used up, the tape reel will unreel at one time, several inches of tape which will immediately be taken up into the tension arm mechanism. Tape drives using this design operate at speed up to 50 inches per second. At densities of 1,600 bpi, they can pass data at 80 Kbytes per second.

The other arrangement for isolating the high inertia tape reels from the basis tape drive is based in the use of a vacuum system. This system isolates the tape from the capstan drive by means of two columns of tape held in place by a vacuum.

The tape slack drops inside the chamber between predetermined upper and lower limits. Small inlets are provided near the lower and upper ends of each chamber to permit an airstream to blow across to sense the position of the lower loop of the tape within the chamber. This information is transmitted to the circuitry of the tape drive and will automatically feed more tape into the chamber when the loop reaches its upper point. The action ceases as soon as the loop reaches its lowermost point. Tape drives using this mechanism operate at speeds of 200 inches per second, at densities of 1600 bpi, and can transmit information at a rate of 320 Kbytes per second. A servo system then maintains the correct length of tape between reel and capstan drive.

Using systems of this sort, the stop and start times can be less than 5 ms. These are the times required to accelerate a tape to a speed suitable for reading or writing and the time required to fully stop a moving tape. The speeds at which the tapes move past the heads vary greatly, most tape transports having speeds in the range from 12.5 to 250 in/s. Lincoln Laboratory has constructed a very fast (900 in/s) mechanism in which the tape is driven directly by the reels of the tape transport. The slower tape speeds, combined with fast starting and stopping, are probably more adaptable to systems in which smaller amounts of data must be transferred.

Most tape systems have two-gap read-write heads. The two gaps are useful because, during writing, the read gap is positioned after the write gap and is used to check what has been written by reading and comparing.

3.1.5 RECORDING FORMATS

A number of techniques are used for generating the bit patterns to be stored on the tape. The most common of these are NRZI (Nonreturn Zero Inversion) and PE (Phase Encoding) and GCR (Group Coded Recording).

In the NRZI format, a flux change takes place only when 1 bit is recorded. This has the advantage in that if a flux change is missed, the succeeding bits are still recognized correctly because a change in flux always represents a bit. In the PE format, an O bit is recognized by a flux change in the opposite direction. This means that within the distance in which a bit is to be recorded, a flux transition must take place at the beginning so that a flux change in the proper direction will take place within that bit cell. This requires twice as many transitions for an equivalent amount of data as are involved in NRZI format. The PE recording format, however, has the advantage in that errors in the preceding bit patterns are not propagated in the succeeding data.

Phase encoding also provides a self-clocking capability in that distinct pulses must be generated for each bit cell position. Consequently, if there is a change in the longitudinal dimension of the tape, the self-clocking feature of the PE recording format automatically compensates for it.

Group Coded Recording (GCR) has a higher density (6250 bpi) than either NRZI or PE. This allows for greater storage as more data can be packed on a tape. GCR is, therefore, more commonly used because of its storage capacity.

Data are recorded on tape as a series of records separated by Inter Records Gaps (IRG). A physical record consists of one or more bytes stored in series. It is theoretically possible to load one reel of tape with one continuous record of information. However, the computer addresses information on the tape by physical record number, and for this reason the record length must be kept to a reasonable size. The IRG is usually a 1/2 to 3/4 inch length of blank space on the tape with the purpose of providing a tape length sufficient to permit the tape transport mechanism to come to a halt from its full speed operation, and to start up again from its halted position and return to full speed. In other words, the tape transport must be able to decelerate from full speed to a halt and reverse the process all within the length of an IRG.

A record can be conceived as an 80 column card image containing 80 characters of information. Records can range in size from a single character up to as many characters as can be configured by the specific computer. A recording format holding only 80 characters is somewhat wasteful in that in this case 1/10 inch contains meaningful data for every 3/4 inch of blank space (800 bpi density). Consequently, logical records may be blocked together to form one physical record on the tape. The blocking factor indicates the number of logical records stored within one physical record. To determine the end of a file, a file mark is used.

Data are recorded on magnetic tape using a coding system. Generally one character is stored per row along the tape. The tape has seven or nine tracks or channels, one of which is a parity bit, which is added to make the number of ones in every row odd. Data are recorded on magnetic tape in blocks, with gaps between blocks and usually with unique start and stop characters to signal the beginning and the end of the block.

The codes used to record on tape vary, but two commonly used IBM codes are the BCD and the EBCDIC ones. IBM standard tape is 1/2 in. wide and 1.5 millinch thick; with either seven or nine tracks. In both codes the Os are simply blank and are indicated by a vertical line. Recording densities are 200, 556, 800, 1600 or 6250 bits (or columns) per inch (which means the same number of characters (or bytes) per inch, since a character is recorded in each column).

There is a tape marker a few feet inward from each end, usually a silver strip about 3/4 x 1/8 inch dimension. They are sensed by the tape drive, by means of photoelectric devices, as being the physical limitation for writing on the tape, that prevent overrunning of the tape. The few feet at each end which are not used for recording are allowed so that the tape can be wound on the reel.

In addition to a parity check for each byte of recorded data in a nine track tape, two other check characters are provided, called a Longitudinal Redundancy Check Character (LRCC) and Cyclic Redundancy Check Character (CRCC). Seven track tape drive formats use only the LRCC. During a nine track write operation, the CRCC is developed in the CRC register in the tape driver controller. It is written on the tape 4 byte spaces after the end of the record. The value of the CRCC is calculated on the basis of a polynomial such that the probability of the CRCC missing error is very low.

The LCR character is an odd or even parity count of all the bits in each track of that record. In a nine track format, the count of the bits in the preceding CRCC is included in the LRCC computation. The LRCC is written 4 byte spaces after the CRCC or 4 byte spaces after the last item in the record for seven track formats. In nine track formats the parity bit generates an odd count. In seven track drives, the parity count is odd if binary data are written, but even if BCD data are recorded.

3.2 VIDEO TAPE

Video tape consists of magnetic tape used for recording visual images and sound, in the frequency range of 0-5 MHz. It is a one half inch tape, using helical recording (VHS) format which is compatible nationwide and works with the international standard of the National Television Standard Committee (NTSC), Phase Alternating Line (PAL), and Sequential Couleur a Memoire (SECAM).

Present Development Status

Current development includes finding ways to refine the magnetic tape and further expand the digital videocassette concept. There are efforts under way to seal cassettes to prevent an accumulation of dust particles and loose oxides. With an increase in particle dispersion and orientation high video output will result. Digital videocassettes have been developed using ceramic/metal particles for high durability.

Data Capacity

Data capacity standard is two hours of playing time in the United States. In Europe and Japan, playing time is three hours. NTSC criterion television signals produce/record at 30 pictures per second or 3.33 cm/sec of film at 60 Hz. PAL/SECAM television signals produce/record at 25 frames per second, 1.4 cm/sec of film at 50 Hz.

Copyright Issues

Pictures and sound of videotape can be copyright protected.

Storage

Tapes need to be stored vertically in dust proof containers, free from magnetic fields (computers, TV monitors, audio equipment) in a controlled environment of 60-70 degrees fahrenheit and humidity of 24% or less.

Ease of Copying

Copying can be accomplished without much degradation of the original tape. Each time a tape is played or copied minute degradation of the magnetic tape occurs. After 20-30 playing deterioration of the tape is visible.

Ease of Amendment or Updating

Tapes can be edited and updated using electronic editing. Usually this is done for small changes. Major changes usually require new taping.

Typical Cost

Videotapes usually cost $3.00-$5.00 per 2 hour tape. Tape holders average about $.50. VCR players can cost as little as $150.00 and upwards.

Durability

Tapes last for approximately 200 plays but begin to deteriorate after 20-30 plays. Tapes can last up to 20 years if stored properly. They are adversely affected by dust, debris, head and tape separation, wrinkles, creases, and pressure. Tapes should be at room temperature for 8 hours before play/record. This reduces stretching and fracturing of the oxide particles. Tapes should not be stacked one on top of the other nor struck in any way. Mailing videotapes requires careful labeling so that they are not accidentally exposed to strong magnetic fields, struck nor stacked with other items.

Summary

Videotapes are accurate duplications of audio and visual signals on flexible substrates and soft surface of magnetic tape. Magnetic tapes are semi-fragile requiring careful storage and mailing conditions.

