Microfilm as Used in Reproduction and Transmission Systems

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THE REBIRTH OF MICROFILM some thirty years ago (microfilm was first invented in 1859 by Dagron) opened for the scholarly community the door to the world's knowledge. Because of its inherent versatility the uses of microfilm have broadened far beyond the dreams of its early developers. It is fair to state that in view of past developments the horizon for microfilm is relatively limitless. A review of the multitude of applications of microfilm to various techniques and systems seems appropriate in view of recent advances in the area of documentary reproduction and leads to some tentative conclusions regarding changing emphasis and potential developments.

The basic application of microfilm in the library should not be glossed over. Although microfilm may be used as the primary means of disseminating information as, for example, the American Documentation Institute Auxiliary Publication Program,[1] University Microfilms Doctoral Dissertation Program,[2] and the Publication Board Project,[3] its major application is to stand in as a substitute for the original document which for some reason is not available to the library or scholar.

Microfilm in roll or unitized form (as employed in aperture cards or jackets) requires an intermediate optical arrangement to facilitate its use. In this regard, microfilm is relatively difficult to use. This inconvenience, however, is offset somewhat by the basic lower cost of the microfilm itself (provided of course that the original document is out of print or otherwise unobtainable).

In practical application, the use of roll microfilm for long runs of material, particularly newspapers, as a substitute for the original file is increasingly accepted by the librarian and scholar. To a lesser degree the substitution of microfilm for serials is also gaining acceptance.

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In both applications, there is justification for use of the roll microfilm, inasmuch as each roll of microfilm can be utilized in substantially the capacity for which it was intended without jeopardizing reference usage.

The potential use of microfilm in the field of rapid searching or selection of specific information or types of information has lead to the development of a multitude of sophisticated machines. Their names, among others, are well known—the Bush Rapid Selector, Filmorex, Minicard, and more recently Film Library Instantaneous Presentation (F.L.I.P.). Common features of this group include, beside the use of microfilm (roll film or bits of film or sheet film), a photographic code consisting of dots or bars arranged in predetermined patterns. The film containing the coding is read by a scanning device which has been instructed to act on a specific code pattern, either stopping the film for viewing on a screen or activating a copying device which may reproduce the document or documents desired.

The Microfilm Rapid Selector, originally developed at Massachusetts Institute of Technology under the name of "The Bush Rapid Selector," was one of the earliest machines of the type which provided for the storage of abstracts and other data in microfilm form and which, in addition, contains a special coding to permit the speedy selection of required data and, when required, the copying of the information by means of high speed photography. In the Rapid Selector, the choice of a desired abstract is accomplished by means of photoelectric scanning devices coupled electromechanically to a high speed flashtube and a rapid-advance recording camera. The selection is accomplished through comparison of a code area, associated with each abstract on the film with a code card inserted in the Rapid Selector.

The master microfilm utilized in the Rapid Selector is prepared by a specially designed camera which provides a continuously variable reduction ratio from the abstract to the film. A bank of lights, representing abstract code numbers, is photographed along with the abstract. The code bank light target forms a dot-pattern code which is photographed on the film along with the abstract material, while a standard card, punched on a specially designed card punch, is used to interrogate the microfilm selector. The punched card, containing the code which is complementary to the desired film dot pattern, is inserted into the Selector. When the film code area dot pattern and the punched card are exactly complementary, no light passes through the card holes, a blackout occurs, and the abstract is reproduced. The

Rapid Selector, as experimentally developed by Vannevar Bush in 1940 at the M.I.T. was further refined in 1949 by the Engineering Research Associates, Inc., of St. Paul, Minnesota, under a contract cooperatively sponsored by the Departments of Commerce and Agriculture. As finally constructed, the E.R.A. Selector is said to have a frequency response adequate for film speeds from twenty to five hundred feet per minute.[4]

Another high speed microfilm selector has been developed in France by Jacques Samain. This device, known as Filmorex, utilizes microfilm in sheet form measuring 72 x 45 mm. The right-hand side of the film contains two pages of text and the left-hand side contains the code area where electronic selection is made. A special camera designed for 70 mm. film is required for producing the microsheets. This selector has also been designed to utilize 35 mm. film.

