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Current Comments

Portable Information — Is the Dream Becoming a Reality?

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In 1945, Vannevar Bush wrote an article in the *Atlantic Monthly* which has become a classic in information science. Bush, who helped pioneer computer science, called on American scientists to redirect their war research efforts toward the problems of peace. Encouraged by science's advances in controlling the material environment, Bush was optimistic that the same ingenuity could be applied to the intellectual environment. He even described a device called "Memex" which could aid the individual to access the rapidly expanding record of man's knowledge. In Bush's own words Memex would be "a device in which an individual stores his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory."[1]

In the earliest days of the international documentation movement the symbol for the solution to total access was microfilm. In those days, when on-line computing was not even dreamed of, it was natural that Memex should be thought of as a microfilm storage device. But Memex came to stand for more than just a device. Memex and the idea of the world brain expressed the ideal of universal bibliographic control, which I discussed in my paper "World Brain or Memex?"[2]

Memex inspired many of us in those early days. When I worked with Emik Avakian on the development of the Automatic Microfilm Information Selector (AMFIS), we acknowledged the inspiration of Memex in our paper.[3] AMFIS was designed around microfilm, but the microfilm was stored in an unusual and innovative way. Instead of traditional microfilm reels, the film was arranged in strips and stored on large scrolls which could be accessed simultaneously in two dimensions. It is not important to expound on the mechanical details of AMFIS. A practical low-cost device was never produced. However, I believe a modern version of it was built for a government agency in Europe.

There is a vast literature on so-called microfilm. The term microfilm is really a misnomer. There is nothing micro about the film itself, whether 35mm, 16mm, or 8mm in width. What is micro is the image of the document on the film. Typically, the image of a one page document is stored in an area that requires less than 1/500 of the original area. For example, using a reduction ratio of 1 to 24, the area of the film used is 1/576 the original.

Microforms come in a variety of sizes and formats. Many newspapers are stored on spools or reels of microfilm. Microfilm reels are continuous rolls of transparent 35mm or 16mm film, like movie film but without sprocket holes. They are usually stored on a single, open spool or on one or two spools enclosed in a cartridge or cassette. Strips of microfilm are often inserted into clear plastic rectangular jackets. In the old days film strips of articles were stored in small film containers. Individual frames of 35mm film are also mounted in rectangular "windows" on punched cards. This microform, called an aperture card, is used mainly for engineering and architectural drawings, but it has other applications.

Microimages of documents can also be stored on fiche—the French term for card. So-called microfiche are simply sheets of film equivalent to several rows of strips. While microfiche usually involve reduction ratios between 10X and 48X, ultrafiche use between 90X and 150X. Ultrafiche store 1,000 or 3,200 pages on a 3" x 5" sheet of film, depending on the type of ultrafiche you choose. But they just haven't been widely accepted. An *economically* viable system for reading such microimages has not yet been developed. Theoretically, one could use a laboratory microscope to read ultrafiche, but finding a desired frame would be a serious problem.

When Avakian received patents on AMFIS,[4,5] I was surprised to learn that the first patent for a commercial application of microfilm was granted almost 100 years earlier in 1859.[6] In fact, the use of photography to capture printed texts is as old as the daguerreotype process of producing photographic images on silver-coated plates, developed during the 1830s.[7] Since that time microfilm has revolutionized archival storage of information. Vast collections of previously inaccessible documents are now available to scholars because of microfilm. But even though it has been available for more than 120 years, microfilm hasn't yet fulfilled its promise as a substitute for print media.

There is one primary reason why film has not become a viable substitute for journals and books. There has never been a suitable portable device for reading microforms *comfortably*. Many people have learned to use microform readers in libraries for reference purposes. But they are generally not willing or able to do so for most normal reading purposes. For example, if we published *Current Contents*® on microfiche it would speed up mail delivery and reduce our dependence on paper—but who would read it?

