Optical Memories: Archival Storage System of the Future, or More Pie in the Sky?

by Sam Kula

Optical memory systems are perhaps best known through the various forms of videodiscs now being developed and which are threatening to invade the home entertainment market in the autumn of 1977. Both MCA/Philips in the United States and Thomson-CSF in France have announced the imminent appearance of relatively low-cost player units (interpreted as under one thousand dollars) that will hook on to a standard television set and provide up to thirty minutes each side of moving images from a twelve-inch disc. The systems announced to date (Telefunken-Decca's TelDec in Germany and RCA's SelectaVision in the United States are two other runners in the videodisc sweepstakes) are all designed to play back pre-recorded discs in very much the same way phonograph records are used today. The playback units demonstrated look like record players or modified tape decks (the discs can be either flexible or rigid) with controls simplified to the level of the proverbial twelve-year-old.

Those monitoring this development may be justified in adopting a skeptical stance at this point. The videodisc player and programme that would place copies of feature films in a home for less than ten dollars each has been "imminent" for more than five years. The technology has been operational in the laboratories for at least twice that long, but manufacturing and marketing a reliable player that can compete in the marketplace has proven difficult and costly. Many obstacles have been overcome, however, and the recent arrangement whereby two of the frontrunners, MCA and Philips, joined forces in the Discovision system for masters and replication with Magnavox manufacturing the players may well succeed in placing the units on the market as announced.

All of which is—or should be—irrelevant to archivists, whose concern should not be with the hardware of the industry or the software (primarily re-cycled films) served up to stimulate demand for the playback units. The underlying technology may offer great promise but it is a discouraging fact that archives traditionally have waited to adopt products marketed commercially rather than to adapt an emerging technology to their needs. Given the tremendous potential of optical memory systems for archives in several media (text, photographs, moving images) restricting use to home entertainment (your very own copy of *Jaws* or *King Kong!*) would be a shocking waste. Any assessment of optical memories should perhaps begin with a comparison between optical and conventional fourth-generation magnetic memories—the computer-driven storage and retrieval systems that have promised more than they have delivered to archives for more than twenty years. [1]

To begin with, the physical limitations of magnetic memories (particle size is finite and the limit appears to have been reached), whether tape or disc, argue in favour of optical memories on the question of density and single-record capacity. Total system capacity (linking up memory units for system-wide searches) and speed of access, however, are proven factors with magnetic memories, while still developmental in optical systems. One configuration suggested for optical discs, for example, is very similar to the old style juke box—a stack of discs on a central pole rotated into position in sequence for search or read.

A major limitation of optical memories is that they can only be read. Rather than erasing the old record and posting new data, as one can do with magnetic memories, another record must be created and coded at the old record to the new address. Other factors, such as transfer rate, also favour magnetic memories, especially in applications where high-volume computations, continuously updated data flow and extremely rapid on-line access is required, as for airline reservations. Archivists may not consider these limitations particularly restrictive. A read-only format without the possibility of accidental erasure has definite advantages when one is dealing with permanent records, and the transfer rate is unlikely to be of great concern in building a long-term, limited-access file.

The key to all optical memory systems is the development of low-power, low-cost helium-neon lasers—incoherent light sources that can be focussed precisely and used both to write the record by forming minute holes or ridges in the recording medium and also to read the record so created. In the proposed commercial applications the mastering of videodiscs requires relatively high-power lasers while the read function utilizes a very low-power device—less than one one-thousandth of a watt, used widely in industry, reliable and safe. By eliminating the mastering phase, however, which is only required for high-volume replication, it is possible to develop optical memory systems with recording media allowing the use of low-power lasers in both write and read modes. The hardware would thus be similar to a videocassette recorder/playback unit, such as the Sony U-Matic, and at much the same cost.

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1 I am indebted for an introduction to this topic and much of the information to a conference, "Prospects for Optical Memories and Recording," organized by The Institute for Graphic Communication in October 1975, and held at Castle Hill, Ipswich, Massachusetts.

Dr. John Locke, working at the University of Toronto's Institute for Aerospace Studies has developed a new recording medium that enables him to both read and write with a low-power laser. He is predicting storage densities for digital data that could conceivably allow the recording of every one of the 4.4 million books in the University of Toronto Library on five hundred one-sided discs occupying no more than ten metres of shelf space! The medium, moreover, is not photographic—there is no chemical or processing stage. This allows read-while-write verification while recording, and posting of additional data at a later time to complete the record. Both write and read could then be "in-house," essential for security and protection of fragile originals.

The use of the laser, harnessing light to both read and write, is the source of the substantive advantages optical memories can provide for archivists. The technology that produces thirty minutes of moving images, colour and sound, from the densely packed "tracks" (dots, micron size, laid down in a spiral pattern and normally "read" from the outside in) on a twelve-inch disc can also produce "frames"—drawings, maps, photographs or pages of text—each addressable individually and retrievable through random access.

In terms of engineering specifications, an optical memory system would have to have a capacity of at least 10^6 bits/record to be competitive with magnetic memories. In fact optical memories can easily achieve capacities of 10^9 bits/record. At their present state of development optical memories can achieve forty-five times the capacity of magnetic memories of similar size and with comparable rates of access.

Translated into more immediate archival comparisons, the technology about to be marketed, the twelve-inch videodisc, can accommodate 54,000 frames, the equivalent of 180 books of 300 pages each. To reproduce the matter that can be stored on twenty twelve-inch discs (1,080,000 pages), occupying approximately 2.2 centimetres of shelf space would require 10,000 separate microfiche cards. In fact, standard microforms offer a linear reduction of approximately twenty times the original, or a storage density roughly four hundred times greater than the original. In comparison, a digital optical system can achieve a storage density close to three million times the original, or seven to eight thousand times that of conventional microfilm. With this level of density the contents of a set of the *Encyclopaedia Britannica* could be held in ten square inches of record, a reel of computer tape (2060 feet) in one-half square inch, and a five-drawer filing cabinet in three square inches.