3.3 TAPE CASSETTES AND CARTRIDGES

Magnetic tape and cartridge is a commonly used method of backing-up computer hard disks. The cassettes are small, changeable, and inexpensive; they are frequently used in small "home" computers. The tape move mechanism in the conventional home tape cassette is often used for small systems. This is not of sufficient quality for larger business and scientific computer usage. There are various types of digital and analog available.

There are also larger tape cartridges which contain long strips of magnetic tape and which resemble large cassettes. These cartridges provide a more convenient way to package tape, and greatly simplify the mounting of tape reels. The tape cartridges also provide protection against dirt and contamination, since the tape is sealed in the cartridge.

In tape cartridge technology, thin film read/write heads are used. The use of microprocessors are applied to both the controller and dual drive unit. There is a transfer rate of 3.0 megabytes per second between the control and dual drive. This makes the cartridge an ideal solution for high-performance tape storage requirements.

A number of digital cassettes and cassette drivers are now in production, and each has different characteristics. For example, Data General Corporation offers a cassette drive with an average tape speed of 31 in./s a 282 ft 0.15 in. magnetic tape per cassette, storage per tape of 800,000 bits and transfer (reading) rate of 12,800 bits/s. A 22 in. reflective leader and trailer are used to mark the beginning and the end of the tape (a photo diode senses this strip).

In contrast, Unisys cartridge tape can record data at 37,871 bytes per inch as opposed to the 6,250 bytes per inch on open reel GCR tape formats. Tape cartridges use an 18 channel thin film head versus a 9 channel ferrite head on reel tape. This difference in channels allow for a greater volume of information being stored on a tape cartridge.

In the area of storage, the overall advantage to customers of cartridge to reel tape is significant. For example, four cartridges can fit into the library space allocated for one reel tape.

Cartridges are high performance magnetic tape storage medium. There are several cartridge designs available. These vary not only in performance capabilities, but also in the division of hardware between cartridge and transport. The 3M cartridge and drive are representative; the cartridge contains 300 ft of 1/4 in. tape capable of more than 2 x 10 7 bits. The 3M transport operates at 30 in./s when reading or writing, and at 90 in./s in search mode. A novel elastic band drive moves the tape and also supplies tape tension. Tape drive, hub, and guide components are referenced to the base of the cartridge and require no external guidance. There are several new cartridge systems designed to "back up" Winchester disk drives.

3.4 DIGITAL AUDIO TAPE (DAT)

DAT drives use helical-scan technology to record large amounts of data on very slow moving 4mm tape. There are two magnetic heads each for reading and writing operations. The tape wraps 90 degrees around the rotating drum's circumference, and the heads move in a spiral motion from the bottom to the top of the tape.

There are several formatting standards used by DAT drive makers. The Data/DAT standard developed by Hitachi is efficient in its writing techniques as it allows existing data to be overwritten; however, it is not fast in the data transfer category and does not allow the storage capacity as does the DDS standard which was developed jointly by HP and Sony. DDS drives write data sequentially, appending data the existing information. The DDS standard also allows data to be read randomly, starting at any point on the tape.

DDS is able to pack up to 2 GB of data on a 60 meter tape because it constructs a sequence of fixed-capacity data groups on the tape. To achieve SCSI-2 burst mode compatibility, the DDS standard was enhanced. The new DDS-2 standard doubles the storage density while maintaining full DDS functionality with complete backward compatibility. More recently, DDS-DC was created to provide DDS-2 with a data-compression standard.

3.5 FLOPPY DISKS

Floppy or Flexible disks were developed in the 1970s and exist with a diameter of 8 inch, 5 1/4 inch or 3 1/2 inch. Looking rather like a gramophone record, this flat circular plastic plate, spinning at 600 rpm is capable of holding an enormous amount of data. It allows access to data at an amazing speed. In 1984, almost 600 million units were produced and the market increased annually by some 40 percent. In recent years, floppy disks have become relatively less important than hard disks and optical disks.

A diskette or floppy is a thin flexible disk, enclosed in a protection jacket. The jacket consists of two layers laminated to each other in a vinyl outer layer with a non-woven, lint-free, synthetic fiber lining. The trend is to make things smaller and smaller as the technology advances. As hardware components became smaller, disk drives reduced in size. Unfortunately, this resulted in a temperature rise inside the drive which may cause deformation and damage of the diskette. The answer to this problem was the development of heat-resistant, free from wrap age, TG (Tight Grip) jackets. They are composed of high quality PVC material which protects the magnetic disk against any deformity caused by exposure to relatively high temperatures (up to 60° C). This protective jacket also has proper rigidity and it uniformly presses the inner liner to the magnetic disk so as to fully utilize the cleaning effect of the liner. This cleaning inner liner is used to trap fine particles of foreign matter which otherwise could damage the magnetic surface or head. The nonwoven fabric collects and eliminates even fine microscopic dust and dirt from the magnetic layer so other cleaning is not necessary nor recommended. The embossed texture of the surface on some jackets resists fingerprints and marks. The jacket is normally black but assortments of color jackets are available for easy file management. Once the PVC foil and the liner are laminated together, the shape of the jacket and all the required holes are punched out, such as the head access slot, the index hole, the central hole and the stress relief notches. Subsequently, the jacket is folded and sealed on two sides. Precision is of utmost importance for the future quality of the product.

The magnetic disk, which is inserted into the jacket, starts its life as a 66 cm (26 inch) wide and 10 km (6 mile) long polyester film with a thickness of 76 um. The film is coated on both sides with a layer containing magnetic iron oxide with a uniform thickness of about one hundred micro inches (2,3 um). The layer consists of iron oxide particles which are thoroughly pulverized, mixed with binders, solvents and lubricants to a pulpy mass that is pumped into a coating machine, where in a clean, dust-free room the polyester film is coated.

Data is written on the magnetic layer using magnetic fields. Although the magnetic layer particles' orientation on audio tapes is essential for good performance, it is fatal on floppy disks. The reason is that since recording is performed circumferentially, the output may increase or decrease in some areas, even within the same track, when a magnetic particle has orientation. This output fluctuation is called "modulation" and if it is high it leads to poor reliability and read errors. Several manufacturers of magnetic data storage material achieve nonorientation of magnetic particles during the formation of the magnetic layers in different ways. For example the Super Random Orientation (SRO) process of Maxell succeeds in making the direction of each magnetic particle thoroughly random by applying this special treatment immediately after application of the magnetic coating, before the particles are fixed in place by the binder. While the magnetic layer hardens its non-orientation becomes permanent. Finally the film is dried, calendered and coiled and after a few days, rest in special chambers.

The magnetic disks, at this stage (also called cookies), are punched out of it. The cookies are polished on both sides, known as burnishing, to give them a smooth finish which enhances the electrical performances. The smoother the finish the better the protection against structure friction and head wear. After the burnishing, the cookies are put in their jackets ready for certification, i.e., the electronic testing of the magnetical properties of the diskettes. After certification, the jackets are sealed and the protective hub ring is put into place to prevent edge damage. This hub is very important as floppy disks are inserted and ejected over and over again. At each insertion the disk drive read/write head must begin at the correct position on the track to perform accurately. The disk drive finds the desired track by measuring its distance from the rim straight across the disk. Even a slight error in the chucking of the disk in the drive will shift the track position and prevent accurate reading and writing.

Before labeling and final boxing, the disks are subjected to intensive quality assurance procedures. Already with the acquisition of the raw material a large list of specifications and properties were verified. Dimensions were strictly controlled, the strength of the seals were tested and each diskette had to pass stringent electronic tests (e.g., drop-in - and drop-out level, resolution, modulation, amplitude and peakshift). Finally, wear tests were performed on random samples taken out of production.

As computers have grown increasingly compact, 3 1/2 inch floppy disks have taken center stage due to their small size. But there's more: HD (High Density) 3 1/2 inch disks have a memory capacity of 2 MB (even more than the much larger 5 1/4 inch disks). These micro disks have a hard plastic jacket, designed to offer maximum protection against heat and shock. The material is also treated to resist static electricity and dust adhesion. The metallic auto shutter prevents entrance of dust, dirt and other foreign matter. Accurate chucking is one of the basic requirements. High precision metal hubs ensure accurate track positioning. Maxell guarantees that even after 10,000 insertions chucking performance is accurate within 3 um.