Of course, one can cite countless examples of excellent programs for microfilming periodicals. Not the least of these is the University Microfilms International (UMI) effort founded by Eugene Power. UMI offers more than 700,000 doctoral dissertations, out of print books, and journals in the form of continuous reels of transparent 35mm film. Other firms like Bell & Howell, Princeton Microfilms, and the Microfilm Corporation of America also offer current and back issue journals on microfilm.[8]

Certain publishers, like Pergamon Press, have also offered microfilm and microfiche programs. In recent times, according to Ionel Benglas of Pergamon, microforms have been in greater demand since their cost is increasingly competitive with hard copy and because of the great savings in expensive shelf space.[9] But this demand is limited to libraries. And no active research library can completely substitute microfiche for an actively used current research journal.

I say this in spite of the apparent success of the *Journal of Chemical Research*.[10] Since it started in 1977, the *Journal* has published about 240 papers in microform a year. H. Grunewald and G. Ourisson and all those who sponsored this journal are very enthusiastic about synopsis-type research journals backed up by microform. Has the millennium really arrived? I doubt it. It is the printed synopses that are read while the microform versions of the full articles are used selectively.

If only a fraction of the investment made in producing microform editions of journals were devoted to reader development, there might be greater acceptance of microform as a substitute for printed publications. Several organizations involved in promoting the use of microform have made efforts to develop portable readers. The Council on Library Resources (CLR), an organization sponsored by the Ford Foundation, has a long-term interest in this area and has funded many reader development projects.[11] Carl Spaulding, who retired from CLR, notes that UMI, Bell & Howell, Eastman Kodak, and the Massachusetts Institute of Technology have also tried at various times to come up with working models of portable readers for microfiche, but few have tried to design portable readers for roll microfilm.[12]

Until truly portable readers become available, microforms will continue to play an archival role only. The price of paper and postage will have to escalate enormously before the leading journals stop publishing printed versions. In the meantime, many more marginal journals may fall by the wayside unless they adopt cheaper methods of production and distribution. They might be used in microform editions if better readers were available.

The first time I heard about the problem of portable microform readers was when I met Atherton Seidell in Washington. Seidell was involved with microfilms and readers as early as 1935. He coined the term "filmstats," combining photostat with microfilm. A filmstat was a short strip of film.

Seidell realized the need for portable readers if microfilms were to be widely accepted by individual users:

> Without means of reading the greatly reduced-size print upon 35 mm filmstats, the service would be of no value. It is important that the magnifying or projecting devices for this purpose shall be within the means of the individuals for whose benefit the service is organized. It has been found that a very simple magnifier of the reduced print can be made by mounting an 8- to 10-power inexpensive lens in one end of a short cylinder, and two plates between which the film is held perpendicularly to the lens at the other end. A ground glass beyond the film equalizes the illumination of the print. Such a simple magnifier [manufactured by the Spencer Lens Co., Buffalo, New York]... can be purchased for about $5....[13]

Remember that this is a 1935 price—the same magnifier would cost about $25 today!

Just before World War II, Seidell began reproducing the periodical holdings of the Army Medical Library (now the National Library of Medicine) on 35mm film using a motion picture camera. Estelle Brodman, librarian and professor of medical history at Washington University in St. Louis, Missouri, worked closely with Seidell during this time. Brodman recalls,

> When Dr. Seidell found that it was difficult, if not impossible, for the Army medical officers to read the microfilm unless they had some kind of reader, he designed one. He first suggested that they should read it under the microscope. Many of them, of course, didn't have microscopes at hand—remember we were then in World War II—so that was not very helpful. He proceeded to make a very inexpensive hand-held viewer—I think it cost something like $1.25—which he sold to the officers whenever they wrote and asked him for it.[14]

I had one in my possession until we moved to our new building.

Today, many companies offer hand-held viewers for microfiche and film jacket formats. From 1956-67, while he was president of CLR, Verner Clapp kept a large collection of hand-held viewers in his office. Spaulding remembers that a few viewers had eccentric designs. One hand-held viewer, for example, looked and, in use, was held like a shotgun! After Verner died, Spaulding put the collection in a basement storeroom at CLR.[15] Verner was one of several people I knew who were obsessed with hand-held portable microform readers. Among them was the late John Flynn, a former editor of *Biological Abstracts*. I met him when I first came to Philadelphia in 1954. He told me that only the development of a portable reader and the use of microfiche were the solutions to the biologist's reading problem.