As impressive as the potential capacity is—a million pages in less than an inch of shelf space is a quantum leap forward in miniaturization—the most engaging characteristic of optical memories for archivists must be their operational efficiency and relative stability over time. The record is a series of minute holes or relief dots formed by a laser beam in any one of a variety of substances (photochemical, photopolymer, photoconductive) and in at least one application, using a polymer plated with rhodium, the record has been certified as archival by the United States National Bureau of Standards. The development of a chemically and physically stable record, resistant to environmental changes and atmospheric pollution, and economical for long-term conservation is a distinct possibility. The photopolymers used in some experimental applications are permanent and very inexpensive.

An important factor in extending the life of optical memories is that they are "read" by a light source as the disc revolves. [2] Nothing touches the record itself. The number of plays is theoretically limitless as there is practically no wear. Precisely focussed, the beam can ignore dust, dirt and scratches collecting on the surface to read the impressions that constitute the record. The record itself can be sealed in a transparent coating. Utilizing a servo tracking beam, the "reading" light can be controlled with such precision that both the upper and lower surfaces of the disc or plate (perhaps 1 millimetre in thickness) could be encoded and read separately, thereby doubling the capacity of an individual record.

At even half the capacity proposed for the commercial videodisc, say twenty-five thousand frames, the cost of recording a page of text could well be less than one-half cent. Equally impressive is that copies could be "pressed" using current phonograph technology for less than twenty-five cents a record in large quantities. Costs for each record rise as the number of copies required decreases, but with the existence of a master, a researcher could conceivably order a copy of a 100,000-page manuscript collection at a cost of less than five dollars. Replication of entire holdings, for security and diffusion programmes, would be feasible and practicable.

Pie in the sky? Possibly. A healthy dose of "show me" is in order when one considers likely archival applications. For example: how does one get the document into the system? One approach may be the use of a high-resolution television scanner (1000 lines as opposed to the broadcast standard of 425 lines) to "read" documents in much the same manner as microform cameras do, one page at a time, but with a continuous feed. The electronic signal generated then serves as input for the optical memory system. To secure a copy of the document the system is reversed. The

2 Both the TelDec and RCA's SelectaVision utilize phonograph type styluses to "read" holes or ridges in the record. This introduces a wear factor so severe it may make freeze frames, essential for photographs, maps or textual material, impossible. These are accomplished in all videodisc applications announced by "reading" one track, normally a single revolution of a record spinning at 1800 rpm, again and again, literally eighteen hundred times for a frame held on the screen for one minute. For all practical purposes this is only possible with a record "read" by light.

optical memory feeds a high-resolution television display which can be coupled with a photocopier to provide hard copy.

The quality of the copy—the restored record in its original format, whether paper or film stock—will thus be dependent on electronics developed both to feed the system and to provide the copy. If current television broadcast standards are applied, the quality will be relatively low, perhaps suitable for text, but unacceptable for maps and photographs demanding high resolution for detail. The technology exists, however, (1000-line television monitors are now used in the industry) and if applied can produce results that will show no greater degradation from the original than the reproduction processes now in use.

One great advantage of optical memory systems is that all media, including text, maps, continuous tone images and line drawings, prints and paintings, and photographs can be "read" in the same pass and stored in the same record. Moving images (films and videotapes) and recorded sound require special projection or playback equipment to generate input, but once scanned and converted they can be "interfiled" with the other media from the same collection on the same record.

Optical systems, primarily the videodisc, now being developed for the entertainment industry are designed with the proprietary interests of the owners of the programmes in mind. The mastering is extremely complex and expensive, but the process of "stamping" out copies is direct and inexpensive for large volumes. The videodisc is, however, only one of the formats possible. An alternative was developed for the Digital Recording Corporation by Battelle-Northwest, Richland, Washington, a division of Battelle Memorial Institute, the research and development organization in Columbus, Ohio. In this system the record is a "card" that is fixed in position and read by a scanner that moves across the surface. The "read" instrument is a laser light source and the record is not touched during the operation. The record is encoded in much the same way, using a TV scanner and photoresist materials which can be processed and sealed for permanence. A five by seven inch "card" in this system can easily hold as much information as a twelve-inch videodisc. Because the card/record is fixed, even greater densities can be achieved. The manufacturers also claim that a playback unit need not occupy more space than a four-drawer filing cabinet. One of the storage units proposed would hold one thousand "cards" in four circular trays that would rotate into position before the scanner with each "card" dropping into position in much the same manner as a slide projector operates. Access times of under five seconds for each random search are claimed for this configuration, with searches of individual "cards" reduced to a few milliseconds. In terms of microfilm, such a storage unit could hold the equivalent of more than five million frames.

More pie in the sky? Perhaps. The optics of moving scanners are extremely complicated. Archivists will never know unless they probe behind the press releases to investigate the technology emerging from the laboratories. The archival crises of the next decade will revolve around storage capacity, the permanent conservation of a wide variety of materials that self-destruct (acidic paper, xerox copies, dye transfer colour photographs and motion pictures), and the demand for access on and off the premises of the archives. Optical memory systems appear to offer interesting prospects for solutions to problems in all these areas. It is unlikely they will be forthcoming, however, from applications designed for home entertainment. Research and development has never been the strong point of archives, if it has existed at all. Perhaps it is time to begin seriously investigating the new technology to discover if a piece of that pie in the sky was meant for us.