Re-Evaluation of Microfilm As a Method of Book Storage

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EVER SINCE THE INTRODUCTION of microfilm into library work librarians have harbored the hope that its use might lead to a reduction of storage costs. These hopes have not been realized, except in certain high-rental areas by organizations such as law offices or some special libraries. From time to time estimates have been made comparing the cost of conversion to microfilm as against that of retaining originals, and these have always come out in favor of the originals unless some additional consideration was introduced, such as acquisition, preservation, or avoidance of the cost of binding.

A particularly important study of this question was reported by Pritsker and Sadler[1] in 1957 in an article whose title has suggested that of the present account. These authors concluded that "On a cost basis, microfilm is feasible as a form of storage for a large collection only if librarians are willing to accept a high reduction ratio, little or no inspection of the finished product, an image less perfect than could be obtained by using a 35mm. planetary camera, and the destruction of the text. If a positive copy of the film is required, the cost of microfilm storage is prohibitive."[2]

However, the Pritsker and Sadler article left some unanswered questions. Most important, perhaps, of these was: What would happen if the cost of the master negative should be shared among a number of subscribers to service copies? Would this so alter the situation that

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microfilming might be able to compete successfully, on a cost-of-storage basis, with the originals?

The announcement by an important research library of its intention to limit the storage space in its new building in the prospect of being able later to microfilm as economically as to construct additional book stacks[3] recently provided the occasion for reviewing the situation in the light of present techniques of microfilming and present costs of construction of storage space, and also for considering the possible effect of distributing the cost of the master negative among a number of subscribers to service copies.

The following elements were considered in this review:

- The cost of making the master negative
- The cost of making service copies
- The number of subscribers
- Comparative costs of constructing storage space for the originals and for the microfilms

Not considered in the review were the following elements:

- The comparative cost of maintenance (heating, lighting, cleaning, etc.) of the storage spaces involved
- The comparative costs of servicing collections in original and in microform, including specifically the cost

[1] Alan B. Pritsker and J. William Sadler, "An Evaluation of Microfilm as a Method of Book Storage," *CRL*, XVIII (1957), 290-296.
[2] Pritsker and Sadler, *op. cit.*, p. 296.

[3] Herman H. Henkle, "Crerar Use of Microfilm in Science Information Service," *National Microfilm Association Proceedings*, X (1961), 74-78.

TABLE 1

CHARACTERISTICS OF HYPOTHETICAL COLLECTION OF BOUND PERIODICALS

Number of volumes	100,000
Average number of pages/volume	400
Total pages	40,000,000
Most often occurring page size	ca. 8½ x 11 in.
Maximum page width	11.5 in.
Portion of the collection meeting requirements for cover-to-cover copying at standard camera settings	70%
Portion requiring page-by-page inspection to determine alternative settings for magnification or exposure or use of color film	30%
Portion to be filmed in color cover to cover	1%
Portion to have an average of 5% of pages in color	10%
Portion requiring lower than standard reduction ratio (any material requiring lower reduction setting would be copied on entire-volume basis on separate camera)	10%

of special equipment needed for servicing microfilm

The comparative costs of necessary alterations of catalog records

The comparative cost and satisfaction to the reader in the use of originals as contrasted with microfilm

Questions of copyright in the multiplication of service copies

THE FORBES AND WAITE STUDY

In order to secure data on the cost of making the master negative and service copies of a substantial collection of originals, Forbes and Waite of Lexington, Massachusetts, a firm of systems engineers specializing in information systems design including photographic applications, was given by the Council on Library Resources the assignment of estimating the cost of microfilming a hypothetical collection of 100,000 bound periodical volumes by the most economical method consistent with preserving all the printed information contained in the originals in a form in which it might be transmitted without material loss to the third photographic generation (i.e., from the master negative film to a service copy, and thence again to another copy in film or enlargement). This stipulation for preserving "all the printed information contained in the originals" involved the consequence that originals printed in color should be copied on color film. In making their study Forbes and Waite were permitted to plan to reduce the cost of the master film by using methods that would result in the destruction of the original volumes, and to spread the cost of the master through the sale of service prints to a number of subscribers. It was understood, furthermore, that in no case might the negative be used as a service copy.

Before presenting Forbes and Waite's findings it may be well to review some of the considerations which affect the cost of a microfilming program of this kind, and to follow the steps by which Forbes and Waite reached their results.