Specifications for Flexible Disks

8 inch disks

Dimensions	Jacket external dimensions	203,2 x 203,2 mm.
	Disk external diameter	200,2 mm.

Single-Sided, Single-Density, Soft-Sectored

Number of tracks	77
Track density	48 tpi (tracks per inch)
Capacity	242.944 Bytes
Number of sectors	26
Data transfer rate	250 K bps (Kilo bits per sec.)
Encoding	MFM/FM
Record length	128 Bytes

Double-Sided, Double-Density, Soft-Sectored

Number of tracks	77 x 2
Track density	48 tpi (tracks per inch)
Capacity	985.088 to 1.2 12.416 Bytes
Number of sectors	8, 15 or 26
Data transfer rate	500 K bps (Kilo bits per sec.)
Encoding	MFM/FM
Record length	256, 512 or 1024 Bytes

Single-Sided, Double-Density, Hard-Sectored

Number of tracks	77
Track density	48 tpi (tracks per inch)
Capacity	630.784 Bytes
Number of sectors	32
Data transfer rate	500 K bps (Kilo bits per sec.)
Encoding	MFM/ FM
Record length	256 Bytes

Double-Sided, Double-Density, Hard-Sectored

Number of tracks	77
Track density	48 tpi (track per inch)
Capacity	630.784 Bytes
Number of sectors	32
Data transfer rate	500 k bps (Kilo bits per sec.)
Encoding	MFM/FM
Record length	256 Bytes

Eight inch disks come in two types--with and without write-protect notches. To write on disks that have notches, one has to use a write-enable label to cover the notch. It has to be removed after recording to prevent loss of valuable data. On disks without notches data can be written at any time.

5 1/4 inch disks

Dimensions	Jacket external dimensions	133,4 x 133,4 mm. Disk external diameter 130,2 mm.

Single-Sided, Double-Density, Soft-Sectored

Number of tracks	40
Track density	48 tpi (tracks per inch)
Capacity	163.840 Bytes formatted 250.000 Bytes unformatted
Number of sectors	16
Data transfer rate	250 K bps (Kilo bits per second)
Encoding	MFM/FM
Record length	256 Bytes

Double-Sided, Double-Density, Soft-Sectored

Number of tracks	40 x 2 or 80 x 2
Track density	48 tpi or 96 tpi (tracks per inch)
Capacity	327.680 or 655.360 Bytes formatted 500.000 or 1.000.000 Bytes unformatted
Number of sectors	16
Data transfer rate	250 K bps (Kilo bits per second)
Encoding	MFM/FM
Record length	256 Bytes

Double-Sided, High-Density, Soft-Sectored

Number of tracks	80 x 2
Track density	96 tpi (tracks per inch)
Capacity	985.088 Bytes formatted 1.600.000 Bytes unformatted
Number of sectors	26
Data transfer rate	500 K bps (Kilo bits per second
Encoding	MFM/FM
Record length	256 Bytes

Single-Sided, Single-Density, Hard-Sectored

Number of tracks	40
Track density	48 tpi (tracks per inch)
Capacity	102.400 or 81.920 Bytes formatted 125.000 Bytes unformatted
Number of sectors	16 or 10
Data transfer rate	125 K bps (Kilo bits per sec.)
Encoding	FM
Record length	256 or 128 Bytes

Double-Sided, Double-Density, Hard-Sectored

Number of tracks	40 x 2
Track density	48 tpi (tracks per inch)
Capacity	409.600 or 327.680 Bytes formatted 500.000 Bytes unformatted
Number of sectors	16 or 10
Data transfer rate	250 K bps (Kilo bits per sec.)
Encoding	MFM/M2FM
Record length	512 or 256 Bytes

All 5 1/4 inch disks are equipped with write-protect notches; note however that they work in the opposite way the 8 inch disk notches do. As a matter of fact, 5 1/4 inch disks rather have write-enable notches, i.e., when a write-protect label covers the notch, data no longer can be written to the disk.

3 1/2 inch disks

Dimensions	Jacket external dimensions	94 x 90 x 3,3 mm

Disk external diameter	86 mm.

Single-Sided, Double-Density, Soft-Sectored

Number of tracks	40 x 1 or 80 x 1
Track density	67,5 or 135 tpi (tracks per inch)
Capacity	163.840 or 327.680 Bytes formatted 250.000 or 500.000 Bytes unformatted
Number of sectors	16
Data transfer rate	250 K bps (Kilo bits per sec.)
Encoding	MFM/FM
Record length	256 Bytes

Double-Sided, Double-Density, Soft-Sectored

Number of tracks	40 x 2 or 80 x 2
Track density	67.5 or 135 tpi (tracks per inch)
Capacity	327.680 or 655.360 Bytes formatted 500.000 or 1.000.000 Bytes unformatted
Number of sectors	16
Data transfer rate	250 K bps (Kilo bits per second)
Encoding	MFM/FM
Record length	256 Bytes

Double-Sided, High-Density, Soft-Sectored

Number of tracks	80 x 2
Track density	135 tpi (tracks per inch)
Capacity	985.088 or 1.400.000 Bytes formatted 1.600.000 or 2.000.000 Bytes unformatted
Number of sectors	26
Data transfer rate	500 K bps (Kilo bits per second)
Encoding	MFM/FM
Record length	256 Bytes

When the write-protect hole in the plastic jacket of a 3 1/2 inch disk is open, the disk is write-protected. When it is closed data can be written on the disk.

The difference between a double-density and a high-density 3 1/2 inch disk can easily be noticed by the presence of a second hole on the high-density disk opposite to the write-protect hole. This allows the drive to use a light sensing method in order to differentiate between a HD and a DD disk.

Care and Handling

The surface of a flexible disk should not be touched. It is susceptible to damage. Even fingerprints can cause data to be lost. One should always store flexible disks away from direct sunlight or heaters. Temperature extremes, especially heat can damage disks.

Operating environment O to 60 ° C
Storage environment O to 60 ° C
Transit environment -40 to 60° C.

Any sudden change in temperature must be avoided. A change of 20° C. per hour is the limit. Always insert the disk carefully by grasping the upper edge and placing it into the disk drive. Never force the disk into the drive. Keep disks in their envelope and store disks, not intended for immediate use, in their specially designed containers. Always file them upright. Do not bend or fold flexible disks. Put the identification labels in a suitable position. Never use them in layers. Never place heavy objects on a disk. Do not clip, staple or rubber-band flexible disks together. Do not use solutions like alcohol, thinners or freon to clean the disk. The special liner cleans the disk surface continuously. No other cleaning is necessary. Dirty or damaged disks should be discarded as placing them in a disks drive can contaminate the read/write head. Do not write on a flexible disk with anything but a soft, felt-tip pen. Ideally, write labels separately, then place them on the disk jacket. Magnets and magnetized materials should never come close to a flexible disk. Be particularly careful with magnetized paperweights, motor and power cables. Data can be lost from a disk exposed to a magnetic field. Keep the area of operation as clean as possible. Occasional static electricity on disks can attract contaminants.

Cataloguing

The normal rules of cataloguing are also applicable for magnetic disks, although some exceptions do exist. The following should be noted:

The name and the address of the manufacturer as well as the coordinates of the license holder must be mentioned.

Conditions for which the license stands should also be noted.

Identify the version of the software and the date on which the program or the data are released.

Note the physical description of the medium to include size and type (3 1/2, 5 1/4 or 8 inch, double density or high density, removable hard disk or Bernoulli, etc.).

Identify the number of diskettes and accompanying material such as handbooks or manuals, hardware keys (to put on printer ports as protection) etc.

Other special characteristics include whether the programs are compressed or not. If so which algorithm has been used (which program is needed for decompression). Which format is used to encode text files (ASCII, WP, WORD, WordStar etc.). Which format is used for database records (DBase, FOXPRO, SUPERBASE etc.). Which program is needed for optimal use of the unregistered data. The type of computer and drives needed. Other hardware needed (SOUND BLASTER card, plotter, printer, scanner, mathematical coprocessor etc.). Also indicate the amount of free memory needed to run the program.

