contains the compound number, dates tested, type of test, etc. The remaining part of the record is variable and may change from time to time to accommodate changes in our testing procedures.

The data in this final state are kept on magnetic tape and are available for reports, searches, etc. In general, searching is quite easy, being mainly a read operation followed by a set of logical IF statements and a write operation. Reports describing test results are circulated to the laboratory personnel on a regular basis.

The reports may be more or less complex depending on the form and use. As anyone familiar with this business knows, the logical or operating part of a search program is generally rather simple. The complications arise if one tries to accommodate a user who does not know the programming techniques and who insists on a fancy tabular presentation of results.

The data and computer services provided are available for more esoteric uses and these are limited only by the users interest and expertise. Extensive computational ability is provided, and the computer power available ranges from simple library routines on the GE-235 to the number-crunching capability of the CDC-6000 series machines.

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Document Access*

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Received April 14, 1971

Long-range, copies of needed documents will be rapidly and inexpensively supplied to users in libraries or at their desks by querying an electronic network linking document sources (central libraries and publishers). In the interim, local libraries will slowly progress through increased dependence on local holdings of microfilm to development of and dependence on regional, national, and discipline networks for access to most of the documents desired. These developments will depend, however, on resolution of the copyright problem by mechanisms that will fairly remunerate the copyright owners. As background, and because radical change is not expected overnight, the paper also reviews conventional and sophisticated storage systems, including microfilm, facsimile, and video; copyright aspects; costs; need for speed; other user considerations; and standards.

Libraries, file rooms, depositories, and archives have long been the sources to which chemists and others turn for desired documents—in person, in writing, or by wire. To meet this demand, local sources of documents have usually tried hard to possess copies of most of the documents normally requested. On-demand purchasing or borrowing have come next, with photocopies employed almost universally as a substitute for the latter.

Lately, however, stress has been placed on this system by the vast number and growing cost of documents available and issuing, the intensification of demands caused by improved methods for identifying relevant documents, increasing costs and charges for present access routines, increasing impatience with the time required for these routines, and increasing establishment of branches which need substantially the same document services. These trends have coincided with a growing awareness of the potentials of modern techniques and equipment for some of these routines—lower cost, better quality facsimile; closed-circuit TV or videotape files, with videotape buffers; large-scale and remote-access systems employing microfilm and microfilm reader-printers; and even computerized files, replete with cathode-ray-tube or microfilm outputs. Accompanying this has been the growth of state and regional library networks using conventional methods but slowly experimenting with the newer ones.

Some of the problems and potentials inherent in this

*Presented before the Division of Chemical Literature, 161st Meeting, ACS, Los Angeles, Calif., March 29, 1971.

situation have been recognized, at least at the national level, and have been the subjects of conferences and studies. It seems timely, nevertheless, to review briefly in this paper the state of the art for document access and to peer reasonably far into the future. This may be particularly timely because the new information systems for alerting and for storage and retrieval have recently monopolized the limelight. Only a few information managers[1] and projects such as MIT's Intrex have clearly pointed out that providing pertinent documents is also vital.

However, simply because I am concentrating in this paper on obtaining access to needed documents does not mean that I am decrying the importance of information alerting and retrieval systems. Moreover, when I deal, later, with increasing dependence on outside sources for delivery of the document copies needed, I am in no way casting aspersions on local needs for more and better alerting tools, and for more and better reference sources and systems.

It is true, I believe, that on-line, direct-access systems for pertinent-document identification will have a gradual effect on existing methods for alerting and retrieval, and I also believe that there will be increasing interaction between these new systems and on-line, direct access to documents. For the present and for the next decade or so, however, we must be careful not to throw the bathtub away with the bathwater. We are likely to continue to need search rooms and alerting subscriptions to journals longer than we will each need full-range document holdings, although I am definitely not forecasting the near-future demise of local document collections.

STORAGE SOURCES

Libraries, file rooms, depositories, and archives have proliferated and grown over the years. Now, however, many are facing serious problems of inadequate space and/or insufficient funds—a growing inability to keep pace with local user demands.