1. *Standard microcopying*. The negative microfilm of a quality acceptable for library use is normally produced from material in book form by employing a planetary camera (typically, a camera supported by a vertical column over a horizontal copy-board), a book cradle and glass pressure plate (to effect flatness of the pages to be copied), and 35mm. silver halide film.

A first question concerns the form of the product. Is roll film the best form of storage? Forbes and Waite consider the alternatives—microfiches (film in card or page sizes), microcards, electronic recording on plastic, electronic recording on magnetic tape, etc. They conclude that of the available means, roll film still offers the most economical form of storage for graphic records and the one lending itself to utmost convenience of use through currently or prospectively available viewing, copying, or enlarging equipment.

However, the cost of the normal copying process described above is so high as to put it out of the running in competition with the cost of storing the original. Because the major part of this cost is in labor, a first place where savings must be effected if competition is to obtain is in labor cost; and this must be done without lowering the quality of the product below standards of acceptability.

2. *Page-turning devices.* A substantial labor saving might be achieved if an automatic book-cradle/page-turner were available which would make it possible for one operator to supervise several cameras concurrently. The only such device is, however, only now undergoing testing.

3. *Shearing spines.* It is nevertheless still possible to effect a considerable labor saving in the photographic operation by avoiding the necessity for raising and lowering the pressure plate each time a page is turned. This can be done by shearing the spines from the books so that the pages may be laid separately on the copy board where they will lie flat without a pressure plate. The adoption of this technique of course requires that the bound volumes be destroyed. Forbes and Waite were permitted to assume the dispensability of the volumes and consequently propose to shear the spines.

4. *Inspection.* A next possible step in labor saving consists in omitting inspection. Pritsker and Sadler gave six excellent reasons to justify omission of inspection, yet librarians generally would be strongly opposed, since it would place too much reliance upon the unchecked attentiveness of the camera operator and upon the perfect functioning of his equipment. Accordingly, Forbes and Waite assume inspection.

5. *Silver halide* vs. *other films.* At this point attention may be given to saving cost of materials. Is a silver halide film required for the master negative, or can a less expensive photosensitive material be used? Principal objections to alternative photosensitive materials are their slowness and their sensitivity in the ultraviolet. In the present state of the art, Forbes and Waite conclude that there is still no real alternative to silver halide film.

6. *16mm.* vs. *35mm. film.* It may, however, also be asked, is 35mm. film required by the size of the image, or may a higher ratio of reduction be employed, permitting the use of 16 mm. film (or its equivalent, two rows of images on 35mm. film, as in the "duplex mode" used by some rotary cameras)? (It may be noted that black and white 16mm. film costs approximately a fourth of 35mm. film for the same amount of material copied,

TABLE 2

COMPARATIVE DIRECT COSTS, PRODUCTION OF MASTER NEGATIVE OF 40 MILLION PAGES OF BOUND PERIODICALS BY VARIOUS METHODS

Camera set-up	Time required (years)	Film	Resulting rolls of b&w film	Resulting rolls of color film	Direct cost
All planetary cameras (6)	5.25	16 mm.	19,162	485	$332,372
Hand-fed rotary cameras (2) with planetary auxiliaries (2)	4.00	16 mm.	20,702	485	263,183
Automatic-feed rotary camera (1) with planetary auxiliaries (2)	4.00	35 mm. (duplex mode)	11,774	600	271,445

while for color film the savings are even higher.) The answer to this question depends on the ability of 16mm. film to meet the requirement of preserving "all the printed information contained in the originals."

The resolving capability of the human eye at comfortable reading distance is approximately six lines per mm. If the detail which the eye can perceive in the original is to be preserved in the camera negative and to be transmitted to second and third generations of film, the camera negative must be capable of resolving a number of lines per mm. at least equal to the ratio of reduction multiplied by six. For example, material reduced at a ratio of 1:19 would require a resolution of 114 lines per mm. in the negative film. The lens must of course have at least equal resolving power. Now an 11-inch-high page can be copied across a 16mm. film (i.e., with the lines of type parallel with the edges of the film) at a reduction of 1:19, and since the resolving power of the best commercially available planetary microfilming equipment is 120 to 140 lines per mm. at this ratio of reduction, this layout is indicated. To quote Forbes and Waite: "This arrangement will allow side-by-side placement of sequential pages, will accommodate foldouts of any length, and will permit photographing two standard-width pages at each exposure when printing occurs on both sides of the leaves (the usual case)."[4] At the same time this arrangement permits use of a lower reduction of 1:14 for pages higher than 11 inches (and for other pages unsuitable for the higher reduction) by copying them lengthwise instead of across the film.