The sheet films in the Filmorex system are stored without regard to classification. Information can be extracted at the rate of six hundred sheets per minute with selected microsheets automatically ejected when the pre-selected codes correspond with each other. No method of reproduction is incorporated in the Filmorex system, rather the selected sheets of microfilm are read in a microfilm viewer or enlarged photographically.[5]

The most recent addition to the field of rapid selectors utilizing microfilm as the storage vehicle has been developed by the Benson-Lehner Corporation of Los Angeles. This device which has been christened "Film Library Instantaneous Presentation"—F.L.I.P, for short—is basically similar to the Bush Rapid Selector. The machine is designed to quickly locate a desired frame in a 1,200 foot reel of 16 mm. microfilm and to project the frames on a built-in viewing screen. A binary coded number is photographed in the form of black bars on a clear background. The film scanning speed of the present existing model of F.L.I.P. is said to be approximately sixty inches per second. An entire 1,200 foot reel can be scanned in about four minutes. A detailed description of F.L.I.P. has been published in a recent issue of *Library Resources and Technical Services.*[6]

Another device for rapid selection of data, similar in principle to the other selectors, though distinctive in its approach, has been developed by the Eastman Kodak Corporation under the name "Minicard." Although the Minicard System is potentially capable of handling information of all types, its initial application has been in the area of documentary information.

The minicard itself is a piece of microfilm 16 mm. x 32 mm. in size, near one end of which has been inserted a slot which permits the card to be handled by means of a metal "stick." The minicard contains either digital information in the form of clear or opaque dots and images of documents, or digital information alone. A single minicard may carry from zero up to twelve image areas, each area of which may record a copy equivalent to a legal-size page 8½ x 14 inches. Digital information, when no graphic images are made, amounts to seventy columns of forty-two bits each or a total of 2,940 bits. The metal sticks in which minicards are handled have a capacity of two thousand cards. A sorting speed of 1,800 cards per minute is attained for sorting and selecting operations.

The Minicard System combines many of the desirable features of the punched card and the microfilm systems.[7]

The concept of rapid and automatic selection of desired information stored on microfilm has yet to make an appreciable impact on library operations. However, this is not meant to imply that the future may not see developments facilitating greater usage in libraries.

The Minicard System, for instance, makes use of high reduction (60 diameters) and R. R. Shaw mentions [8] the theoretical possibilities of reductions ranging in the area of three hundred times. How long it will take such advanced technology to reach the library and/or library laboratory is difficult to predict. Whether extreme high reductions would prove feasible in anything but film to film reproduction on a production or reference basis seems problematical. In discussing the microfilm reproduction of libraries, particularly with regard to mechanical retrieval of masses of data, it is essential not to overlook the disparity of the stock in trade of the research library—books, serials, pamphlets, manuscripts, newspapers—all in various sizes, formats, both as to external dimensions and size of type and, more importantly, in all conditions of legibility.

Another application of microfilm, which has been demonstrated only on an experimental basis, is in the field of rapid communication. Known as "Ultrafax" and developed by the Radio Corporation of America, this process was demonstrated several years ago at the Library of Congress. Applying principles of television and photography, the device was said to be capable of transmitting "at the speed of light" a facsimile (microfilm) image over a distance up to twenty miles (further distances with the use of relay stations) at the rate of thirty leaves of text a second. Coupled to the system was a rapid film processing or "hot photography," which delivered a single frame of film ready for printing or projecting in forty-five seconds.[9]

To date Ultrafax as such has not reached the stage of commercial development even though the concept of image transmission is commonplace. Recent developments indicate that commercial applications are being made in the transmission of motion pictures by wire. Perhaps this will stimulate advancement of the transmission of facsimile reproduction of research materials between stations (libraries) as speeds approaching the "speed of light."

The potential of the transmission concept as demonstrated by Ultrafax, however, must be tempered by consideration of other elements of the process—namely, the production of the microfilm used for transmission, the developing time at the receiving station. These factors, among others, tend to diminish the "speed of light" concept in this day of rapid communication. Perhaps more feasible would be the rapid transmission of existing microfilms or "live" research materials to receiving units capable of making a facsimile film copy quickly and economically. There is little doubt, in concluding this discussion of rapid selectors and a rapid transmission system, that the tools exist. Whether they are the appropriate tools for applications to library operations has yet to be demonstrated.

It is in the hands of the microphotographic technicians that microfilm has become increasingly more useful and important for research. The impact of current laboratory usage of microfilm as evidenced in the production of research materials, although not always immediately or obviously recognized by the consumer, is of significant importance. Specifically microfilm is the all important factor in the production of micro-opaques and enlargement prints, the latter use having been stimulated in the past few years by the successful introduction of dry printing known commercially as Continuous Xerography, and Electrofax.

In discussing the micro-opaque, it seems unnecessary to point out that it should not be confusedly considered as synonymous with microfilm, although the headline in a recently published journal announced a "Journal on Microfilm," when the headline ought to have read "Journal on Micro-opaque" (in this instance on microcard). The term "micro," which is prefixed to the term "film" yielding the word "microfilm," is equally applicable to the term "opaque"—hence "micro-opaque." Perhaps the common use of the term "micro" lends to confusion. In practice, the term "micro-opaque" is equally applicable to such commercial products as microcard, microlex, and microprint, among others.