The concept of the local library is a deeply imbedded one, at least in education and the learned professions. From their student days on, most professionals learn that they must depend heavily on nearby libraries for most of the documents which they require. Knowing this, concerned citizens and librarians have developed an elaborate array of municipal, country, and state libraries, replete with branches; Government libraries; college and university libraries; and special libraries within a wide variety of organizations, private and public.

Each of these libraries strives in its own way to satisfy the needs of its particular clientele. Each usually buys as many as possible of the books, journals, theses, patents, and other documents that its users have demanded or seem likely to require—a practice which is a major source of revenue for document publishers. When it does not have documents which its users request, each library then resorts to its own combination of practices for rapid-as-possible purchase or interlibrary loan.

Interlibrary loan, including the provision of photocopies in lieu of papers, is an old and established practice. To expedite their part in it, participating libraries have joined in the listing of their holdings in "union lists of serials" and "union catalogs" on a local, national, discipline, or other scale, and some major libraries have also published voluminous compendia of their individual holdings. The Chemical Abstracts Services' CASSI is an outstanding example of a discipline-oriented, computer-based "union list of serials."[2]

Recently—but not yet very commonly—libraries in a given area (sometimes a large one) have interchanged or mechanized their holdings records in such a way that each can then call on the others for needed documents by teletype or similar means. Actual or implied agreements on future coverage have sometimes also been reached, to husband resources. The research libraries of at least one private company—Bell Telephone Laboratories—have been similarly linked by computer, making possible almost instantaneous knowledge of the availability of a desired document anywhere in the network.[3]

Indeed, "library networks" and "switching centers" have become "in" phrases, and the subject of significant books and conferences.[4-6] Much more will be heard about them in a variety of contexts, especially including financing.

Libraries are not alone in their problems of document storage, however. They are joined by the file rooms and report collections of major Government agencies and private companies, and by the similar information operations of the airlines, licensing agencies, police departments, and others who must store and access large volumes of documents. These latter operations are so large and so numerous that it is often they and not the libraries that have been calling the tune in the development of document-access systems and equipment. This is evidenced by the predominance of references in the systems and business press to the actual use of these new systems by nonlibrary document handlers, and by the relative paucity of references in the library literature that report library use.

As regards the Government agencies, few fail to recognize the importance and influence that their major collections of reports have had on libraries and individual users alike. These agencies have also brought onto the scene a document form—microfiche—which came into wide use largely because of publishing economies rather than user demand.

To complete the document-storage picture, one must consider document depositories and archives. These are usually stores of documents that are too long, too numerous, too old, or too little used to fit into conventional libraries or file rooms, but which are still important when details are needed for scientific, business, or legal reasons.

CONVENTIONAL STORAGE SYSTEMS

Almost every child is familiar with the appearance of a conventional library—row on row of stacks of shelves burgeoning with books and bound journals, adjacent to reading areas. File rooms have begun to look much the same; vertical shelving has largely replaced file cabinets.

Indeed, shelving units are now available which conserve aisle space by use of double, sliding segments of shelves which have one segment missing from each front row to permit access to the back row. In another system, entire stacks are suspended in such a way that they can be moved together until aisles need to be created by pushing them apart. Even more sophisticated is a storage unit which, on signal, mechanically brings the desired file segment to a central station.

Depositories, archives, or record centers usually look like second-class file rooms,[7] except where they rely heavily on microfilm. When their documents are little used, these are often stored in cardboard boxes before being put on shelving. The latter often goes much higher than in file rooms, necessitating the use of special ladders.

STORAGE SYSTEMS IN TRANSITION

The document sources and storage systems I have so far described have been developed over the years to house and to access conventional documents. They all require considerable space and increasingly costly manpower for their

use. It is not surprising, then, to find modern technology being applied on a growing basis.

I, for one, have been strongly advocating microfilm as a prime medium for the storage and accessing of primary and secondary journals, patents, reports, correspondence, and other documents. Our own studies have shown that it is faster and less expensive to locate and to work with microfilmed pages, using modern microfilm reader-printers, than it is to find and to use the same pages in bound volumes, and that savings in space are significant.[8] The use of microfilm for effective document storage was the subject of an extensive ACS symposium[9] as recently as 1969, and events since then have but emphasized the trend toward substituting user-oriented microfilm packages for stores of the original documents.