Film cost could, it is true, be further saved by the use of still higher reduction ratios. Ratios of 1:30 to 1:40 are used in filming business records, but the resulting films, as in the case of bank checks, are for purposes of verification only and are not required to convey "all the printed information in the originals." Eastman Kodak's Minicard uses ratios up to 1:60, but requires a whole family of special equipment for its exploitation. AVCO's Verac and National Cash Register's Photochromic Micro-Image Memory employ ratios up to 1:200; but these are still under development. Yet the use of these higher ratios, if found possible, might result in substantial reduction of the cost of microfilming through saving of materials and processing, and the possibility, must, in consequence, not be neglected.

7. *Rotary cameras.* Once a decision has been made to shear the spines off the books and to use 16mm. film, can a further economy be achieved by using a rotary instead of a planetary camera, thus greatly reducing the labor cost and speeding the operation? Forbes and Waite give a qualified positive answer.

The Recordak rotary camera Model RF-1 will turn a page over and photograph the reverse side on a second pass. Although the machine must be hand-fed when this turning device is in operation, it is still approximately three times as fast as a planetary camera. However, there are two adverse considerations—the turning mechanism is not 100 per cent reliable, and the resolution of the system rarely exceeds 100 lines per mm. and is often below. Forbes and Waite recommend that before this camera be used it be perfected for the work.

Recordak and Remington Rand both make rotary cameras which can be operated with automatic feed in the "duplex mode," i.e., they photograph the fronts and backs of pages side-by-side in two rows on 35mm. film. However, such a placement would be very inconvenient for projector viewing or subsequent enlargement, and would also entail the use of the more expensive 35mm. film for the color and other abnormal material to be copied on a planetary camera and spliced into the machine-made film. Forbes and

[4] Forbes and Waite, *Costs and Material Handling Problems in Miniaturizing 100,000 Volumes of Bound Periodicals;* prepared for the Council on Library Resources . . . Lexington, Mass.: 1961. 30 p., 13 folding charts (processed).

TABLE 3

Direct Costs, Production of Master Negative of 40 Million Pages of Bound Periodicals, Using Planetary Cameras, and 16mm. Film, 5.25 Years

Operation	Equipment	Equipment cost	Equipment maintenance (per year)	Production rate (per man/hour)	Direct labor	Supplies	Total
Inventory check	—	—	—	180 vols.	$1,315	—	
Transport	12 book trucks	$900	$90	114 vols.	1,184	—	
Preinspection	2 photometers	900	90	6.25 vols.	32,000	$100	
	2 work places	300	30				
Shearing of backs	1 paper cutter	1,800	360	25 vols.	9,000	40	
	1 work place	300	30				
Microfilming	5 planetary cameras for b&w	11,700	570	375 exposures (2 pages/exposure)	120,800 —	57,733 —	
	1 planetary camera for color	2,340	117	75 exposures (1 page/exposure)	—	—	
	6 work places	900	90	—	—	—	
Film processing & splicing	1 film processor	2,275	228	2 rolls	26,500	3,947	
	1 temperature control	600	60				
	3 splicers	450	45	25 splices	—	—	
	3 work places	450	45				
Postinspection, boxing and labeling	3 microfilm readers	3,600	180	1500 pages	40,200	—	
Storage	1,680 feet of shelves or cabinets	2,360	100	—	—	—	
Capital investment		$28,875	. . .	. . .	. . .	. . .	
Labor, supplies		. . .	. . .	. . .	$230,999	$61,820	
Annual costs, 5.25 years		. . .	$2,035	. . .	43,999	11,775	$57,809
Total, capital investment and costs, 5.25 years		. . .	. . .	. . .	. . .	. . .	$332,372

Waite do not recommend this type of camera for use in the project considered.