In the past, floppy disks were used for everything, from program and data storage, to archiving, software distribution, back-up and data transport. Today, hard disk, tape and optical storage take care of these functions. Although floppies have increased in capacity over the years (from 160 Kb in the early years to 2.88 Mb and more to-day), the floppy capacity has not kept pace with the massive size requirements of today's tasks (hard disk back-up and data storage). The capacity of a disk can be enlarged in several ways, by increasing the linear density, by increasing the track density or, by increasing both linear and track density at the same time. Increasing the linear density means putting more bits on a track. Increasing the track density means cramming more concentric tracks into a limited area.

Standards

It is the object of magnetic storage media standardization to facilitate data interchange between data processing systems. Both national and international standards for all magnetic media have been created. It is also assumed that future standards will include other storage media and new recording modes. The basic magnetic properties are given by primary reference media. They are one of the main bases of these standards. Selection of primary, and calibration of secondary reference media is mainly done at the National Bureau of Standards (NBS) in Washington and at PTB in Braunschweig. The reference material FM 8630 is provided for the definition of the magnetic characteristics according to the standard ISO 8630 for the 130 mm (5 1/4 inch) disks. The reference material RM 9529 is provided for the definition of the magnetic characteristics according to the standard ISO 9529 for the 90 mm (3 1/2 inch) disks

Future Trends

A constant search for larger capacity and smaller size will lead to the development of future flexible disks. They will have a higher density (the 3.3 MB disk will be the first generation of the new 3 1/2 inch family). Disks will also be smaller (the 2 inch disks will reduce materials cost).

3.6 HARD DISKS

The Hard Disk Drive (HDD) represents about 90% of the storage market revenue and is a unique compromise between access time and low cost per bit storage. The first commercial drive was the IBM Ramac (1956), which used 50, 24-inch diameter disks with a capacity of 5 megabytes and an access time of about 1 second. Today a 3 1/2 inch diameter disk with a height of one inch can easily store 1.5 gigabytes with an access time of less than 10 milli seconds.

As storage density increases the same capacity can be offered in a smaller package. More sophisticated controllers provide added value, such as Zone Bit.

Recording from Imprimis (now part of SEAGATE) increases the capacity by thirty or fifty percent. The implementation of new data-compressing algorithms will certainly further increase storage capacity. The advantages of hard disk drives include speed, cost and universality. No optical device for the moment can even come close to matching the speed of a HDD with a software cache. Optical devices are not so slow that they are unusable, however, some of the newer devices, magneto-optical for example, are approaching hard disk drive speeds.

When disk intensive programs are used, such as animation packages, spreadsheets and data base programs, that make frequent use of temporary files, a hard disk is a more effect mechanism to store the information. Physical size and power requirements are another advantage of hard disks. In almost any laptop a 2 1/2 inch drive holding a disk with a capacity between 20 MB and 100 MB of data is used and it can run for hours on battery power. Recently, 1.8 inch drives came on the market with a weight of 60 grams and a height of 1 to 1.24 cm., and holding 43 MB, 63 MB, 85 MB and even 126 MB storage capacity. The drives are developed by the AURA Associates (USA). They are manufactured by NEC. The spinrate is 5400 rpm achieving a data transfer rate of 4.5 MB per sec., with a seek time of about 18 milliseconds. Another advantage is the cost. Optical storage cost 20 to 30 times more than magnetic HDD storage. Only when dealing with massive quantities of information, are optical systems cheaper, then the limitations of hard disks become apparent as it requires a lot of space for backup. When data enters the multi gigabyte or even terabyte range, hard disks become unmanageable.

Data is stored on a hard disk by magnetizing areas on the surface of the disk. Bits are stored on concentric tracks on a disk that spins at 3600 rpm. Performance can be increased by incrementing the number of bits per track or by raising the number of tracks on the same area. The technology of recording data on magnetic disks differs from the one used for CDs, CD-ROMs or some WORMs. Constant Linear Velocity (CLV) recording is used for the latter. In this case, data is arranged in a single spiral track with a uniform bit density. To obtain this, the speed of the disk has to be variable between the outer and the inner edge. The closer the head gets to the outer edge the faster the disk has to spin. Data is located by its temporal position, measured in minutes and seconds. Each second consists of 2 Kbytes of data. On the other hand, Constant Angular Velocity (CAV) is used on floppy disks, hard disks, and on read/write optical drives. The data is organized into sectors and tracks. The number of bits per sector remains constant. Data is packed most tightly in the shorter tracks near the center of the disk. This method does not allow as much data packing onto a disk as CLV allow. The sector/track addressing method makes locating data much faster.

Until a few years ago, the recording surface of a hard disk was a plastic binder filled with gamma ferric oxide with a particular crystal structure. Today most hard disks are coated with a continuous thin film of pure magnetic material that is sputtered or plated onto an aluminum platter. Recently some manufacturers begun to make hard disk drives that use glass platters. Glass platters can be made flatter and smoother with a higher rigidity. This latter quality is especially important for drives that spin faster than the usual 3600 rpm. The most popular of the used magnetic materials are cobalt-nickel alloys. Hard carbon coatings protect the recording media from contaminants and from damage caused by the read/write head during starting and stopping. Early disk drives were designed to keep the heads flying several microns above the surface. More recent designs keep the heads about 0.1 to 0.5 um above the surface. In such an environment even microscopic dust can cause disastrous failures. All moving parts are sealed in a chamber filled with very clean air. This chamber should not be opened except by qualified technicians in a "clean room."

It is no longer the magnetic medium that limits the capacity of magnetic storage but the physical dimensions and the type of the read/write head as well as the possibility of its accurate positioning. Demonstrations at the IBM Magnetic Recording Institute (San Jose, CA, USA) proved that a noninductive head was capable of reading bit densities as great as 1.8 million bits per square millimeter (triple the data density of most magneto-optical drives).

Data compression can also spare room (it can double the capacity) on hard disks and floppies. To use "lossless" or "noiseless" data compression proprietary algorithms are used to ensure that no errors can occur during the compression or decompression. Different companies are working on the problem and some solutions are already on the market, for example, SuperStor from Addstor, Disk Expander from InfoChip's, Stacker from Stac and also the DOS version 6.0 from Microsoft has its own data compression facility called DoubleSpace.

In the past, most hard drives used Variable Density Recording (VDR) which writes data at a constant rate to a disk rotating at a constant angular velocity. The data on the inner tracks is denser than the data on the outer tracks, which means that the outer track space is used less efficiently. A way to gain more capacity is to use an alternate, more efficient storage method called Constant Density Recording (CDR). Here, each disk is divided into concentric zones in which recording densities are optimized and are nearly equal. Because the outer zones are larger than the inner they can contain more bits and also more sectors. As the motor speed is constant, the head traverses more bits in the outer zones than in the inner zones in the same lapse of time and the data transfer rate in the outer zones is higher. Densities can also be increased by embedding servo data (fine-head-positioning information) on a disk. On the other hand, by increasing densities the probability of errors also rises and high data transfer rates even make it worse, so accurate and rapid error detection and error correction must be implemented. Magneto-optical disks obviously require such sophisticated methods of detection and correction. As bit densities on hard disks increases, error detection and error correction become necessary

3.7 REMOVABLE STORAGE SYSTEMS

The need for increased data security, transportability and backup led to the development of this product. The use of CAD as the preferred form of modeling has also created a need for removable media-drives. Scanners allow incorporation of drawings, photos and other graphical images in documents. This requires greater processing power and more data storage. Despite the different types of removable media, there is little variety within each type. With the exception of the removable hard drives, the mechanisms come from a select group of manufacturers: SYQUEST Technology, RICOH Corporation, IOMEGA Corporation, BRIER Technology, and INSITE Peripherals.

To increase the storage capacity of a magnetic disk we can apply two techniques.

Increasing the Linear Density

This is a tactic used to increase the capacity of a 3 1/2 inch floppy disk from 720 KB to 1.44 Mb and from 1.44 Mb to 2.88 Mb with the help of a higher coercivity medium. For example, barium ferrite may be substituted for iron oxide to double the number of bits which can be stored on each track.

Increasing the Track Density

Increasing track density is not commonly applied. The lack of a medium-bared positioning information and a feedback mechanism were the reasons floppy disks remained at 135 tracks per inch.