Modern hand-held viewers have magnifications ranging from 8X to 48X and some offer electric light sources and even limited projection capabilities.

The prices are considerably higher than Seidell's prototype, ranging from $20 to more than $100.[16] However, they are primarily useful for quick reference purposes. Reading an entire article with them can strain your eyes and give you a headache!

To avoid eyestrain and headaches, the microimage should ideally be projected onto a screen or wall to approximate the size of the original text. Most hand-held viewers are too small to project a legible, full-size image of the original document. But there are many larger microform readers on the market today that fold up and can be carried like a briefcase. These so-called "portable" readers weigh anywhere from two to 40 pounds, with magnifications ranging from 8X to 75X. The prices vary from $100 to nearly $600.[16] The microimage can be projected onto the front of an opaque screen, like a conventional slide projector. But most readers project onto the back of a translucent screen and the image is viewed through the screen.[17]

While the portable readers solve the problems of eyestrain and headache associated with hand-held viewers, they still have several drawbacks. A basic problem with readers projecting images onto the front of a screen is ambient light, the illumination of the room or area surrounding the microform reader. William Hawken, a well-known authority on microforms, explains, "Ambient light tends to dilute the image on a screen and to reduce its contrast and therefore its legibility. The greater the amount of ambient light striking the screen, the higher the luminance [brightness] of the screen must be for equal legibility."[18] The problem of ambient light is avoided if the user can vary the intensity of the light source, but any extra options add to the cost of the reader. It would be cheaper to use some sort of hood to block out ambient light, but this adds to the inconvenience of using microform readers.

A similar problem exists with readers projecting microimages onto the back of a translucent screen. The screen diffuses the light from the reader lamp, but the illumination is not spread evenly across the screen surface. As a result, a "hot spot" of bright light appears at the center and gradually fades into darker corners. This is called "fall-off," and it can be avoided only if you buy a machine having a complex and expensive design.[19]

Another common, but not serious, problem with microform readers is image stability. The projected image is magnified 24X or 48X, so any small motion of the plates holding the microfilm is magnified as much—the image can easily jump off the screen, and centering it becomes a chore. Film holders may drift because of the reader's vibration, or even because of gravity![17] This is no longer a serious problem as it once was, because manufacturers have developed very solid film carriers in the last few years. It may still be a problem if you want to use microform readers in automobiles to store maps and other information. I suppose one could stop the car to read the map! But even motor vibration might cause flicker.

The stability of the reader in general is important. Portability makes the reader vulnerable to rough handling and constant jarring. A microform reader really is a sensitive precision instrument—lens, bulb, circuitry, screen, film holder can all be damaged or misaligned. Parts aren't interchangeable between reader models made by different companies—if your reader breaks down, you may have to ship it a considerable distance for repair. The solution is to buy a reader with a very sturdy, shock-resistant case, but that increases the price.[19]

To reiterate, microfilm has not lived up to its expectations because reliable portable readers are not yet available. Spaulding says there are good portable readers for microfiche, but stable portable readers for roll microfilm are more rare.[12] Lew Handelsman, vice president of Computer Micrographics, Los Angeles, California, agrees that "there is no ideal portable reader available today; the ones on the market are passable but are not perfect; there are certainly drawbacks to all of them."[20] Alan Horder, head of research at the National Reprographic Centre for documentation in Hatfield, England, doesn't see a "quick fix" for the problems of portable microform readers: "It would appear that most of the possible variants of the basic projection design...have already been explored. Radically new technology would seem to be needed before a solution to this problem is achieved."[21]