I have stressed user-oriented because that has been the key which has unlocked the door for a medium which had long been used chiefly for archival document storage. A user may now sit in front of a microfilm reader-printer into which he inserts a cassette which he has selected from a drawer or shelf stack by reading the label on its edge in the same manner in which he reads the spine of a book. By throwing a switch and watching a moving line or odometer numbers, or by keyboarding a page number, he rapidly advances the roll of microfilm to the page desired without ever touching a film leader or in any way handling the film. By pushing a button he may then make a hard copy.

Until recently, microfiche—microfilm cards containing microfilmed pages in rows and columns—has been publisher- rather than user-oriented. In quantity, it has been less expensive to issue and to mail a microfiche than a printed document, but the use of microfiche in reader-printers has required manipulation that has sometimes been disliked by the casual user. As for any other card, microfiche has also been subject to the vagaries of card filing.

Some remedies have appeared, however. Sets of microfiche can be shingled in binders in transparent holders or slotted sheets, so that loss or misfiling is evident. Sophisticated microfiche devices are available which store edge-coded microfiche at random in a carousel from which a given microfiche and page can be brought to the screen by keyboarding.[10] This device has been adapted, on a pilot basis, in Project Intrex' remote-access system.[11, 12]

A few even-more-sophisticated (and expensive) microfilm systems combine both document storage and lookup. In some of these, binary search patterns are microfilmed at the same time as the documents; in searching, the equipment displays or copies the images which match the keyboarded code.[13, 14] One very large system can provide random access to any of 200,000 unit documents—tabulating cards, aperture cards, or microfiche.[5, 15]

A recent entry into the document-storage picture is the use of videotape. One filing system which employs it has its videotaped documents keyed for on-demand recall by author, subject, etc., at the time that they are entered into the system. About 170,000 8½ × 11 inch pages (equivalent to nine four-drawer file cabinets) are stored on a single 12½-inch-diameter reel of 2-inch wide videotape. When called up in response to a request, the pertinent documents are quickly read off onto a buffer tape or disc so that the central file can remain intact. This buffer tape or disc can then be read at will—pages "turned" back and forth by the reader—and hard copy can be prepared if desired.[16]

So far, however, only microfilm has begun to find extensive use in libraries. The American Chemical Society, through its Chemical Abstracts Service and its Books and Journals Division, has recently led in this effort; all of its primary journals[17] as well as *Chemical Abstracts*[8] are now available on 16-mm cartridge microfilm. Moreover, the microfilmed editions of some of the primary journals may soon include supplementary information that might in the past have gone only to archives.[18] Now joining in this effort are many other societies and the commercial microfilm publishers which hold microfilm-edition copyrights or are filming long runs that are in the public domain.

Books on microfilm—specifically as high-reduction microfiche—are only now beginning to appear in any quantity[19, 20] although microfilm has for some time been used as the intermediary for producing on-demand single copies of out-of-print books.

Equipment for all these systems, as mentioned earlier, has rarely resulted from library demands. Whether we like it or not, more often the equipment has come from systems designed for the catalog files of businesses or the records systems for airlines, railroads, and police.

ACCESS SYSTEMS IN THE YEARS JUST AHEAD

Rows of document stacks, microfilms, and even videotape systems as they have been described here so far have all had one thing in common—they are intended primarily for local use, and their interchangeability is based on available space, costs, and librarian-user flexibility. In the years just ahead, moreover, emphasis can be expected to shift only slowly from local storage of documents to access to remote document stores, including direct access.

I have commented earlier on the beginnings of library networks. These are already having some effect in a few locations and in a few disciplines, but much more is needed before networks can become a real influence. However, the present, everyone-autonomous system leaves much to be desired. Even in the field of chemistry—a literature-conscious field if there ever was one—many journals (including core journals) are accessible nowhere, according to a recent "Review of the Availability of Primary Scientific and Technical Documents in the United States."[21]

What is likely to happen in the immediate future is greatly increased use of microfilmed editions of journals, and some books, both to improve local holdings and to mitigate shortages of space. Library networks will proliferate and grow, but these will be at the university- and Government-library levels and among major libraries in specific disciplines. These, in turn, will begin to become the network nodes or switching centers that will be used increasingly by the special libraries for remote access.

