

# Music To A Researcher's Ears

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**The compact disc, which has already revolutionised domestic audio entertainment, is poised to exert quite as big an influence on the world of the business user.**

In the last year the compact disc (CD) has become the most successful consumer product of all time: worldwide sales of players have reached nearly 50m players, and disc sales are running at several billion a year.

The bright silvery disc holds music stored digitally on its surface in the form of light and dark areas or pits - millions of them, that form a spiral track around the disc from the centre outwards. These pits are read by a laser beam which is directed at the surface, and the reflection is read by electronics which convert the light and dark pulses into sound. Because nothing touches the surface of the disc it does not wear out and the quality of sound reproduction is excellent without the clicks and pops associated with even the highest quality black vinyl record player.

It is the compact disc which provides the basis for CD-ROM (Read Only Memory) technology. The CD-ROM appeared in 1985, with the basic technology from an audio system upgraded for use with a computer. The CD-ROM disc is physically identical to the regular CD and is made in the same way. The difference between the two is the type of material held on the disc. The CD-ROM disc holds computer data and the CD-ROM player has additional electronics so that a computer can read the information.

The data is represented by the light and dark pits on the disc - the binary 0s and 1s associated with digital information. The density of storage is extremely high. The pits are very small and the laser very precise. A single CD-ROM has a capacity for 650 Mbytes of computer data, enough to hold an entire set of encyclopaedias, or 300,000 pages of information, or 5,000 colour photographs,

and so on. Information held on the discs is permanent: it cannot be erased, changed or added to and, provided the disc has been made properly, will last for many years.

High density storage devices existed before CD-ROM but never with the cost benefits it offers. The CD-ROM reader (or player) for example has much in common with the CD audio player. With upgraded servo motors for faster response times and error-correcting technology to ensure data integrity, together with an interface for most personal computer (PC) systems, a CD-ROM reader costs as little as £600 (as of September 1989). CD-ROM readers are available either built in to an existing PC or as an external unit like a printer. They are also available for laptop and portable computers, perhaps for sales representatives with digital catalogues.

The integrity of the data held on CD-ROM is less than one bit error in 10<sup>12</sup> or 125 Gigabytes - so incorrect data is extremely rare.

CD-ROM discs are made with the same equipment as that used for CD Audio discs, benefiting from the cost reduction resulting from high volume CD production. A CD-ROM is considerably cheaper to manufacture than, for example, the amount of printed material it represents. A single CD-ROM can cost as little as £1 to produce.

Thus, a CD-ROM reader is a computer peripheral which connects to a standard personal computer or workstation. The CD-ROM disc itself is an excellent publishing medium for the cost effective distribution of large quantities of information. The neat thing about materials in CD-ROM form is that they can be searched and cross-referenced usually within seconds using a computer.

The introduction of CD-ROM has opened up new applications for the PC, typically those which involve the easy and cheap distribution of a large amount of data.

## On-line Database

A number of large databases are available, targeted at both specialist and general businesses. These are

usually available on-line: you subscribe to the service and, using your computer terminal, gain access to the database over a telephone line. In addition to telephone costs, charges often accrue as you use the database services. Some systems charge on a per character typed or received basis, which means that casual browsing or mistakes can be costly. But the advantage of on-line databases is that for data that is volatile the information is up to the minute. However some databases contain information that is either static or changes only once a quarter.

Some of these databases are now being converted to CD-ROM. The benefit of this approach is the reduction in usage cost: there are no telephone charges, and typically no costs for using the data once the subscription fee has been paid. This means that the database can be used any time and, usually, faster: the system is not shared among many users.

Database updates are typically produced quarterly - monthly in some cases - and useful libraries of information are soon collected. A number of databases are available in the CD-ROM format, from medical (Medline) to financial (Extel, which features information on 4,000 public and 21,000 private UK companies).

### **General Purpose Discs**

As the CD-ROM reader establishes itself as a standard computer add-on, it is increasingly found in modern offices and professional establishments, and a number of general purpose discs are beginning to appear.

Among the growing selection is the 21 volume Encyclopaedia Grolier. More than 9m words are contained on a single disc, including the latest information on science and technology, the arts, geography, medicine, health, social science, religion, philosophy, law, sport, politics - more than 30,000 concisely written abstracts may be electronically cross-referenced and searched. The entire unabridged Oxford English Dictionary - a dozen volumes in its paper form - is also available on CD-ROM, and can be searched in a highly interactive computer - assisted manner. A combined English, French, Dutch, German, Italian, Chinese, and Japanese dictionary is available on a single disc. There is even the King James version of the Holy Bible.

### **Commercial CD-ROM Applications**

The British Post Office provides a complete listing of all UK postal addresses on a CD-ROM.

Telephone directories are also to be found on CD-ROM with discs available for Germany, US and Switzerland, although not yet for the UK. Previously weighty book catalogues are now also to be found on CD-ROM.