In fact, a portable system was developed a few years ago by IZON, a company formerly based in Stamford, Connecticut. The IZON reader makes use of new advances in fiber optics and lens technology.[22] Instead of using a single lens to magnify the microimage, the IZON reader uses 504 plastic microlenses to project full-page images of reduced-size text. By using so many lenses, it significantly reduces the focal length of the reader, that is, the distance between the lens and the image focused on the screen. The IZON reader measures only 14" x 10" x 2½", no larger than the average-size book. Compare this to portable briefcase readers measuring about 16" x 15" x 15", when open for use.[16] Also, IZON uses fiber optic backlighting, which ensures even illumination across the viewing screen with no "hot spots" or "fall-off." However, the IZON reader only works with IZON film! A special camera converts full-size pages, microfiche, and microfilm to IZON film. One 8" x 10" sheet of IZON film can store 195 full-size pages. Although research and development for the IZON reader is completed, IZON couldn't find a corporate partner to produce and market its reader. IZON is no longer an active company, but interested readers can write Joseph Donovan at IZON, 666 Fifth Ave., New York, New York 10019.

Whether or not the IZON reader represents the breakthrough we've been waiting for, it is somewhat ironic it has come at a time when the cost of silver, used in all master and some distribution copies of microform for archival purposes, has risen astronomically. Microform publishers have anticipated rising film costs and switched over to diazo or vesicular film for most distribution copies. Both are cheaper than silver film, but images on diazo or vesicular film fade after a period of time. Also, vesicular film is sensitive to heat and can deteriorate even under the heat generated by the reader's light source.

Any type of microform—silver, diazo, or vesicular—is vulnerable to defects in production. The camera may be slightly out of focus when photographing the text, the lens or text surface may be obscured by dust, or the film itself may be damaged.[23] (p. 364) There is a clear need for quality control in producing microforms. In a 1975 survey of 157 libraries' experience with microform, about 50% reported "occasional" to "large" problems with microform quality. About 30% reported "none" or "rare" problems.[24] (p. 58)

I won't repeat here all the advantages of miniprint over microform. I've discussed miniprint before.[25] Remember that microform requires the use of silver, diazo, or vesicular film. Miniprint is a photo-offset printing process involving paper and ink only. Reading miniprint requires nothing more elaborate or expensive than a magnifying glass. For example, the publishers include magnifying glasses in *The Compact Edition of the Oxford English Dictionary*.[26] But this is for quick reference use of this dictionary only. I have a somewhat more sophisticated reader that was designed for miniprint (see Figure 1).

Both microform and miniprint may become obsolete if rival information storage and retrieval systems continue to become cheaper. Many libraries and research institutes currently have online access to a variety of data bases. At present, you can only retrieve citations or abstracts. In the near future, "full-text files" will be common—complete texts of articles and books, including graphs and figures, will be retrievable.[27] These are harbingers of the electronic journal.[28] But there is no guarantee that the cost of storage and retrieval will go down indefinitely. Spaulding thinks the

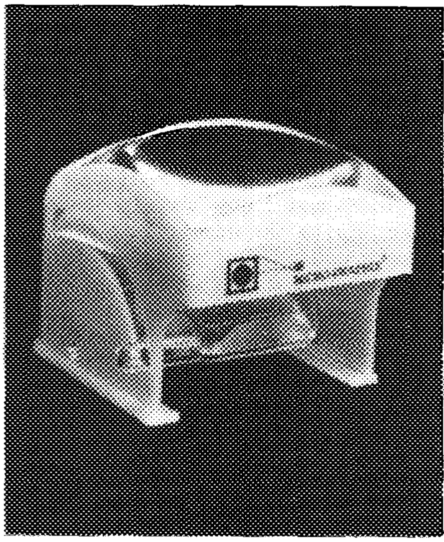

Figure 1: Reader for miniprint publications, manufactured by Micro-Graphix.

cost of transcribing documents from written form to machine readable form is the greatest obstacle on the road to full-text computer storage.[12]

