Table II. Number of Dissertations Containing Selected Key Words

Area	Volume 30 (1969–70)	Volume 33 (1972–73)	% change
Acid(s)	181	192	+6.1
Analysis or analytical	44	64	+45.4
Chemical	46	66	+43.5
Chemistry	69	69	0.0
Complexes	138	118	−14.4
Compounds	125	115	−8.0
Electron	47	37	−21.3
Energy	27	38	+40.7
Enzyme	19	28	+47.4
Halide(s)	31	24	−22.6
Hydrocarbon(s)	16	23	+43.8
Infrared	18	22	+22.2
Kinetics	53	55	+3.8
Ligand(s)	25	26	+4.0
Molecular	67	78	+16.4
Molecule(s)	32	54	+68.8
Nmr	11	30	+172.7
Olefin	25	8	−68.0
Organic	42	40	−4.8
Physical	23	20	−13.0
Protein(s)	52	78	+50.0
Proton	12	23	+91.7
Salt(s)	41	38	−7.3

biochemistry and biological chemistry increased by a combined total of 56.

Table II shows a summary of the number of dissertations containing selected key words. Only key words that were listed for a minimum of 20 dissertations in either Volume 30 or 33 of DA are included in the summary (a total of 23 key words). Also shown in this table is the percentage of change in appearance of the key words. Significant increases were noted in the frequency of appearance of analytical, energy, enzyme, hydrocarbon(s), molecule(s), NMR, and proton. Significant decreases were noted for the key words olefin and halide(s).

Although a minimal amount of data is shown, it appears warranted to conclude that there has been some change in the doctoral research patterns of Ph.D. candidates in institutions of higher education. Emphasis has shifted toward the areas of biochemistry and polymer chemistry and away from the traditional study of organic chemistry. The amount of research in the other areas of chemistry has not changed significantly over the four-year period studied. However, there has been an overall decrease in the number of dissertations as measured by the number of abstracts in DA. The shifting of emphasis of selected areas of chemistry was also noted in the changing patterns of the frequency of appearance of selected key words. In general, there was an increase in the number of words pertaining to the areas of biochemistry and biological chemistry and a decrease in words normally associated with organic research. Also, significant increases were noted in the frequency of appearance of the key words NMR and energy studies.

The information presented in this paper can serve as a baseline for examining changing patterns of doctoral research of Ph.D. candidates in the next decade. In turn, this information may be of value in determining areas of needed research.

LITERATURE CITED

(1) The Sciences and Engineering, *Dissertation Abstracts,* Vol. 30, University Microfilms, Ann Arbor, Mich., 1970.

(2) The Sciences and Engineering, *Dissertation Abstracts,* Vol. 33, University Microfilms, Ann Arbor, Mich., 1973.

(3) Nebergall, W. H., Schmidt, F. C., Holtzclaw, H. F., "College Chemistry With Qualitative Analysis," 2nd ed, D. C. Heath, Boston, Mass., 1963.

Microfilm-Based Information Systems and Their Use in an R&D Center†

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Received July 12, 1974

One of the major problems facing industrial information centers is that of storing the voluminous masses of information and data needed by the scientists. Microfilm is becoming the accepted media for this storage. Through standard indexing and retrieval practices, microfilm can be incorporated into information systems to replace the document holdings. There are cost and time savings through the elimination of space filing requirements and in search time. Case histories of applications of microfilm-based systems are given.

INTRODUCTION

Today's industrial research organizations are producing and accumulating large masses of data and information which are pertinent to successful R&D operations. Those responsible for information handling are faced with the problem of storing this material in a minimal amount of space, yet it must be available in a form readily accessible to users.

†Presented at the Division of Chemical Literature, 167th National Meeting of the American Chemical Society, Los Angeles, Calif., March 31–April 5, 1974.

TYPES OF MICROFILM

Few organizations can afford to buy and store all the information that could possibly be needed for future operations by their technical staff. Space requirements to store this information in a paper format would restrict most organizations in what they could afford to keep, much less purchase. Thus, there must be a means of reducing the space requirements for this material. The use of microfilm is one means of achieving this end.

There are two major types of microfilm, microfiche and roll microfilm. Microfiche is a 4 × 6 in. slab of film that can hold images of approximately 98 $8\frac{1}{2} \times 11$ in. pages. Roll film can be either 16 or 35 mm. A 100-ft roll of 16-mm film can contain the images of approximately 2500 $8\frac{1}{2} \times 11$ in. pages. Sixteen-millimeter film placed in a cartridge occupies only $5 \times 5 \times 2$ in. of space instead of that which would be required for 20 standard 100-page laboratory notebooks or 2500 $8\frac{1}{2} \times 11$ in. pages. The type of microfilm that is best suited for each application is determined by one's needs and the kind of information retrieval system that is used.

MICROFILM PRODUCTION

In most organizations the technical information professionals are responsible for the storage and retrieval of pertinent information and data. Logically this is the group that should determine which microfilm should be used for each specific application.