US patents are now being made available on CD-ROM, the whole archive requiring some 200 discs so far. The European Patent Office is also expected to follow suit with the 60m pages of European patents being prepared for conversion to CD-ROM.

There is also an increasing number of CD-ROMs featuring abstracts of full text articles from magazines and newspapers. The ability to search all the back issues of a number of journals for a particular subject is very attractive. Examples of this trend include the computer Library from Ziff, with abstracts and full text of articles from more than 120 computer magazines over the previous year. Another example is UMI, which has produced a growing library of over 100 CD-ROM discs containing business periodicals and recently, IEE & IEEE journals.

Disclosure Inc has developed a CD-ROM based service called LaserDisclosure. Each week it converts to CD-ROM the SEC (Stocks and Exchange Commission) filings including annual reports, 10-Ks, 10-Qs, proxies and appropriate exhibits on more than 6,000 companies traded on the New York Stock Exchange. The documents are held as actual image copies and can be viewed on the screen of a suitable PC and printed on a high speed office laser printer. Producing about 100 discs annually, the system is used by many Wall Street financial houses. A London Demand Centre uses the system to service document requests emanating from the UK.

### **Library Applications**

ADONIS is a trial CD-ROM document delivery service that supplies more than 200 biomedical journals (published from 1987). The discs are used by major document delivery centres throughout the world to fulfil requests for individual articles received by the centres in the course of their normal activities.

A consortium of publishers including Elsevier, Blackwells, Wiley, Pergamon and Springer Verlag, together with library and academic centres from Europe, America, Australia, Mexico and Japan, plus the British Library, defined the ADONIS Project.

The original concept behind ADONIS was based on the hypothesis that if new technology could be used to respond to requests more cheaply than the current labour intensive photocopying procedures, the money saved could be shared with the copyright holders without changing the price the centres charged for the supplying documents.

Each week the contents of the journals are indexed and the pages scanned to create digital images. These and the index are then converted to CD-ROM and distributed to the participating document supply centres.

Each centre has a computer system which is capable of reading the CD-ROM discs and producing copies of journal pages on request. The British Library, which was responsible for defining the computer system, uses a standard IBM PC AT compatible computer. The journal pages are viewed on an A4 display, and can then be hard copied via a high resolution, high speed laser printer. Requests that arrive at the BL are entered by a librarian into the computer system, which locates the article on one of the ADONIS discs. The article is then transferred from the CD-ROM to the laser printer, which produces a high quality image of the document in a few seconds. This process is faster and cheaper than the traditional method: locating the journal in more than 90 miles of shelving, photocopying the article and returning the journal to the shelf. The reproduction on the laser printer is also of higher quality. In addition a fax link has been designed for the ADONIS system, enabling urgent medical document requests to be processed almost immediately.

Nearly 90 discs have been produced for ADONIS and more will be added as the project enters its second and commercial phase. Like the other multiple CD-ROM applications described earlier, such as those by UMI, Disclosure and the European Patent Office, ADONIS required a solution for selecting and changing CD-ROM discs automatically under computer control. The solution that the British Library has is the CD-ROM "Jukebox" produced by Next Technology and called VOYAGER. As the name implies the jukebox, when connected to the computer system, automatically selects and loads CD-ROM discs. Unlike a traditional music jukebox however, VOYAGER has multiple disc players and can thus be used simultaneously by several computers. It has a capacity for more than 250 discs providing storage potential for 80m pages of information, or 175 Gbytes of data.

## How They're Made

There are four main stages in making a CD-ROM: data preparation, pre-mastering, mastering and replication.

### Data Preparation

If the information for conversion to CD-ROM exists in machine readable form - ie it is already on a computer - data preparation is relatively straightforward. To ensure that the information may be found rapidly on the finished CD-ROM, the information may require indexing. The index is a file used by the retrieval software in order to find pieces of information on the disc.

You may already be using retrieval software with the data on a magnetic storage device, but beware, it is not always advisable to use the same retrieval system when the data is held on CD-ROM. This is because of technical differences between magnetic and CD-ROM media: first, the CD-ROM is usually much larger than the magnetic store. Second, while the magnetic store holds data in specific tracks and sectors on the disc, the CD-ROM holds the information somewhere on a continuous spiral. These differences require different search strategies and therefore different retrieval systems. Database software for magnetic discs usually performs poorly when used with CD-ROM including CD-Answer, HP LaserRetrieve and HyperKRS.

If the information is not yet in computer form - it may for example be paper or photographs - it can be sent to a scanning bureau for digital conversion.

Once in machine readable form the information can be sent to a CD-ROM production company - used to receiving data in a variety of magnetic forms such as 9-track tape (from a mini or mainframe computer), cartridge tape (from a tape streamer), and even large numbers of floppy disks.