Progress will be slow, however, for reasons that will become increasingly evident in the latter portions of this paper. Even the 1970 "Conference on Interlibrary Communications and Information Networks," after spending a week discussing the topics contained in an imposing array of commissioned papers, could come up with nothing much more specific than that the (not yet appointed) "National Commission on Libraries and Information Science (should) direct the development of a comprehensive national plan to facilitate the coordinated development of the nation's libraries, information centers, and other knowledge resources."[5]

In regard to the use of other systems, it is possible that library use of facsimile will soon make its long-awaited breakthrough.[22] Office-size equipment for the facsimile transmission of documents over telephone lines has now been available for several years, and was the subject of several library-network studies shortly after it appeared.[23, 24] Few if any libraries then put it into continued use, but some thousands of intracompany facsimile systems currently use it to transmit business documents.[25] The facsimile network inside Jersey Standard alone has a few hundred instruments at nearly 40 locations and transmits/receives an average of about 6000 pages per month. Ser-

vice-bureau networks have also sprung up to transmit documents ranging from legal documents to medical records.[26]

Equipment rent for the smaller sending-receiving instruments is well within normal library means—around $100 per month or so per compact transceiver—but transmission times for these smaller instruments are still around 6 minutes per page for anything approaching library-quality copies. Moreover, transmission of type sizes smaller than 8-point is not very legible with these compact transceivers. Despite these limitations, this type of facsimile equipment is the first-round base for an experimental network for document transmission being developed by the National Agricultural Library—a network already operating with Penn State University and Rutgers University as receivers—and for a further network proposed by Rutgers University to make its holdings and those of the National Agricultural Library available to nearby libraries.

Faster, more versatile equipment is also available for larger loads.[22, 27] It is already possible to transmit facsimile images from microfilm—even microfilm in combined storage and retrieval equipment.[28]

Before we look further ahead, however—say, 10 to 20 years—we ought first to consider briefly certain basic factors which we have largely deferred until now. These are copyright aspects, costs, need for speed, other user considerations, and standards.

COPYRIGHT ASPECTS

As is the case for other property, most documents usually belong to someone—originally to their authors or to the distributors (publishers) to whom authors have legally assigned their copyrights. Because of copyrights, indeed, only within certain limits do publications really belong to those who have purchased copies through normal channels. "Proprietary use" and "proprietary rights" are phrases now coming into wide use, and it is these rights which come into play when one is concerned with photocopies, facsimile, closed-circuit TV, videotapes, video records, computer storage and recall, and other methods of document storage and access which depend on modern technology instead of copies of the documents as originally produced.

Volumes have been written on copyright, fair use, and other aspects of copyright law,[29] so it is not my purpose to belabor the subject here, especially since ACS members have recently had a chance to review the subject in *Chemical and Engineering News*.[30] What is important is that, as it is presently written, the copyright revision bill again pending in the Senate (S.644) would almost certainly severely limit photocopying under "fair use" or any other "for free" concept, and would also place a stamp of illegality on most document-access practices which attempt, "for free," to use modern technology instead of direct purchase from the copyright owners. How fast (and if) this situation would be remedied by the co-proposed "National Commission on New Technological Uses of Copyrighted Works" seems moot.

Because I am active on "copyright" and "proprietary use/rights" committees, I must at this point make it clear that what I am about to say expresses my personal views. These are that *libraries absolutely must have the continued ability to provide document copies to the users whom they serve.* Also, if we are indeed law-abiding citizens, and believers at all in property rights, that we do not want to attempt to deny fair revenues to the copyright owners of the original documents. I, for one, want to see them stay in business to produce more and better documents for our use.