As an integral step in the production of micro-opaques, microfilm may be compared to "cold type," as utilized in the printing of a book. The production of a micro-opaque begins with the photographic reproduction of a document on either 16 or 35 mm. microfilm, the arrangement of the micro-images on the film in a desired format, and finally the photographic contact printing, as in the case of microcards, or the production of multilith prints as in microprint. The principles involved in the manufacture of micro-opaques are basically identical to conventional photographic production of a contact print from a film negative, or the production of a multilith plate from photomechanical film. The obvious and important difference is the miniaturization of the original text down to a normal maximum reduction ratio of sixteen times.

The microfilm used in this process must adhere to rigid specifications, which may vary with the peculiar requirements of various commercial producers. Inasmuch as the microfilm employed in the production of micro-opaques must be a reverse image of the finished product, it is imperative that the master negative appear in reverse as an image of the highest quality without annoying blemishes, and so arranged as to produce a positive image of pleasing symmetry. In order to achieve this end, the micro-images are arranged on the film in such dimensions as to achieve equal length lines of images on the micro-opaque and an equal number of micro-images on each line. Spacing between images is equal within reasonable tolerances. Microfilm thus prepared is cut into "lines of type" and these in turn are grouped together in a "stripping" operation in sufficient number to complete the micro-opaque format. From the microfilm negative thus arranged, it is possible to reproduce as many copies as required. In this manner, microfilm is adapted to serve the needs of libraries by making possible the "publication" of research materials which might not otherwise be available.

Another important use of microfilm as utilized in photographic laboratories is the production of enlargement prints either on photosensitive paper, developed by standard photographic processes, or on untreated paper stock printed by electrostatic principles.

The process of providing enlargement prints by the conventional photographic process of projection printing from the microfilm to cut sheets or rolls of sensitized paper had been the standard in photographic laboratories up until some fifteen years ago. Drawbacks in lack of speed, small production, led to the development of automatic equipment with the elimination of many manual methods. The development of the V-Mail enlarger during World War II and a continuous processor met the needs for mass production. In the few years of its availability on a commercial basis, however, continuous xerography has penetrated activities in the field of documentary reproduction by enlargement printing to a significant degree. This process which has wrought a "revolution" in laboratory operations makes use of the best optical features of the older continuous enlargers coupled with the dry electrostatic printing. The xerographic process itself, the physical factors such as the size of copies obtainable, format of images on the microfilm, and economic factors have been excellently described by W. R. Hawken in a recent issue of *College and Research Libraries*.[10]

While continuous xerography is available in several production models, one of which reproduces only from loose-sheet originals, another which reproduces only from microfilm, and a third model which combines both methods, those models utilizing microfilm are of direct interest in this discussion.

The successful commercial application of continuous xerography has rapidly advanced the production of enlargement prints through the use of microfilm and has to a very large extent, though by no means entirely, supplanted the production of enlargement prints by conventional photographic methods. While the electrostatic principles as applied in continuous xerography offer excellent results in the production of textual material, graphs, etc., where the width of the printing does not exceed ⅛ inch, the process does not reproduce satisfactory half-tone illustrations. Doubtless, further developments will overcome this deficiency in the application of the electrostatic principles.[11]

The flexibility of the microfilm camera coupled with that of the continuous electrostatic printer (within the twelve inch maximum paper width)[12] permits the satisfactory, economical reproduction of an appreciable portion of research literature. The development of continuous xerography has opened the door to the relatively inexpensive reproduction in "hard form" of materials hitherto unavailable for economic reasons.

The creation of storehouses of microfilms specially prepared for use with the Copyflo Xerography has been undertaken by at least one large commercial producer of microfilm, University of Microfilms in Ann Arbor, Michigan. Proposals have been made to form cooperative ventures for the orderly replacement of deteriorating research materials on microfilm (something that might have been done in the last twenty years) with the added feature that the microfilm be prepared to fit the requirements of the xerographic process. One is tempted to surmise whether today's specifications may not be tomorrow's stumbling block.

A promising use for the continuous electrostatic process, particularly at the Library of Congress, is the reproduction of single or limited quantities of out-of-print Library of Congress printed cards. There has been a persistent demand over the years for inexpensive single copy reproductions of catalog cards from existing card catalogs. The National Union Catalog, for instance, has reproduced substantial holdings of regional union catalogs through the use of microfilm and continuous enlargement prints on silver paper. The resulting photocopies have proved adequate from the point of view of legibility; however, they have never been accepted wholeheartedly by librarians principally because the cards tended to curl. This characteristic of the photographic paper, in addition to a greyish background in the finished product, precluded against their wholehearted acceptance as a final solution. In the hope that the continuous electrostatic process would resolve the difficulty, the Library of Congress Photoduplication Service has developed a system to microfilm standard library catalog cards for subsequent duplication on the xerox continuous printer. As perfected, this system will produce a library card on 100 per cent rag card stock, if necessary, entirely suitable for permanent interfiling with the usual printed cards. The keystone of the system is a microfilm camera which has been adjusted to provide sufficient overlap between each exposure so that all film is exposed between the images. The camera is permanently set over a table with the reduction ratio fixed at approximately ten times. The cards are photographed over Plexiglass, with underlighting supplied to eliminate all shadow problems. As a final touch to the system, an index mark is filmed at the edge of the roll and located between each card so that the roll of paper may be cut on an automatic cutter.