The production company will transfer the data to a production system which is basically a high performance microcomputer with a large (1200 Mb) hard disk, tape reading facilities, encoding technology and software for indexing, pre-mastering and CD-ROM simulation. After the information has been indexed to your specification using appropriate software, the data is ready for the next stage of CD-ROM production.

### Pre-mastering

Really an extension of the data preparation process, pre-mastering requires that the prepared data be

formatted and encoded to conform to the CD-ROM specifications. The CD-ROM specification has become a standard, internationally recognised as ISO 9660. The ISO 9660 describes the way data is held on the disk and the manner in which error detection and correction is achieved. By ensuring that your CD-ROM conforms to ISO 9660 you can be assured the disc will be usable on the majority of CD-ROM readers available for most personal computers, mini-computers and workstations.

Once pre-mastered, the data, while remaining on the large hard disk system, is tested using software which acts as a CD-ROM simulator. This mimics the characteristics of a CD-ROM reader and allows the performance of the disk to be evaluated before committing the data to CD-ROM. Performance increases can be made at the simulation stage, and cost savings can also be made by ensuring that mastering and replication are undertaken only when it is certain that the data is correctly prepared.

The mastering and replication stage is typically conducted by the same companies which produce audio CDs, although the disks usually undergo more stringent testing after replication. The mastering processes are conducted in strictly controlled clean environments.

The pre-mastered data is sent to the replication house in the form of a tape, which is used to program a high powered laser to create a master which is in turn used to create a metal stamper. The final disk image is etched into the surface of the stamper.

The stamper is used in an injection moulding machine to stamp the very fine pit patterns into the hot malleable polycarbonate which forms the disk. When the plastic cools it retains the exact impression of the pit pattern. The disc is then coated with the thin metallic layer which gives it its reflective properties, and finally lacquered by a protective coat of clear UV cured epoxy resin.

Exact replications of the disk can be produced in tens, hundreds or even thousands. With CD-ROM each disk is individually tested to ensure integrity and quality of manufacture.

Another method of mastering, more suitable for low quantity replication, ie 1-10 discs, is a process known as "direct-to-disc" mastering. This technique uses a different material for the disk which allows it to be written to by a host computer.

The "direct-to-disc" mastering technique was pioneered by Yamaha with its PDS (Programmable

Disc System). The PDS is a relatively costly system, but it is available to most CD-ROM production companies. Using this approach the data, once pre-mastered and approved, can simply be written directly to the PDS disk without the costs associated with full mastering. The resulting disk operates with most standard CD-ROM readers.

### Costs

The costs for data preparation and pre-mastering vary depending on the initial state of the data, ie whether it is in computer form and in what format. The typical range is between a few hundred and few thousand pounds.

Full mastering costs are consistent regardless of the information being converted to CD-ROM, and producing the stamper costs in the region of £2,000; low volume disk replication (10-100 discs) costs about £15 a disk.

Direct-to-disk mastering which includes the disk itself costs in the region of £300.

### A Multi-media Future

Looking at the past 10 years of personal computer development we can see two definable generations based on power and the interface between the human user and the computer. The first generation produced machines such as the original IBM PC and the Apple II. They offered limited graphic capability and the user interface was essentially text based - commands were issued to the computer via text input in response to a computer prompt. Typical applications which characterised this first generation included Wordstar and Visicalc.

The second generation produced more powerful machines which made heavy use of graphics to communicate with the human operator, making the system easier to use. This second generation was heralded by the Apple Macintosh and the IBM PC AT with the Microsoft Windows environment. Applications such as Page Maker and Excel are good examples of second generation graphical based applications.

The third generation is open to speculation but it would seem reasonable to expect that it will feature audio and video material in addition to its graphical support. Application software could feature audio visual tutorials and assistance to make the software easier to learn and use. Training material, for tasks ranging from training staff about new products to inter-personal and management skills, will turn the PC on your desk into a powerful training tool.

Databases with photographs and sound could be developed for use as a catalogue of stock or as an electronic sales catalogue. Corporate presentations could be produced by clipping together video sequences on desktop computer.

Audio and visual information requires a large amount of storage, which is where CD-ROM XA comes in. This allows audio and video sequences to be stored and retrieved from the same CD-ROM which contains your data. The video sequences appear as full motion sequences in sections of the screen. The video sequences could be used to demonstrate a new product, or take the form of a talking head explaining how to use the computer.

For full screen, full motion video from CD-ROM for use on your computer, a technology known as Digital Video Interactive (DVI) is required, DVI allows up to 72 minutes of near television quality video to be played back on a PC. This video can be controlled by computer software and fully interactive presentations of information are made

possible. The technology, which is in the form of an upgrade card for a PC, is produced by Intel (the semiconductor company) and is promised for early in 1990.

Arthur Anderson is just one of the many companies already developing software for DVI systems, and with IBM's recent announcement of its intention to support DVI and introduce multimedia based products to the marketplace, we look set to start the 1990s with multimedia desktop systems. The future is just around the corner. □



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