Accordingly, I believe firmly that document users, including libraries, ought to abandon one-sided efforts to persuade Congress to define "fair use" and related uses to permit extensive "for free" photocopying, computer storage, and the like. Instead, users—preferably jointly with publishers—should press either for no immediate change in the document storage and accessing parts of the present copyright law, pending the report of the aforementioned National Commission (and/or interactive studies by all groups concerned), or—boldly—they should press for inclusion of reasonable, well-defined compulsory-licensing provisions that would not raise legal barriers to progress in document access and would also ensure a fair return to the copyright owners. If the pending bill can provide for compulsory licensing and collection of royalties for phonorecords and CATV, why not also for photocopies of documents?

Under this, "fair use" could be supplemented or replaced by a "fair compensation" clause, and royalties could be paid into the Royalty Tribunal that the bill would establish. Eventually, perhaps, copyright-reproduction tax stamps could be sold to librarians, to be affixed to each photocopy (or even each page), or copying equipment could be equipped with special counters for copyrighted material.[31]

Pending or failing something like this, the ability of individual and collective users to obtain copies of documents could become a matter for contracts, perhaps initially a combination of licenses from major publishers, such as the ACS, or fee payments to the document-access equivalent of the music-composers agency, ASCAP. I, for one, would be glad to settle for the fee (two cents per page per copy) asked by Williams and Wilkins in its recent copyright suit.

Such a solution is not impractical. ASCAP has proved that. As regards record keeping by users, our own library routinely keeps excellent records of its "fair use" photocopying—of what it is copying—in order to allocate photocopying costs to customer divisions. Also, we have had no difficulty in studying copies of our outside orders for photocopies to see what sources are involved and to what extent. Statistical sampling might be substituted, but even if it were not our own Library's costs would not exceed $1,000 per year for extra record keeping; about $2,000 per year for "rights" fees (at two cents per page) for in-Library photocopying; and increased costs of about $1,000 per year for outside photocopying (at two cents per page for "rights" fees), or a total of about $4,000 per year.

We know that some photocopying is also being done by Library users themselves, although we provide no self-use photocopiers in our Library. Perhaps the Company might have to pay as much as $5,000 to $10,000 per year for all copying "rights," probably well less than the total we now pay for page charges. While our management—as others—is quite concerned with photocopying costs, I feel certain that it would be willing to see such an amount paid rather than to have to deny photocopies to its staff for legal reasons. Self-discipline in making or ordering photocopies may indeed have to be taught, but that ought to take place anyway.

COSTS

The table lists unit costs of our own operations and illustrates some of the points at issue.

Neither of the $1.60 nor the $5.50 unit costs include amortization or maintenance of the collection—about $2.50 per photocopy for the latter (above the $1.60) if photocopying is estimated at one third of our total use. Few outside libraries presently levy a service charge (corporate membership) for the equivalent. Sooner or later, however, central libraries will have to charge for all of the costs associated with each of their services.

Let us look, now, at the costs of facsimile copies. Recent information indicates that facsimile, even at a rate of 1,000

Esso Research (Linden) Unit Costs for Photocopies

	Cost, $	
Internal Photocopying	Per Page	Per Document
Library handling of requests for internal photocopies (sorting and validating requests, removing volumes from shelves, sorting and reshelving volumes after photocopying)	0.17*	1.00
Internal photocopying costs (labor, materials, equipment rent or amortization, sending photocopies to requesters)	0.10	0.60*
Total	0.27	1.60
Outside Photocopying		
Ordering photocopies from outside libraries (identifying holding sources, preparing and mailing requests, reordering when first sources cannot supply, sending photocopies to requesters)	0.42*	2.50
Outside photocopying charge	0.50	3.00*
Total	0.92	5.50

*Figures starred are derived, based on data showing 6 pages per document for internal photocopying. Documents ordered outside could have slightly more pages.

monthly transactions (about our present outside-photocopying level), might now well add $0.50 to $1.00 per page to our costs for outside copies, assuming that outside libraries and ours were equipped for this service. At low levels of use, incremental costs might approach $5 to $10 per page. (The aforementioned experimental service offered by Rutgers University would cost $1.00 per page plus telephone charges, with a $2.50 minimum.) These costs will come down, especially when transmitters can handle bound volumes and microfilm as well as single sheets, when receivers can routinely be operated unattended (already possible for some), and when unit transmission times are measured in seconds or fractions of a second instead of minutes. For the present, however, there is a real increment of cost that must be balanced against the value of speed.