8. *Nonstandard material–preinspection procedure.* The economy of the filming operation requires that routines be standardized. However, a certain proportion of the material will require specialized treatment. This must be identified by preinspection which will note special requirements based on abnormal page or type size, paper color and reflectance, ink color, density of impression, bleed-through, overprint, and need for color reproduction. Color work would in any case be done on a separate camera, and if a rotary camera were employed for the standard treatment, all alternative treatment would have to be performed on

TABLE 4

Direct Costs, Production of Master Negative of 40 Million Pages of Bound Periodicals, Using Hand-Fed Rotary Cameras and Auxiliary Planetary Cameras with 16mm. Film, 4 Years

Operation	Equipment	Equipment cost	Equipment maintenance (per year)	Production rate (per man/hour)	Direct labor	Supplies Total	
Inventory check . . .	—	—	—	250 vols.	$ 1,000		
Transport .	Same as Table 3	$ 900	$ 90	150 vols.	900	—	
Preinspection		1,200	120	6.25 vols.	32,000	$100	
Shearing of backs .		2,100	390	25 vols.	9,000	40	
Microfilming .	2 rotary cameras	4,214	422	1,250 exposures (2 pages/exposure)	58,278	61,930	
	2 planetary cameras	4,680	234	225 exposures (1 page/exposure)	—	—	
	4 work places	600	60	—	—	—	
Film processing & splicing .	2 film processors	4,550	455	2 rolls	21,500	3,532	
	2 temperature controls	600	60				
	3 splicers	450	45	25 splices	—	—	
	3 work places	450	45				
Postinspection, boxing and labeling . .	Same as Table 3	3,600	180	1,500 pages	40,200	—	
Storage . . .	1,820 feet of shelving or cabinets	2,555	100	—	—	—	
Capital investment		$25,899	. . . .	. . . .	. . .	. . .	
Labor, supplies		. . .	. . . .	. . . .	$162,878	$65,602	
Annual costs, 4 yrs.		. . .	$2,201	. . . .	40,719	16,401	$59,321
Total, capital investment and costs, 4 yrs.		. . .	. . . .	. . . .	. . . .	. . .	$263,183

auxiliary planetary cameras. Forbes and Waite recommended that the preinspectors rotate in the postinspection job so as to see the results of their work.

9. *Service copies.* Pritsker and Sadler were compelled for economy's sake, as seen in their conclusion quoted above, to contemplate the use of the camera negative as a service copy. Forbes and Waite were not permitted to do so, but were encouraged, instead, to seek economies through prorating the cost of the negative in the sale of service copies to a number of subscribers. Again they surveyed all the possibilities for the form of the service copies, and again they elected roll microfilm. Again there was a choice between silver halide and the dye-base

TABLE 5

COMPARATIVE DIRECT COST, PRODUCTION OF SERVICE PRINTS OF 40 MILLION PAGES OF BOUND PERIODICALS BY VARIOUS METHODS

Print material	Quantity	Direct cost	
		1 print	10 prints
Diazo*	2 x 10^6 feet of black and white 16mm. film	$24,920	$226,700
Silver	2 x 10^6 feet of black and white 16mm. film	36,692	366,920
Kalfax	2 x 10^6 feet of black and white 16mm. film	43,867	398,950
Kodachrome	48,500 feet of 16mm. color film	7,553	75,530

* As pointed out above, diazo has a life-expectancy of approximately 50 years. The amount of $3,507 added to the original cost and compounded annually at 4 per cent would in 50 years realize $24,920 to replace the original print.

films. For the purpose of service prints, however, the slowness and ultraviolet sensitivity of diazo are not as disadvantageous as in the case of the camera negative. In addition to its lower cost, a diazo print would itself be a negative from which positive third generation prints or enlargements could be made and which would provide negative projection-viewing which many consider preferable to positive-viewing. It has higher resolving power and resistance to wear than the silver films. Consequently, although it has a life-expectancy of only fifty years, Forbes and Waite recommend it. Also they point out that in fifty years the difference in cost at 4 per cent compound interest would increase to 3.6 times the cost of the original diazo print and thus more than cover replacement.

THE FORBES AND WAITE FINDINGS

With the foregoing considerations in mind, a summary of the Forbes and Waite findings can be presented.

The characteristics of the hypothetical

TABLE 6

COMPARATIVE COST OF SERVICE COPY OF MICROFILM OF 40 MILLION PAGES OF BOUND PERIODICALS USING ALTERNATIVE CAMERA SET-UPS AND WITH VARYING NUMBER OF SUBSCRIBERS

	All planetary cameras	Rotary plus planetary cameras
Master negative		
Direct cost, from Table 2	$332,372	$263,183
Overhead (50%)	166,186	131,592
Service copy		
Direct cost, from Table 5		
Diazo*	24,920	24,920
Kodachrome	7,553	7,553
Overhead (20%)	6,495	6,495
Total, master and one service copy	$537,526	$433,743
Cost of each additional service copy	35,968	35,968
Subscription to one service copy†		
1 subscriber	537,526	433,743
5 subscribers	136,279	115,522
10 subscribers	86,123	75,745
20 subscribers	61,196	56,006
30 subscribers‡	52,886	49,427

* The cost of each diazo copy beyond the first is $22,420.