INSITE Technology and Briers Technology have now boosted the capacity of floppy disks by increasing track density of 3 1/2 inch floppy disks to 1250 tpi. Their products are also called Super floppies. Both INSITE and IOMEGA are producing a recently developed mass storage device called the Floptical drive. On both sides of a 3 1/2 inch diskette, magnetic recording heads are positioned by optical sensors detecting a positional pattern on the rotating disk. Use of position feedback allows extremely close track placement. Storage capacity is almost 21 MB and the retrieval time is on the same order as that of ordinary floppies.

The first prototype floptical drives ran under DOS and utilized a software driver with an attached removable hard disk. Grassroots Technology, one of the pioneers in implementing flopticals, suggested that it would be more logical to treat them as a floppy. Media makers, 3M and Maxell arranged to have MKE manufacture their drives. These companies formed the "Floptical Technology Association" (FTA). A combined magnetic and optical head structure (called Floptical system) allows 1250 tpi instead of 135 tpi for a conventional floppy disk drive. The floptical diskette offers 20.8 MB of formatted capacity on a 3 1/2 inch diskette. This is very cost-effective for the user. It maintains downward read and write compatibility with standard 720 KB and 1.44 MB diskettes. The FTA believes the ability to read conventional floppy disks will attract enough OEM's and customers to create a de facto standard. The magnetic coating for the diskettes is based on barium ferrite, a higher-grade magnetic particle alternative to the cobalt-treated iron oxide particulate currently in use for HD floppies. Ba-Fe particles achieve the high linear density of 35,000 fcpi needed for the future. They are also being considered for advanced tape systems and are currently used for identification strips on credit cards.

Ba-Fe is chosen for four principal reasons:

It has a very high linear recording density capacity
It has a higher intrinsic signal-to-noise ratio
It is environmentally stable
It is potentially less expensive to manufacture.

The present 20 MB floptical uses a maximum linear density of 18,000 fcpi, while a planned 40 MB floptical will use a linear recording density of 31,000 fcpi. An 80-plus MB capacity product can be achieved by doubling the linear recording density to 62,000 fcpi.

The production process of very high density floptical disks is important for disk reliability and durability. Omega Corporation has developed new proprietary laser servo writing equipment and processes. With Laser Etching every disk is essentially a master, an argon ion laser etches each of the servo marks as the disk spins. This process ensures a high contrast optical pattern while maintaining a smooth surface. Laser etching provides many unique new benefits, including a hard coating for durability and long life. All floptical disks from 3M, Maxell, and IOMEGA are interchangeable with all floptical disk drives from both IOMEGA and INSITE. In addition, all floptical host adapters and software from IBM and Apple Macintosh systems available from a variety of manufacturers are cross compatible. For example, Adaptec Inc.'s (FTA member, Milpitas, CA, USA) media compatibility solution is a 16 bit AT-to-SCSI host adapter and connection kit which can support up to six SCSI devices: two floptical drives, two floppy drives and two SCSI fixed drives. The host adapter enables the PC to boot from all three media types.

Floptical disks will allow single disk software distribution and fewer numbers of disks used for backup. Key computer industry manufacturers are supporting the new INSITE peripherals. The floptical could replace the Apple SuperDrive in future Macintoshes.

Silicon Graphics, which makes high-end graphics workstations, has announced that a floptical will be the standard floppy drive in the next generation of its products. The estimated cost is under $300 (US).

Briers Flextra system (capacity 25 MB) uses a low-frequency magnetic signal embedded in the medium to position the read/write head. The data is stored at one magnetic frequency, while the read-write positioning information is stored at another frequency. These two signals are super-imposed, allowing much more data to be stored on the medium. The system cannot read and write lower capacity floppy disks. Quantum sells Flextra drives under the Quad Flextra name, while Verbatim makes Flextra media available. Briers has now announced a 50 MB version of the Flextra disk that will be compatible with 720 KB, 1.44 MB and 2.88 MB disks.

Both Briers Flextra and Insite floptical have low performance. The overall performance from Flextra is better than floptical. The read/write mechanism of the floptical drive is larger and more complex than the mechanism of Flextra. The estimated price is under $300 (US).

Bernoulli Technology

The removable Bernoulli hard disk offers the advantages of a hard disk (performance and capacity) and also those of a floppy disk (security, transportability). The Bernoulli disk from IOMEGA Corporation (Utah, USA) is also based on barium ferrite media. Two flexible disks, back to back, spin at high speed near a Bernoulli plate. As they spin, the air between the disks forces them apart. Each disk flies towards a Bernoulli plate and the embedded special head. An air bearing created between the plate and the disk stabilizes it to within approximately 2.5 u. The storage capacity of 90 MB is spread over the two disks, held in a cartridge, which can be accessed simultaneously. The device gets its name from the airflow pattern around the plate with the magnetic heads. The air surrounding the rotative disk accelerates when it hits the small space between the disk and the plate with the head. The air above the disk moves more quickly than the air below the disk which causes a difference in pressure that pushes the disk surface towards the plate holding the magnetic head. The Bernoulli effect prevents the disk from ever touching the magnetic head. Whenever there is a power loss, the disk loses lift and falls harmlessly away from the head without any possible head-crash. The media can be shredded which is important for security-oriented organizations.

The Bernoulli drives' performance comes closest to standard hard drives, but Bernoulli media wear out faster. The format is 5 1/4 inch, with a capacity of 90 MB, 180 MB, 360 MB. Access time is 18 milli-seconds (9 milli-seconds with software cache).

Removable Hard Disk Drives

The need for increased data security, transportability, and backup led to the development of this product. The removable hard disk is compatible with all computer systems and work stations. Removable hard drives have storage capacities that are somewhat smaller than conventional hard drives. Because the drives are not sealed, their heads sit farther away from the disk surface to prevent head crashes from small dirt particles.

Docking Hard Drives

They are related devices that provide performance that equals that of conventional hard drives. These devices are sealed and generally employ a SCSI interface. They are typically used as a means of locking up data for purposes of security. Storage capacity is generally on the order of 100 to 200 MB.

Syquest

They are widely available, reliable and perhaps the best known. The drives are half-height 5 1/4 inch devices using a SCSI adapter and with cartridge capacities of 44 MB or 88 MB, 31/2 inch with 270 MB, and (a new 105 MB version is announced). The cartridge contains a single metal disk with a magnetic coating in a plastic shell, with a spring-loaded shutter that opens to get the read-write heads access to the disk. Contamination from dust and other particles is eliminated by a combination of centrifugal force (the drive spins at 3,220 rpm) and air pressure (12,000 psi). Once this purge cycle is completed the heads settle down to read-write height. Much of the technology is derived from the hard drive industry.

Ricoh

A Ricoh drive is similar in some respects to a Syquest drive. It is a half-height 5 1/4 inch device with a cartridge. It uses a SCSI interface. Ricoh has just one capacity: 50 MB. It has several features to enhance the integrity of data stored. Ricoh's performance is below that of Syquest or Iomega drives.

Hard Disk Cards

A hard disk is mounted together with a hard disk controller on the same slotcard. It was first developed in 1985 by the Plus Development Corporation, now the Quantum Corporation, under the name Hardcard. It had a capacity of 10MB in the beginning to several hundred megabytes now. Hard disk cards are simple to install with low power consumption. It is a perfect choice to extend external memory without the need of desktop space, external cables or power supplies. Interrupt settings may conflict with already installed HDD's.

Magneto-Optical Drives

These are retractable optical disks that range in size up to 650 Mb. Information is written on a disk using laser diodes and a standard magnetic write head. Writing data starts with heating one side of the disk to about 180° C. with the help of the lasers. At that temperature the write head, directly opposing the laser on the other side of the disk, produces a magnetic field that changes the magnetic polarity at that spot. After cooling, the disk retains the new magnetic polarity. Reading the information is done with the help of a low power laser beam. The reflected light rotates under influence of the magnetized spots and the shift in polarization is detected by a light detector. Head crashes don't occur easily as the head is further away from the disk's surface than on a conventional drive. The way of storing data makes these drives slower than ordinary drives, but on the other hand, the durability of data storage is much better than magnetic.

Standards

ST412
ST506 Describes a variety of hard disk interface. The physical description of the cables between controller and drive, the electrical aspect (voltage levels and signal timings on each wire) and other critical timing issues for various signals. The standard ST412/ST506 does not imply a specific encoding. It was first used to describe an MFM drive with 17 sectors per track.