At the Philip Morris R&D Center, the Technical Information Facility is responsible for all microfilm purchases and in-house microfilming operations. The basic production equipment consists of a planetary camera for exposing 16- and 35-mm roll film, a microfiche camera which photographs and develops single slabs of microfiche, and a microfiche duplicator and developer. This equipment, which satisfies most of our requirements, occupies an area 10×12 ft. There are many reader/printers and readers on the market for the various types of microfilm.[1,2] The areas of our R&D Center that use microfilm are the library, individual specialized files, infrared and mass spectrometer laboratories, and central file. Examples of these uses will be presented later.

MICROFILM INPUT, STORAGE, AND RETRIEVAL

The input for a microfilm-based information system can have multiple formats, as long as the material can be reproduced by photography and fits the camera's shooting field. Depending on the camera used, the format can range from a standard printed page to items such as infrared spectra and D size (22×33.5 in.) engineering drawings. With the planetary camera the height dimension of the document permitted is determined by the film (16 or 35 mm) and the reduction used. The field width can be adjusted to more than 3 ft.

Many storage devices are on the market for holding processed microfilm.[2,3] There are cabinets designed for holding boxes of roll film or film cartridges. In addition, film cartridges can be kept in a variety of carousels and other manual storage devices, power-driven files, and as part of special retrieval systems.

Small numbers of microfiche can be stored in desk top tray units or in binders similar to looseleaf notebooks. Larger numbers can be stored in items such as wheel files and elevator files which may be automated. When a large number is involved and quick retrieval is essential, storage units are available which offer retrieval *via* a keyboard code. These units usually display the microfiche directly on a viewing screen.

Roll film or cartridge film may be indexed by several methods. Film which is purchased from a micropublisher or that which is generated by one's own filming process can be indexed by code line, image (blip) control, or a Miracode System.

Code line is an address to a document location on a roll of film. During the filming black lines are recorded between the document images. These lines change in a straight progression after a set number of documents (20 to 50). As the film is advanced at high speed in a reader, the code lines appear as solid black lines. These lines are interpreted on an index scale on the verticle side of the screen. When the desired code line is reached, the film is slowed and scanned for the wanted document.

Image control uses an opaque mark (blip) located on the film under each image. The blip is filmed simultaneously with each image which is sequentially numbered. To locate an image the roll number and the frame number are obtained from an external index. When the cartridge is placed in a reader, the frame number desired is entered through a keyboard. The reader logic electronically counts the blips while advancing the film. Upon reaching the correct number, the desired image is displayed.

Miracode uses a binary code located adjacent to each frame on the film. Using a special type reader, the film is inserted and the image code entered through a keyboard. The machine logic searches the code on the film until it finds the desired image and displays it.

Microfiche are indexed visually either by title, author, or a code. They can be filed mechanically in retrieval systems where the carrier of the microfiche is subject to mechanical recall.

MICROFILM APPLICATIONS AT PHILIP MORRIS

1. Library. The library subscribes to journals on microfilm which are 16-mm roll film in cartridges. A room 10×16 ft can hold two cartridge-type reader/printers and two microfiche reader/printers, plus cabinets to store the film versions of the journals of the American Chemical Society, *Chemical Abstracts,* and *Biological Abstracts.* The journal film is indexed by volume and page. Some of the film has code lines to refer to page number, some are indexed by blips, and some have both systems.

By subscribing to the ACS journals on microfilm, the library obtains the supplemental data microfiche copy. These supplemental data are also included in the microfilm edition. There is no reason to index these journal holdings as this is done by the secondary reference sources. The film is coded so that the journal volume and page number, which are obtained from an external source, are easily located on the film.

All doctoral theses listed by *Dissertation Abstracts* are obtainable on film. Thirty-five millimeter roll film is used, which requires a 35-mm reader. There is no indexing as each thesis is a separate film strip. The library places these films in 35-mm jackets and files them by subject. All government documents presently obtained from NTIS come in microfiche form. These have titles which contain an author, subject, and a government assigned accession number, any one of which may be used as the term for filing, depending upon one's system. Philip Morris' library card catalog is a unified catalog which includes the microfiche holdings as well as books and other usual library material.

2. Spectrometry. An area in which roll film has been used is that of the infrared laboratory. Infrared chemists generate many unique and unpublished spectra which they themselves index. However, there is not sufficient storage facility to keep the paper copies on hand. When the spectra are filmed on 16-mm roll film, the only change necessary is to alter the index to indicate the cartridge number and frame number rather than the spectra number.

The mass spectrometric laboratory uses 16-mm jacketed microfiche for their spectra. Each molecular weight series is contained in one or more fiche. When there is need to update, the material is filmed and inserted into the appropriate location. Thus, 12 linear feet of spectra was converted to a microfiche file contained in a 3×5 card file box.

3. Inhouse Publications. Philip Morris R&D publishes several handbooks for internal use only. All supporting data and documents for the entries in the handbooks are kept on microfiche. An alpha code is used to indicate which handbook data base it is from, and the microfiche is given the accession number of the original document. It is foreseeable that in the future heavy users of these handbooks could be issued their own set of microfiche along with the handbook. The data from these handbooks are stored on magnetic tape. The data base is so designed that in the future a user will query the base through an on-line terminal. Each lab will have its own set of microfiche to check the original source material.