In 1969, Image Systems Inc. of Culver City, California, developed one of several systems in which microfiche can be accessed on-line. Called the isi 4000 Mentor (no relation to ISI®), the system uses a carousel to store up to 780 microfiche, but the number of documents you can keep on file is limitless since you use as many carousels as you need. The computer interface hooks up with any computer, either directly or through a CRT console. When you file the microfiche in the carousel, an eight digit "address" is assigned to each frame. If you want to retrieve a particular document you simply type out the address and, in a fraction of a second, the fiche is extracted, the individual frame is located, and the image appears on the CRT screen. The virtue of the Mentor system is that the microfiche file can be accessed on-line even from another city through a common telephone-modem hookup. Also, the file can easily be updated and edited by adding or rearranging the fiche in the carousel.[29]

Holographic storage techniques have a much higher information capacity than microfilm or fiche. Holography uses laser beams to store as much as ten million bits of information per square inch of photosensitive film![23] (p. 351) Peter Waterworth, optical memory manager at Plessey Microsystems Ltd., Towcester, England, says that holographic systems "could store around one million documents per reel of film. The stored data can be manipulated, filed, and, more importantly, transmitted under computer control.... It is possible to remotely search a [holographic] file."[30]

Videodisc players are more portable than these systems based on personal computers since they aren't anchored to telephone lines and CRT consoles. One videodisc the size of a conventional 12" phonograph record may be able to store 1,000 different 600 page books[31] or several million catalog cards.[32] Optional equipment is available that makes access easy—a push-button system has been designed for locating single "frames" of information on videodiscs.[32] However, you can't yet create a personal information file on videodiscs. Master copies of videodiscs are too expensive to produce individually. In fact, you have to press between 1,000 and 50,000 copies before videodisc prices fall in the $2-$15 range.[32]

Videotape systems have recording and editing capabilities, so it is possible to create a personal information file with them. Also, the information storage capacity for videotapes is equivalent to that of videodiscs, and blank two-hour tapes cost only about $20. I know of one videofile document storage and retrieval system developed by the Ampex Corporation more than ten years ago. A document is simply photographed with a television camera, and the image is recorded on magnetic tape in the form of a television picture—it is not necessary to translate the picture into digitized computer language. When the document is retrieved from the videofile it appears on a special television console for viewing, or it can be reproduced in hard copy at a rate of between 18-75 pages per minute.[33]

A special television camera and console are needed to overcome the problem of *resolution* when storing and viewing entire pages on videofile systems. If you put a picture of a printed page on an ordinary television set, you simply can't read the print! A television set creates a picture by scanning the screen with an electron beam, and there are 525 scanning lines on the standard screen in the US. You need at least twice as many scanning lines to create a legible picture of a full page of text. Of course, half a page can be transmitted at double the magnification, and this would reproduce readable text. But few people are comfortable reading half a page at a time. Also, full page diagrams, charts, or graphics couldn't be read on a television screen.

All these promising new technologies—full-text computer files, microfiche carousels, and holographic storage—are still years away from being available for home or office use by individuals. It may be decades before the hardware is miniaturized for convenient portability, even for videodiscs and videotapes that are now available. While we are waiting for the new technologies to mature, I think the mass-market potential of videotape may get us as close to portability as one can hope for now.

Before video recorders became available I used to dream of having the unabridged dictionary, encyclopedias, and other reading material on microfiche, which I could store in the glove compartment of my car. My portable reader would be good enough to read a paragraph or two while driving to brighten up the conversation. When I acquired a new car it would have a built-in microfiche reader, and somehow the problem of vibration would have been solved.

Here's how I now visualize your future trip to the beach. You put this week's collection of reprints under the videocamera at your office. The videotape cassette you've just made requires no development. The videocassette fits easily into your briefcase. You pick up your portable TV playback system and drive off. Before you get to the beach, you can start reading by plugging the system into the cigarette lighter. If one of the kids asks you a question, you insert a pre-recorded videocassette of the encyclopedia. If you get lost en route to Woods Hole or Cold Spring Harbor, just pop in a videocassette map. When you're tired of reading science or answering questions, you can all watch Charlie Chaplin movies on pre-recorded cassettes.

Until all this becomes a reality, I suggest you hang onto your hard copy reprint collection. It doesn't require an electric umbilical cord to relax in a comfortable chair and flip through the pages of a reprint. When you fall asleep you can dream about Memex.

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