ESDI Enhanced Small Device Interface. This standard evolved from the ST412/ST506 standard and was pushed in the early 1980's by the hard disk manufacturer Maxtor. The max.bit information transfer speed is for the moment about 24 million bits per second. A proposed extension to the ESDI standard would raise it to around 50 million bps.

SCSI Small Computer System Interface. This standard was developed in the late 1970's under the name SASI (Shugart Associates System Interface). The standard defines the functional, electrical and mechanical specifications for an 8-bit parallel bus, suitable for connecting physically small computers to each other and to peripherals. SCSI is not a disk interface, it is in many ways far more of a small local area network. Fast hard disk drives, tape drives, optical disks, WORMs, laser printers and even devices such as a mouse can be at tached.

FIPS Federal Information Processing Standard. Publication number 131 is prepared in cooperation with the American National Standards Institute (ANSI).

SMD Storage Module Interface. FIPS Publication number 111. This standard specifies the functional, electrical and mechanical properties of an interface between a mag netic disk drive and its controller. The SMD is very widely used in commerce. It adopts American National Standard X3.91M1 982.

IDE Integrated Drive Electronics. It is currently the most popular hard disk interface, popularized by Conner Peripherals. The RRL or MFM controller is included on the drive itself, eliminating the need for a controller card.

IPI Intelligent Peripheral Interface. This standard defines the functional, electrical and mechanical specifications for a 16-bit. It has parallel master/slave bus interface suitable for connecting a host computer or controller to mass storage peripherals (such as magnetic disk drives, optical disks and tapes). The standard is prepared in cooperation with the ANSI.

PCMCIA The latest trend is to mount the disk drive on a PCMCIA card. The latter stands for PC Memory Card International Association. One of the outstanding features of this standard is that cards can be safely plugged in and unplugged while you are computing. It is as easy as changing floppy disks.

VBRMS Operational Specifications for Variable Block Rotating Mass Storage Subsystems. FIPS Publication 63-1. This standard provides operational specifications for command codes, data formats, sense and status informa tion etc. Additional optional specifications of track for mat and sense information is provided for the most common device types. FIPS Publication number 63-1 Sup is a supplement to the former. It only specifies sense information which is useful to error recovery software.

All popular disk standards (including MFM, RLL, IDE, ESDI, and SCSI are explained in one of the best books on this matter:
Hard Disk Secrets
by John M. Goodman, Ph.D.
IDG Books Worldwide, Inc.
155 Bovet Road, Suite 310
San Mateo, CA 94402 USA

Conclusion

The future of magnetic media is not in doubt. It will remain for a long time the most important form of permanent storage. The alternative technologies (solid state disks and rewritable optical disks) will never replace the pure magnetic storage.

Lexicon

ANSI American National Standards Institute. The commission, together with the computer manufacturers and the com puter users created standards and recommendations for programming, treatment and encoding of data to ensure compatibility between the different systems. Standards are also provided by:

DIN	Deutsche Industrie Normen
ECMA	European Computer Manufacturing Association
ISO	International Standards Organization
JIS	Japanese Industry Standards

ASCII Acronym for American Standard Code for Information Interchange. A widely used code for storing data.

Binary Refers to the base-2 system in which the only allowable digits are "1" or "0."

Bit Binary Digit. The smallest information unit which can be used for information storage. It can be magnetized or non-magnetized. It can be on or off. Values are either "1" or "0".

Byte One byte equals eight bits. Each byte corresponds to one character of data, representing a single letter, number or symbol. A combination of eight bits allows the representation of two exponent eight or 256 different characters or token.

Kilo Byte 1024 Bytes. To simplify calculations
1 KB = 1000 Bytes.

Mega Byte 1048576 Bytes. To simplify calculations
1 Mb = 1000000 Bytes.

Giga Byte one billion bytes.

Capacity The amount of information that can be stored on a magnetic support. The capacity of a formatted disk can be calculated as follows:

Bs = Number of bytes per sector
S = Number of sectors
T = Number of tracks
H = Number of heads (Number of used sides of the disk)

Capacity = Bs x S x T x H

For example: a formatted double sided, double density diskette can hold 256 x 16 x 40 x 2 = 327680 bytes.

Coercivity Possibility of a magnetic material to be magnetized and to hold a magnetized state.

Database A large amount of data stored in a well-organized format. A database management system is a program that allows access to the information

Density Recording density in Bits per inch (Bpi), is the number of bits that can be stored in a linear inch.

Drop-In Noise produced by faults in the magnetic surface of the disk.

Drop-Out Signal loss due to faulty magnetic storage material or malfunctioning of the write/read head.

Encoding Different systems for encoding of data on a magnetic support are used:

FM NRZ (Non-Return to Zero) Frequency Modulation, merely used for single density disks.

MFM Modified Frequency Modulation, initially called double density encoding essentially has replaced FM in the world.

RLL Run Length Limited, the most popular plan, at least for hard disks used in PC's (the process uses no clock signals at all)

GCR Group Coded Recording

Hardware The physical apparatus that makes a computer, silicon chips, transformers, boards, wires etc.

Media Life Based on Weibull B-50 tests, the average media life of magnetic disks exceeds 30 million revolutions with the head loaded normally on a single track.

Peripheral Any hardware device connected to a computer, such as printers, plotters, scanners, etc.

Recording Technology

Longitudinal recording is currently the most used technology. The residual magnetic fields are oriented in directions parallel to the plane of the surface of the disk (550bits per mm).

Isotropic recording is similar to present recording techniques, but with a high resolution medium data can be stored at densities four times the former. (2000 bits per mm.)

Perpendicular recording increases densities by orienting the residual magnetic fields vertical (up and down) relative to the surface of the disk (2500 bits per mm).

Sector Data is organized in wedge-sloped fields or sectors. It locates a field as a sector by the way of sectoring. A floppy disk can be sectored in two different ways:

Hard-sectored disks have index and sector holes which are physically punched out of the disk. There are usu ally 32 sector holes on an 8 inch disk, and 16 or 10 sec tor holes on a 5 1/4 inch disk.
Soft-sectored disks are not physically punched out although the index hole is. There are usually 26, 15, or 8

sectors on an 8 inch disk and 26 or 16 sectors on a 5 1/4 inch and on a 3 1/2 inch disk.

Software The program is a set of instructions that tells the computer what to do.

Track Bits are recorded in a circular line around the disk. Each circle of bits is called a track and each track is numbered. The tracks are put in concentrical circles all over the disk, with a hole in the middle of the disk where the spindle will center the disk on the drive. The first track on the outer edge is called track 00. This is the index track and it is reserved for information describing the contents of the disk (volume, owner, identification codes etc.). The disk drive finds a desired track by measuring its distance from the rim straight across the disk.

Tracks Per Inch (Tpi) Usually there are 48 tracks per inch on a standard disk. A 96 tpi disk also known as an 80 track per inch disk or a quad density disk is a disk that contains twice as many tracks per inch as the 48 tpi disk. In that case the storage capacity has been doubled. On a 3 1/2 inch disks we can have 67 tpi or 135 tpi. This is the maximum track density for the moment for normal drives. Special drive systems are using densities up to 1,250 tpi.

Transfer Rate Measured in bits per second, (Bps). Transfer rate is the velocity with which data are transferred from one unit to another. For example, from the internal memory to a peripheral unit (disk drive or printer).
1 Bps = 1 Baud.

4. OTHER MEDIA STORAGE

4.1 PHOTO MEDIA

Photo media generally consists of black and white or color high resolution negatives, prints, or slides. Generally, all images begin with the use of emulsion-based film.

Present Development

Photo media processes are becoming more automated with emphasis on improving stability, rapid processing and long term image stability for preservation purposes.

Data Capacity

Data capacity is equivalent to the amount of film utilized. Film is typically available in 35 mm through 20 x 25 mm in size. Larger widths and lengths are available for special applications.

Copyright Issues

All photographs and slides can be copyright protected.

Storage

Slides and photos need to be stored in temperature, light and humidity controlled environments.

Ease of Copying

Copying of photo media is a proven, inexpensive process. Repeated duplication is possible with very little loss of sharpness, detail or tonal values.

Ease of End Use

Photos must be taken with a camera, developed from a negative and printed.

Ease of Amendment or Updating

Photographic copies can be made to enlarge specific areas, change image contrast and density as required.

Typical Cost

Costs include sensitized materials, equipment and chemistry.