It is not my intention here, to go into the costs for other media, the creation of library networks, and the like. Suffice it to say that there are predictions that CATV and/or videorecords (VR's) will soon bring the transmission costs of documents down to the cost of mail; if true, this would be well less than $0.10 per page. The sender's handling costs would have to be added to this, plus library costs (if any) in behalf of the user. Little of this will be possible, however, until major libraries can readily meet the demands of users on their document networks, and that could cost millions of dollars. Against these costs, however, user libraries will be able to balance their savings from lessened costs for space and for purchase of documents for reference use only, as I have shown.

NEED FOR SPEED

Probably no phase of document access is more controversial than that of access speed—how fast the user actually needs the documents that he has somehow identified as possibly pertinent to his needs, and how much time is actually required to provide the documents at different levels of cost. On sober thought, the relative need for speed would seem to be based on such factors as:

Why the user is looking for information, and the type of information that he needs. For example, if he is beginning a study in a new field, and for this he wants some good reviews, the user's real need for speed depends on whether he has thought to ask for his documents in advance or is asking at the time that he wishes to begin his actual work. On the other hand, if he needs information to solve a problem that has suddenly arisen, the user's need for speed will depend on whether or not he can devote any waiting time fruitfully to other aspects of his work.

How many pertinent documents the user is requesting. While some of these documents will prove more valuable than others, the requester of numerous documents can read and digest only a portion of them in a given period. On the other hand, if he has identified only a few pertinent documents, the user's need for speed reverts to the "why" and "what" factors in the previous point.

As mentioned earlier, librarians have usually assumed that the user needs the documents he requests very promptly, and they have attempted to assemble their collections and to gear their copying services accordingly.

On their part, by the time that individuals have been educated they have usually been partly conditioned not to expect libraries to supply them instantaneously with every document that they need. Most individuals have geared their operations accordingly, although hard-driving workers have never accepted this situation. It is these individuals who have sparked some of the recent innovations in document access and who are pushing hardest for full use of modern technology. It is they, in concert with their librarians, who will have to persuade managements that the need for speed justifies the higher cost of some of the modern systems.

In business operations, on the other hand, speed has often been of the essence, and the quicker systems have often proved to have over-all economies. Let us not forget that the cartridge-microfilm system was originally designed for rapid display of parts-catalog pages at Sears Roebuck.

As regards the time required to provide document copies, it might be instructive to look at some data for library-document requests from an Esso Research study conducted in the fall of 1965. Our Library's expressed goal at that time was to provide copies of documents in its collection within three days, and delivery of documents that had to be ordered outside within 21 days. The study showed that, on average, these goals were being met 100%; indeed, 90% of in-house copies were received by their requesters in a maximum of three days, and 80% of items ordered outside in a maximum of 21 days (40% in a maximum of 10 days). Of the total requests, 66% were received through the mail, 20% by telephone, and 14% from walk-in users. Over-all, the Library supplied from its own collection nearly 85% of the documents requested. This latter figure was still correct in 1970.

As we will discuss later, it is now possible from experimental systems or special collections to provide near-instantaneous recall of document images, and to obtain hard copies in minutes. There will likely be a really substantial need for very fast copy service if the day ever arrives that most of the documents needed are no longer available locally.

OTHER USER CONSIDERATIONS

It is common knowledge that the present generation of users has been conditioned to prefer and to demand printed ("hard") copies of documents. We also know, now, that users readily accept modern photocopies as the virtual

equivalents of the original documents, except occasionally when half-tones or color are involved.

The advent of microfilm reader-printer systems has taught us another valuable lesson: that even an adversely-conditioned user can come to prefer a different medium if he can gain from it some combination of time or effort saving, elimination of a distasteful task (such as note taking), or some real incremental benefit (such as ability to make and take away full-text copies on the spot), and if the medium itself does not present major new problems.