The same electrostatic principles employed in xerography are utilized, with some technical variations, in other processes commercially available. One of these, developed by the R.C.A. and labeled Electrofax, omits the intermediate step of sensitizing a selenium-coated plate or revolving drum and substitutes a special zinc-coated paper. This machine, which prints up to fifteen engineering drawings (17" x 22") per minute from 35 mm. microfilm positive, has also been combined with the Filmsort equipment so as to permit a loading of up to five hundred Filmsort aperture cards.[13]

More recently the Bruning Corporation has placed on the market an electrostatic printer, also utilizing zinc-coated paper in lieu of the selenium-coated plate or drum, capable of producing multilith mats or single copy reproductions at the rate of four copies per minute up to fourteen to sixteen times larger than the size of the microfilm.

For the librarian the most effective and practical application of microfilm and microfilm techniques in recent years has been the successful introduction of continuous electrostatic printing. While it is quite true that the means have been available for many years to reproduce continuous enlargement prints from roll microfilm onto rolls of photosensitive paper, yet the enlarging and processing equipment, its initial and maintenance expense, the cost of the silver-coated paper, in addition to the double task of exposing and processing—all these factors militated against the production of inexpensive enlargement copy. It seems too obvious to argue for the preference on the part of the consumer for the enlargement print over the microfilm itself. The evidence at the Library of Congress seems to indicate that the use of electrostatic prints, at least where short articles are concerned (and these represent a substantial proportion of consumer demand) are preferred. The technical break-through offered by continuous xerography has made for microfilm an even more important place in the field of documentary reproduction.

Bibliographical Notes

1. The American Documentation Institute Auxiliary Publication Program has as its purpose the formation of an archives of research data which is related to published material but which for some reason cannot be included with the published article. All material in the archives is available to scholars in the form of microfilm or photoprint. A reference as to the availability of the unpublished data is included with the published article to which it is related. The Auxiliary Publication Program is under the custody of the Library of Congress Photoduplication Service, Special Services Section, Washington 25, D.C.

2. This Program is essentially patterned after the Auxiliary Publications Program. Publicity is incorporated in special lists prepared by the University Microfilms, Inc., Ann Arbor, Michigan.

3. The Publication Board Project contains captured documents from former belligerent countries and government-sponsored research reports (familiarly

known as PB's). The Department of Commerce, Office of Technical Services, acquires, catalogs, and publishes a list of new acquisitions in its monthly bibliography: *U.S. Government Research Reports.* (Government Printing Office, Washington 25, D.C.). The Project also contains a collection of Atomic Energy Commission Reports. Beginning January 1, 1959, a collection of technical translations has been made available to the public. The translations are listed in: *Technical Translations,* prepared by the Office of Technical Services and available from the Government Printing Office. All documents in these collections may be acquired in the form of microfilm or photoprint. The collections are in the custody of the Publication Board Project, Library of Congress, Washington 25, D.C.

4. Engineering Research Associates. *Report for the Microfilm Rapid Selector.* St. Paul, 1949.

5. *Filmorex System for Electronic Selection of Microfilm Cards.* (Monthly Circular no. 7 for Members of Unesco Committees and Collaborating Bodies Concerned with Documentation of the Natural Sciences) Unesco, Paris, Dec. 15, 1952, p. 56.

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7. Tyler, A. W., *et al.:* The Application of the Kodak Minicard System to Problems of Documentation. *American Documentation,* 6:18-30, Jan. 1955.

8. Shaw, R. R.: Mechanical Storage, Handling, Retrieval and Supply of Information. *Libri,* 8:1-48, 1958.

9. Sutton, G. W.: Ultrafax Miracle in Transmission. *Cornell Engineer,* 14: 14-15+, May 1949.

10. Hawken, W. R.: Developments in Xerography: Copyflo, Electrostatic Prints, and O-P Books. *College and Research Libraries,* 20:111-117, Mar. 1959.

11. Carlson, C. F.: Xerography. *In:* Spencer, D. A., ed.: *Progress in Photography, 1955-1958.* New York, Macmillan, 1959, p. 20.

12. The Haloid-XeroX Company recently made available a Copyflo Model, Copyrama, which produces material in widths up to twenty-four inches. Copyrama is primarily intended for the reproduction of engineering drawings.

13. Electrofax Dry-Photographic Enlarger. *Franklin Institute Journal,* 261: 584-585, May 1956.