Durability

Photo media is fragile and affected by temperature, light, humidity and chemical changes. Floor coverings, paint and insulation have ingredients that will cause chemical changes in photo negatives and prints. Storage areas should utilize lowest levels of visible light. Temperatures should be between 50 degrees and 70 degrees Fahrenheit. Relative humidity should be between 25-30%. Prints and negatives cannot be stored together due to chemical incompatibility.

Summary

Photo media is an accurate method of visibly capturing information. Automated cameras and systems provide good quality media, with limited expertise, at a relatively low cost. Professional personnel and systems may be utilized where ultimate quality is imperative.

4.2 AUDIO MATERIAL

Audio material can be considered as all types of media on which sound vibrations have been registered by mechanical or electronic means so that the sound may be reproduced. This includes discs and tapes.

There are two types of discs, vinyl and compact. Vinyl discs are used for recording sound. The sound is recorded in a continuous groove cut in a revolving surface by a stylus responding to vibrations. Playback is by a similar stylus connected to a system amplification. Discs are marketed in 17.8cm (7 in.), 25.4cm (10 in.) and 30.5cm (12 in.) diameter sizes. The central hole for the spindle is about 7.5mm in diameter. Recordings on discs are made at 33 1/3 and 45 revolutions per minute. The 78-revolution discs are now obsolete, although they may be found in some collections.

Compact Discs are very popular formats for distributing recordings of music. The discs are usually colored silver. They are 12cm (5 in.) in diameter and 1.2mm thick and have a central hole of 15mm diameter. Maximum playing time for a disc is approximately 1 hour. A small version, 8cm (3 in.) in diameter, is now gaining popularity.

Sound Tapes are contained on an open reel. This format is rarely used for the dissemination of copies of recordings. It is still widely used for the preparation and storage of masters or originals. While wider tapes are available for such purposes as studio recordings, the usual width of tape is 6.3mm (1/4 in.). The tape is wound on a reel. There is a magnetic surface on the inner side. The reels are usually 8cm, 13cm, 18cm, or 26.5 (3 in., 5 in., 7 in., or 10 1/4 in.) in diameter. The amount of tape and the playing time available varies with the thickness of the tape and the speed at which the recording is made. The thinner the tape, the more there is on the reel. Thinner tapes are more likely to stretch or break. Tapes are supplied with colored leaders and trailers, which are lengths of colored plastic tape at the beginning and end without the magnetic surface attached. This area may be used for writing the information concerning the recording. The primary purpose however, is for attaching the tape to the plastic spool.

Cassettes are permanently encased sound tape systems. They incorporate both supply and take-up reels. The tape is magnetic and carries sound signals designed for playback via cassette recorder. The audio cassette has standard dimensions (10.2 x 6.4cm) and features. The tape is 3.8mm (0.15 in.) wide, and in the cassette the magnetic coated surface is on the outward or exposed surface. Cassette recorders and players run at a standard speed of (4.75cm/s, 1.875ips). They are sold with predetermined playing times. Commonly these are C30 (15 minutes each side), C60 (30 minutes each side), C90 (45 minutes each side) or C120 (60 minutes each side). Prerecorded tapes are cut to an appropriate length for the content and do not abide by these standard length dimensions.

Digital Audio Tape (DAT) is another kind of cassette which differs from the traditional one mainly on the recording and playback process. The data on a DAT tape is stored in a digital format. Digital audio tape cassettes are much smaller than the traditional ones (7.2 x 5.4 x 1cm - 2.8 x 2.1 x 0.4 in.). The tape width of 3.8mm (0.15 in.) is the same. They are available in 60, 90, and 120 minute lengths. At a slow speed they can last twice as long. The cassette is completely enclosed and covers the tape. An insertion into the machine pushes back a cover and lifts a lid to reveal the tape. For a more detail explanation on how DAT technology work, see section 3.4.

Cataloguing

The exceptions and additions to the Anglo-American Cataloguing Rules, 2nd edition (AACR2) related to these types of media are as follows:

Title and Statement of Responsibility Area

If the title of a work is a non-distinctive word or phrase, the medium of performance, key, etc., is listed as part of the title. If the title is distinctive, the medium of performance, key, etc., is listed as other title information.

For statement(s) of responsibility, persons or groups are listed in this area if they are authors of spoken sound recordings, composers, collectors of field material, or persons who have contributed more to the recording than performance, execution or interpretation. Those who function solely as performers, etc., are listed in the note area.

Publication, Distribution, Area

For publishers, and distributors, if the item has both the name of the publisher and a subdivision with a distinctive name or trade name, list the subdivision or trade name rather than that of the parent company.

Physical Description Area

List the number of sound cassettes, sound discs, or sound tape reels. List after the specific material designation the total playing time stated on the item, also its packaging, or accompanying material. If duration is not stated, an approximate time should be listed if it can be ascertained.

For discs, the physical description should include playing speed in revolutions per minute (rpm), groove characteristic (if it is not standard for the item), mono, stereo, and digital, as appropriate.

For tapes, list playing speed in inches per second (ips), the number of tracks (if it is not standard for the item), mono, stereo, and digital, as appropriate.

Dimensions for discs should include the diameter in inches.
For tape reels, list the diameter of the reel in inches. If the tape is other than 1/4 inch, list the width in fractions of an inch. In the case of cassettes, list the dimensions in inches only if they are other than 3 7/8X2 1/2 in. List the width of the tape in fractions of an inch only if it is other than 3 7/8X2 1/2.

Note Area

List musical form if this information is not apparent in the rest of the description. List performers and their medium of performance if not given elsewhere in the description, or if appropriate, combine these with a contents note. List date of recording. List any physical detail that is not standard to the item and affects its use. List label name and publishers' numbers. If more than one number appears on the item, list the principal one. If this cannot be ascertained, list all numbers.

Selection and Acquisition

Sound recordings provide the only format for most recorded music and much spoken material. There is a wide range of sound recordings available to library users. There are alternative formats for providing library material to some disadvantaged groups, e.g., blind and partially sighted users.

Audio materials are relatively fragile with the exception of audio CD. These materials can be easily damaged if proper care is not taken. Although the unit cost is favorable, the potentially high damage rate can make sound recordings expensive. Special training is necessary in the care and handling of recordings and in use of playback equipment.

The following points should be considered when establishing a selection and acquisition criteria for audio material:

The Library or Information Center User

Sound recordings should represent the tastes and needs of the general user as well as the specialist.

Price

Cheaply produced items may be inadequately manufactured resulting in inferior acoustical standards.

Quality

The playing time of cassette tapes such as C90 and C120 tapes stretch and become unplayable due to thinned tape. The preferred length tapes are C60 or C45. Reliance on reputable brands is recommended. Upon arrival, sound recordings should be checked visually for obvious damage or faulty manufacturing.

On vinyl discs, it is visually easy to check for warping. As it can make the disc unplayable, a badly warped disc should be returned for replacement. Superficial scratches generally do not affect playback quality, but more severe scratches should be checked by playing and the disc returned if the quality is affected. Faults are rare on cassettes and DAT. If loose ends appear to protrude, the cassette should be returned. The reels should move freely.

Handling and Storage

Each disc needs an ownership mark, location number, and brief details of main entry. A self-adhesive label is recommended and should be placed on each center label obscuring as little information as possible. Disc covers should have similar labels, in a standard position. This label should be large enough to allow for stamping the date due, when circulating.

Cassette labels should also be detailed. On the cassette itself, it is often more difficult to avoid obscuring the printed label although this must be avoided if possible. Cassette cases may be provided with printed details on a sheet which is inserted inside the case (the same can be done with CDs). The tabs at the back of a pre-recorded cassette should be removed (or switched to the appropriate position on DAT) if this has not already been done, to avoid accidental recording and erasing.

Standard adjustable shelving can be used for the storage of sound recordings. It is important that vinyl discs are upright, closely but not tightly packed to avoid storing to an angle. Vertical supports should be provided at close intervals.

Cassettes and CDs can be stored in card catalogue cabinets with the rod removed. Upright storage racks for cassettes and CDs are available. Vinyl discs and cassettes must be housed away from direct light, heat and dampness. Cassettes, both traditional and DAT, must not be stored close to magnetic fields (e.g., television sets, speakers, photocopying machines).

Where the library or information centre provide play back equipment for in-house listening, care must be taken to ensure other users are not distracted. Headphones are usually provided, as are listening posts to allow for more than one listener at a time.