† If it should be decided to dispense with color prints in the service copies (although they would be retained in the master copy) a reduction of about $10,000 could be effected in the subscription price at all number of subscriptions, accounted for by the cost of a color print ($7,553) plus cost of splicing, offset by the cost of a b&w print plus the proportionate cost of the b&w negative.

‡ It is noteworthy that as the number of subscribers increases the difference in cost between the two camera set-ups rapidly diminishes.

TABLE 7

COST OF PROVISION OF STORAGE SPACE FOR 40 MILLION PAGES OF BOUND PERIODICALS IN ORIGINAL FORM COMPARED WITH COSTS (FROM TABLE 6) OF SUBSTITUTING MICROFILM, SHARED AMONG 20 SUBSCRIBERS

	Cost of film	Construction of storage space	Total
Originals	. . . .	\$63,500	\$63,500
Microfilm			
All planetary cameras			
B&w with color	\$61,196	2,620	63,816
All b&w	51,196	2,620	53,816
Rotary plus planetary cameras			
B&w with color	56,006	2,620	58,626
All b&w	46,006	2,620	48,626

collection which was the subject of their study is shown in Table 1. For the reduction of this collection to microfilm, their report provides detailed specifications of the equipment, supplies, manpower, and procedures involved in the several operations concerned with the originals (including inventory check, transport, pre-inspection, shearing of backs, and microfilming), with the handling of the master film (including processing, splicing, post-inspection, boxing, labeling, and storing), and with the production of the service copies. Only the resultant cost estimates are of concern here.

Table 2 shows the comparative costs of producing the master negative by various methods.

Tables 3 and 4 show the details of the estimates of the two principal methods, i.e., all planetary cameras and a combination of rotary and planetary cameras.

Table 5 shows comparative direct costs of producing service prints.

To the direct costs of making the negative and service prints shown in Tables 2-5 must be added costs of rental of space, administration, etc. Forbes and Waite calculate that approximately 4,500 to 5,000 square feet of space will be needed for the operation which will require a full-time supervisor with thirteen to sixteen production people and considerable record keeping. They conclude that overhead charges should be estimated at 50 per cent of the direct charges for the master film and at 20 per cent of those for the service prints.

Table 6 shows the final cost of a diazo-Kodachrome service print when (1) the negative has been made by one of the two principal methods identified in Table 2 and further described in Tables 3 and 4; (2) when the overhead cost has been added; and (3) when the number of subscribers is 1, 5, 10, 20 or 30.

COST OF MICROFILMING VS. COST OF STORAGE OF ORIGINALS

An estimate of the cost of reducing to microfilm a collection of 100,000 bound volumes of periodicals, incorporating forty million pages, has now been reached. How does this cost (plus the cost of providing storage space for the resultant films) compare with the cost of providing storage space for the originals?

1. *A typical case.* To answer this question a typical case will be taken. It will be assumed:

a) That the average height of the volumes is less than 12 in., permitting them to be shelved on seven shelves per section in a 7 ft. 6 in. high stack, on 10 in. deep shelves.

b) That the volumes are shelved "solid," i.e., with no vacant space on the shelves.

c) That the average page-density of the collection is 5,000 pages per linear foot.

d) That the microfilms would be shelved "solid," in boxes 3⅞ x 3⅞ x 1 in., in two rows on 8 in. deep shelves, eighteen shelves per section, in a 7 ft. 6 in. high stack.

e) That the shelved area constitutes 30 per cent of the book stack area for the 10 in. shelves and 26 per cent for the 8 in. shelves (these proportions hold when space for aisles, stairways, etc. remains constant).

f) That the cost of construction is $20 per sq.ft., including cost of shelving.

Under the circumstances dictated by these assumptions, forty million pages would require 2,667 36 in. shelves, i.e., 381 7-shelf sections covering 952.5 sq.ft. and requiring 3,175 sq.ft. of bookstack space, the construction cost of which would be $63,500. The 21,187 rolls of microfilm, at 72 rolls per 36 in. shelf, would require 294.3 shelves in 16.4 18-shelf sections covering 34 sq.ft. and requiring 131 sq.ft. of bookstack, the construction cost of which would be $2,620.