4. R&D Results. R&D operations generate multiple in-house reports and laboratory notebooks. These materials are of great value to the corporation, but the cost of storage on the premises can become prohibitive. At the R&D Center all reports are given an unique accession number (current year's last two digits: XXX), and each report is indexed by keywords and author. Then the report is filmed on microfiche. There is one report per microfiche and the latter are filed in order of their accession number. The microfiche are color coded for confidential reports. All indices referring to these reports use only the microfiche accession number.

All laboratory notebooks are filmed on 16-mm roll film. Each roll of film contains the images of 20–25 100-page notebooks. At exposure, each frame on the film is identified with a blip and a number. Through the use of a blip counter on the reader each frame can be located automatically.

The same information system covers both reports and notebooks. The keywords and the authors for both reports and notebooks are entered into the data base. When a search is performed, one obtains a title of the material and its microfilm address, *i.e.,* microfiche accession number or film cartridge number and the exact frames the material is located on (Figure 1). The microfilm is held in one central location under secure conditions. All answers to the search question can be examined at one time.

As the microfilm contains the Center's major product, *i.e.,* research results, a duplicate copy of the film is stored off the premises in a commercial storage vault for security purposes. The indices for the stored film are on microfiche.

5. Miscellaneous. Some of the research scientists have developed personal files in highly specialized areas. The items in these files usually have been assigned accession numbers. To convert the hard copy file to a microfilm format involves only the task of filming the item and giving the item's accession number to the microfiche. The hard copy file can be replaced with the microfiche edition. Without the constraint of space these scientists have been enabled to develop comprehensive files in highly specialized fields with no change in the coding of the original information. Incidentally, these documents are indexed further in-depth by their users than they would be in the standard data bases.

DRAWBACKS TO MICROFILM USE

Problems occur in converting to a microfilm-based system. A major problem is resistance to microfilm by some of the users. With efficient retrieval systems and legible readers, this reluctance can be overcome.

Microfiche readers are a problem. At present, the portable lap readers leave much to be desired. Some of them reflect the room lighting so that a page cannot be read. Others work well only in a darkened room. Small desk-top readers which can be used on the desk or laboratory bench have proven to be more popular with some users.

There appears to be a lack of quality control among micropublishers. Much of the film received by the library is of poor quality. For example, an entire page cannot be sharply focused at one time, there are "blobs" of dirt on the film, or resolution is so poor that legible prints cannot be produced from the film. Frequently, there is no recourse and one must keep this film. Some of these problems can be caused by microfilm readers, as well as the poor microfilm.

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Author - R. M. Creamer

Date - May 22, 1970

Original Document No. - 4639-73

Title - Preparation of C.P. Coatings and Evaluation
        of the Viscosity of These Coatings

Notes - Microfilm Cartridge No. 182 Image No. 0507
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Figure 1.

Other divisional areas of Philip Morris have contracted some filming jobs to outside organizations and have had similar problems with the quality of the finished product. Poor film quality increases users' resistance.

In-house filming operations have their problems as well. Filming of most material is a monotonous, boring job. Operator errors occur if filming is carried on for a lengthy period of time. Such things occur as photographing one page twice, skipping a page, turning the page while the camera shutter is open, and carelessness in routinely checking the camera focus and exposure. These errors are usually due to operator fatigue or boredom. The operator, whether he is a part-time handicapped person or a fulltime professional, should rotate the filming task with other less wearisome duties.

With a few precautionary measures an in-house operation can produce good quality film. Some questions to keep in mind are:

1. Lighting—has the lighting fixtures been modified during off-hours without notification to the operator?
2. Voltage—is the camera on a separate line or shares the line with other equipment? Has there been a voltage cutback in the supply?
3. Film quality—has an exposure test been run for a new shipment of film or for a new job?

Problems can occur with film that is exposed in-house and sent out for development. Properly exposed film can be ruined by over- or under-exposing during processing. As the film is sent by mail to the processor, it can be lost. Never discard the original material until the film is returned and checked, and it has been indexed and filed.

CONCLUSION

Microfilm is a useful physical form in which to store information and data. Through the use of microfilm, complete reference and source material can be kept on hand in a limited space. The microfilm can carry a unique location number which is entered into the data base as the original source. This permits the scientist to have readily available material which he might need only occasionally. This is stored in a central facility such as a library or a central file. Also, material which the scientist uses frequently can be kept at his bench in a minimal amount of space. A microfile saves dollars through the elimination of costly space filing requirements and through savings in search time. There is no additional cost to add it to an information system as the microfilm accession number is entered as the primary source in the data base.

LITERATURE CITED

(1) "NMA Buyer's Guide," National Microfilm Association, Silver Spring, Md., 1973.
(2) "Guide to Microreproduction Equipment," 5th ed., 1972 and 1973 Supplements, National Microfilm Association, Silver Spring, Md.
(3) Exelbert, R. S., and Badler, M. M., *Information & Records Management,* 8 (1), 48–9, 1974.