Trends

Audio materials such as discs and tapes are widely used in public libraries. They are also used as an instructional media for teachers and students in an academic setting.

There is a trend to move away from vinyl discs collections and instead use audio compact discs. This change is partly due to the increase in recording quality, limitation in space as collections grow, and the need to allow direct browsing by users without the fear of damage to the collection.

Marketing Tools

It is important that librarians and other information providers improve their skills in the areas noted below in order to more effectively assist their customers.

Technical Skills

It is important that information providers develop the skills necessary to assist clients in using the various search and retrieval tools that are available.

Bibliographic Skills

Although bibliographic tools are less well organized than books and other printed materials, there are still a considerable number that can be used. The approach is not straightforward, but their exploitation is not difficult and should be a skill acquired by all staff involved. The net result for the customer is more current information faster.

Advising Users

The information provider should be proactive in advising users by helping them in locating appropriate material that meet their needs.

Being Aware of Developments

Keeping abreast with new technology is critical to the information provider remaining an effective resource for user informational needs.

Financial Implications

Perhaps the major financial implication is the cost of equipment. The initial purchase price should be keenly studied. The majority of media sources are no more expensive than books. Any increase in the materials found should not be excessive with the exception of repackaging and processing.

Finally, the cost of security must also be taken into account. Certain formats such as sound cassettes, and audio compact discs and equipment are susceptible of theft and, therefore, need to be protected.

Security measures should already be in place in the library or information centre so that additional requirements would be minimal.

4.3 MOTION PICTURE

A motion picture may be defined as a film, with or without sound, bearing a sequence of images which creates the illusion of movement when projected. Other terms often used to name this kind of media are: films, motion pictures films, movies, and pictures.

Formats

There are three sizes of motion picture film in common use today:

- o 35mm film - This format is almost exclusively used in public cinemas;
- o 16mm film - This is the common format for distributing films to small clubs, schools and business;
- o 8mm and Super 8mm film - Used for educational purposes an amateur home photography. This format is becoming obsolete and many companies decided to transfer their stocks to videotape.

Special size films can also be considered (i.e., 9.5mm, 55mm, 65mm, etc.), along with other types of material: loops, kinescopes, stock shots, trailers, etc.

Cataloguing

The Anglo-American Cataloguing Rules, 2nd edition (AACR2), prescribes the same rules of entry and description for most materials. Exceptions to those rules are dictated by the nature of a particular medium. All items must be examined by the cataloger and should be screened or played to ensure accuracy of bibliographic information. The additions and exceptions to the general rules used for Motion Pictures are:

Title and Statement of Responsibility Area

The statement of responsibility area should include those persons or bodies who are considered to be a major importance to the work or to media centres' patrons. Other persons or bodies who have contributed to the work may be listed in the note area.

Publication and Distribution Area

The publisher, distributor, and releasing agent are listed. A producer or production agency which has not been named in the statement of responsibility is also given.

Physical Description Area

List the number of film loops or film reels. List the total playing time stated on the item, its packaging, or its accompanying material. If duration is not stated, an approximate time is listed if it can be easily ascertained. If the item is in parts and the parts have the same or almost the same duration, phrases such as [15 min. each] or [ca. 15 min each] may be used.

Other physical details may be listed where appropriate. List the aspect ratio and special projection characteristics, for example, Cinerama, stereoscopy, etc. If this cannot be done succinctly, list the information in the note area.

Dimensions should include the width in millimetres.

Note Area

List featured performers or other participants not given elsewhere in the record. The names are prefaced by an appropriate term such as Cast, Presenter, Narrator, Credits and, if appropriate, a statement of function. Cast may be listed as part of contents note. List the date of original production if it differs from the date(s) listed in the publication, distribution, etc. List other physical details which affect use such as magnetic sound track, negative print, three-dimensional film, etc.

Selection and Acquisition

It is important to have a written selection and acquisition policy, including the objectives of the library and its role in serving the needs of the user and the potential user. Factors influencing the policy include:

- The formats available and their potential use in the library;
- How readily items can be obtained. This will depend on finance and the accessibility of suppliers;
- Replacement needs and the growth of the collection;
- The equipment required to use particular formats and its costs, including maintenance;
- The specialized knowledge of content and format required by staff.

When establishing the criteria for selection, librarians should consider the following points:

- The usefulness of the item;
- The effectiveness of the format for its purpose;
- Scope and logical development of subject matter;
- Appropriateness of narration and other sound effects, titles, subtitles and captions;
- The technical aspects of the item, including tone, clarity, intelligibility, composition and the use of color.
- The physical durability of the item and the expected maintenance and storage requirements;
- The level of the language used.

Handling and Storage

Photographic film has a layer of emulsion attached to a polyester base material. Careful observation will show that the backing is shiny whereas the surface with the emulsion is dull. The image is created in the emulsion by chemical response to light and is fixed there by processing with other chemicals.

Films should not be subjected to temperature changes of more than 11 C (20 F), with 21 C (70 F) as optimum storage temperature. Extremes of 16 C (60 F) and 32 C (90 F) are tolerable. Temperatures above these levels can be damaging. This could result in the film becoming brittle from loss of moisture.

Relative humidity should be at 50%. When humidity falls below 35% and rises above 60% this could also lead to damage. The film emulsion may deteriorate causing brittleness, curling, loss of picture brilliance, and actual film shrinkage.

Films should be stored in metal or plastic cans or fiber boxes to protect them from dust and dirt. Any dirt or dust on the film will accumulate in the film gate area of the projector and cause damaging and visible scratches to appear. Storage containers will also protect films from excessive moisture. Water and film do not mix. Excessive moisture will cause the emulsion to slip from the film base. The moisture breaks down the binder, and the film will lose the entire emulsion layer.

Always store film in an upright position; never stack one film on top of another for a length of time exceeding 24 hours. This excessive pressure on the edges causes warping and molecular damage.

Film should not be handled with the fingers on the picture or sound track area. Oil and moisture on the skin of the human body will cause damage. The moisture could cause emulsion slippage. The oil also attracts dust and dirt to the film.

Most films have at least 10 or more feet of leader material on the head and tail. In projecting the film, the projectionist could handle this footage; however, when the title and picture portion are in position for projection, the projectionist should be careful to handle these content frames only along the edge and avoid fingerprints on the actual film surface. A hair, tiny bits of emulsion, fingerprints, dust particles, etc., can be enlarged as much as five thousand times. These distractions actually cause loss of viewer attention and concentration, resulting in poor assimilation and retention of film content.

Broken films can be repaired using a film splicer and film cement or by using a mylar splicing tab. Small, inexpensive, easy-to-use splicing machines are available at all photographic supply stores.

Trends

Motion pictures have a place of their own in instruction. Media centres, departments of audiovisual instruction, and centres of instructional media are no longer faced with the problem of trying to entice patrons to use motion picture films, but with supplying users' demand for motion pictures in various formats and assisting in selection and utilization. This acceptance of motion picture films is firmly established, and all indications point to a continued acceptance through the decade of the 90's.

It is anticipated, that in coming years many motion pictures will be "projected" via videodisks and videotape cassettes. Tape or disc versions of a film are much less expensive than the original 16mm film (the most used for non-commercial purposes) although they have the disadvantage of not being suited to large-group showings. They are, however, very suitable for small groups or individual usage. These new media formats will not only reduce the price for the purchase of motion pictures, but also will assist in making it possible to individualize instructions utilizing motion pictures where needed.

As the new emerging media formats become widely available and accepted throughout the world, motion pictures will continue to play a vital role in the information process. Sixteen millimeter film will maintain the respected place it has well into the 90's and beyond. As video discs and other media formats become more widely available, the combining of audio with motion pictures will play an expanded role.

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14. Abstract

A guide to multimedia intended for technical and other information centres and libraries. Reviews the current storage devices under three headings:

Optical Storage (CD-ROM, optical disc, photo CD);

Magnetic Storage (magnetic tape in general, video tape, tape cassettes and cartridges, Digital Audio Tape—DAT, floppy disc, hard disc, removable storage systems);

Other Media Storage (photo, audio, motion picture).

The features considered include ease of access, cost, reading and writing capabilities, and durability; and it is stressed that the key to success is effective management to enable immediate access to information when required.

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