For the conditions of the typical case, it appears, in consequence, that when there are twenty subscribers the cost of a print to each by the most expensive method of Table 6, plus the cost of the storage space for it ($61,196 plus $2,620, totaling $63,816) is almost exactly equal to the cost of providing storage space for the originals ($63,500). This may be seen in Table 7, where it also appears that if black and white were acceptable in the print to the exclusion of color (though color would be retained in the master) the difference in favor of film would advance to slightly less than $10,000; while if, in addition, rotary cameras could be employed, the difference in favor of film would raise to approximately $15,000.

2. *Variations from the typical case.* It is obvious, however, that almost every one of the assumptions adopted for the typical case is subject to wide variation. The principal of these are:

Page density. Pritsker and Sadler based their estimates upon a count of 4,600 pages per linear foot, which they found to obtain in the storage library of the School of Engineering at Columbia University. From the unpublished masters' thesis from which their article was condensed it appears that this figure was composed of a count of 4,142 pages per foot for monographs and 5,152 for periodicals.[5] The present authors have found the following wide range in various papers:

	Pages per foot
Mimeographed documents (printed on one side of the leaf without hard covers)	2,400
A sampling of 21 bound volumes of professional and general journals (including 7 in chemistry, others in physical and social sciences, law, etc.) in the library of Georgetown University	5,240
Collier's Encyclopedia, 1962	6,560
English-finish book paper (U. S. Government Printing Office specifications; without hard covers)	9,600
Machine-finish book paper (U. S. Government Printing Office specifications; without hard covers)	11,010
Who's Who in America, vols. 27-32	12,362
Anthony Trollope, *Barsetshire Chronicles* (London: Nelson, 1914; New Century Library, Royal India Paper edition)	18,336

It is apparent that page density can vary widely and that the actual density in any particular case will materially affect the ability of microfilm to compete with the originals in cost of storage. Thus, the one roll of film that could replace 10.8 inches of mimeographed material would replace only 1.4 inches of the Royal India Paper edition of the *Barsetshire Chronicles.*

Proportion of shelved area to total bookstack space. This, too, can vary within wide limits. In many bookstack installations the proportion is as low as 20 per cent. In the typical case, above, the assumed ratios of 30 per cent for 10 in. shelves and 26 per cent for 8 in. shelves contemplated 34 in. aisles between ranges of shelves and a 3 ft. 6 in. main aisle. (In a typical Library of Congress Annex bookstack, with 10 in. shelves separated by one inch on a 21 in. base, the propor-

[5] Pritsker and Sadler, "An Evaluation of Microfilm as a Method of Book Storage," Department of Industrial Engineering, Columbia University, 1956. Unpublished master's thesis, p. 12-13.

TABLE 8

COST OF PROVIDING STORAGE SPACE FOR 40 MILLION ORIGINAL PAGES OF PERIODICALS—EFFECT OF VARIATIONS IN PAGE DENSITY, PROPORTION OF SHELVED TO TOTAL BOOKSTACK AREA, AND CONSTRUCTION COST

PAGE DENSITY OF ORIGINALS IN PAGES PER LINEAR FOOT	PROPORTION OF SHELVED AREA TO TOTAL BOOKSTACK AREA	COST OF CONSTRUCTION AT VARIOUS RATES PER SQ. FT., INCLUDING SHELVING		
		$15	$20	$25
4,000	20%	$89,269	$119,025	$148,781
	30%	59,513	79,350	99,187
	40%	44,634	59,513	74,391
*5,000**	20%	71,438	95,250	119,063
	30%	47,625	*63,500*	79,375
	40%	35,719	47,625	59,531
6,000	20%	59,513	79,350	99,188
	30%	39,675	52,900	66,125
	40%	29,756	39,675	49,594
7,000	20%	51,019	68,025	85,031
	30%	34,013	45,350	56,688
	40%	25,509	34,013	42,516
8,000	20%	50,006	66,675	83,344
	30%	33,338	44,450	55,563
	40%	25,003	33,338	41,672

* The italicized figures are those of the typical case, *supra*.

tion of shelved to total area is 28 per cent.) If in the same bookstack the aisles between ranges were reduced to 20 inches the proportion would rise 40 per cent, and even higher ratios can be achieved by various methods of compact storage.

Construction cost. This can vary, in one- to multiple-story buildings of institutional or warehouse character, from $10 to $30 per sq. ft.

Table 8 shows the effect of a number of these variables upon the cost of providing storage space for forty million pages of journals.

It appears from Table 8 that the cost of constructing storage space for forty million pages of bound periodicals, shelved "solid," can vary from a low of $25,003 (when the page density is 8,000 per foot, the shelves occupy 40 per cent of the bookstack area, and the cost of construction is $15 per sq. ft.) to a high of $148,781 (when the page density is 4,000 per foot, the shelves occupy only 20 per cent of the bookstack area, and the cost of construction is $25 per sq. ft.). Meanwhile Table 6 indicates a cost of $136,279, at the five-subscriber level, for microfilm.

The wide discrepancy between these figures shows, if any demonstration were necessary, the need for precision in estimating before taking action in this field. However, it also provides wide latitude in response to the question under consideration. It appears that while there are situations in which it is more expensive to microfilm than to retain the originals, the reverse is true if suitable conditions exist in terms of cost of storage of the originals and the number of subscribers.

3. *An actual example*. In an attempt to apply the findings of this report to an actual situation, the collection of bound volumes of medical journals prior to 1946, housed on level C of the new National Library of Medicine was examined. The characteristics of the situation were found to be as follows:

Area employed for book storage (including shelving, aisles, stairways, elevators, etc.)	15,300 sq.ft.
Portion of storage area occupied by shelving	4,160 sq.ft.
Portion of shelved to total storage area	27 per cent
Height of stacks	7 ft. 6 in.
Shelf length	35.5 in.
Total linear feet of shelving	34,256
Linear feet of shelving now occupied	17,210
Average page density (sampled)	4,866 pages per ft.
Cost of construction per sq.ft. (entire building)	\$28.90[6]

The collection now housed in the area (approximately 126,000 volumes) is estimated to contain 83.74 million pages. At the rates cited in Table 6 the cost of a service microfilm copy to each of ten subscribers (including color film when the original was in color, and a proportionate share of the costs of the negative) would be \$180,342 per subscriber for all-planetary work, and \$158,610 if rotary cameras could be employed.

If all shelves in the area were filled to capacity (i.e., "shelved solid") at present page density, the collection would amount to 166.7 million pages. Under the conditions cited the cost to a subscriber would be \$358,900 (all-planetary) or \$315,700 (rotary cum planetary).

Meanwhile the construction cost of the area (neglecting the stack equipment), if computed at the average for the whole building, may be estimated to have been \$442,170. Even if a differential of nearly \$5 per sq.ft. is made in favor of stack areas, giving a cost of \$24 per sq. ft., the construction cost would have to be estimated at \$367,200.

Conclusion

The findings of Pritsker and Sadler can now be extended and brought down to date. They found that microfilm can be successfully applied to reduction of storage costs only at the sacrifice of a less-than-perfect image, no inspection of the film, use of the negative as a service copy, and destruction of the original text. The loss of color information also was implicit in their discussion. It now appears that such application can be effected without any of these sacrifices (except that of destruction of the text) provided that a suitable number of participants can be found. The number of participants required (five or more) will depend upon circumstances, principal of which are the page density of the original material, the cost of providing storage space for it, and the extent to which it contains material (in color, of unusual size, etc.) requiring special treatment in the microfilming.

While it is true that in the right combination of circumstances (number of subscribers, page density of original material, etc.) the resultant savings in storage cost from reducing a collection to microfilm may be substantial, yet it is obvious that the difficulty of organizing a project involving multiple subscribers, together with considerations omitted from the present discussion, such as provision of viewing equipment, the question of copyright in the multiplication of copies, etc., will prove under present conditions strong deterrents to an undertaking in the interest of space saving alone. However the situation might change radically if, for example, a high-ratio-reduction microfilming process should become practical.

This study has been held strictly to the question of storage costs, in order to elicit the facts of the relationship of microfilming to them. However, storage costs are possibly less important than other aspects of library work which microfilm can affect, such as acquisition (or distribution), preservation, binding, and service. It is hoped that this report may, in a sense, dispose of the storage aspect so that the others can be given their rightful attention. ■■

[6] This is an arbitrary figure, and includes all costs in any way referable to NLM construction. It includes costs for furniture and equipment, murals, special sewer connections, landscaping, road-net improvements, moving, and similar costs which are not ordinarily considered on a per-square-foot basis. On the other hand, it does not include cost of land acquisition.