We have already looked at speed as a factor, and have found it to be an important consideration, albeit cost-related. The ability to obtain hard copies is another desirable factor. We will look again at these factors in the last section of this paper, because they constitute some of the major reasons why modern technology is likely to change our ways of document access.

There is at least one other factor, however, and that is education. It is heartening to hear that present students—at least many of those in education, the sciences, and engineering—become quite comfortable with the use of computers, microforms, and other "new-fangled devices" when they are exposed to them as a matter of course.

STANDARDS

Competition is healthy when it hastens the development of practical ways to use new scientific principles, but it is unfortunate when the competitors go on for years without standardizing those details which would permit a reasonable level of interchangeability for the user. For example, we are presently confronted with real incompatibility of 16-mm microfilm cartridges among the manufacturers of cartridge-type microfilm reader-printers. Moreover, something (perhaps a nostalgic affection for 35-mm microfilm) has for years delayed the shift of a major holder of microfilm copyrights to the publishing of journals in 16-mm microfilm cartridges, notwithstanding the success of societies and competitors, and certainly to the detriment of users.

Until this year, we were faced with two standards of layout for conventional microfiche ("conventional" meaning reductions of about 19×-24×), not to mention the flood of different and greater reductions now appearing. Moreover, tentative plans for wide use of microfiche at a new reduction ratio by the U.S. Government Printing Office may throw the whole field into further turmoil.[32]

We are told that we could not afford a "universal" microfilm reader-printer—one that could handle rolls, cartridges, and microfiche of all types and reductions.

We also find that office-type equipment for facsimile is incompatible except for most of the machines of two manufacturers. Many of these machines could be made compatible with changes in modulation methods and number of lines per inch; other factors requiring standardization would be start signal, stop signal, and speed.[33] The equipment of five major manufacturers could reportedly be linked up without major changes in these factors. However, the type of printing method could be a stumbling block between these and a sixth manufacturer, the only major one which now employs a nonimpact printer—"the wave of the future" in its opinion.

Nothing in the way of standards is in sight in other areas of new technology, nor is this surprising. The manufacturers of pioneering equipment in any field must usually arrive at their own compromises between optimum versatility and price, and they rarely can leave doors open for later adjustments in these early devices. What we must hope for—and urge, individually and collectively—is that manufacturers adopt some compatibility standards as soon as it appears that their devices will be used to any real extent. Beyond question, however, users have a rough period ahead when it comes to deciding what to buy without fear of near-immediate obsolescence or incompatibility.

LONG-RANGE DEVELOPMENTS

It would be easy, as well as challenging, to talk about the future in terms of the developing technologies and related problems; psychological barriers; the role of the Government in regulation, research, and financing; and all of the other aspects that make short-range forecasting so imprecise. Heretofore, I have not avoided details; I will not really neglect them here, but I prefer to look ahead in another way. I prefer to talk about what I really think will happen, long range, although I can hardly be as original as Vannevar Bush a quarter-century ago.

First of all, I must assume that educators, scientists, engineers, and other professionals, even 10 to 20 years or so from now, will still want to see/have specific documents on many occasions. While they will have become accustomed to being able to call up much specific data and data correlations from remote computers, they will still want confirming background, reviews in fields that are new to them, and detailed explanations of new developments—in other words, documents. In education, also, teachers and students will still want certain documents for away-from-classroom and away-from-teaching-machine study and review. Finally, businessmen and lawyers will still want actual documents for a wide variety of purposes.

I must also assume that we will have become accustomed to getting what we need rapidly, easily, and reasonably inexpensively. Moreover, I must assume that the details of paying for proprietary rights will have been smoothly and unobtrusively worked out—possibly built into the systems in such a way as to inform users of exact costs, in cases of question, and even to provide automatic billing.

If all this becomes true, document users will have available to them at convenient locations (libraries, file rooms, and branch stations, if not always on their desks) devices which they can use to ask for specific documents and which will quickly display these and quickly provide copies, on demand. Some of these devices will also be able to send documents to other such stations. They will be activated by simple pushbuttons or keyboarding, and possibly eventually by voice commands.

Pipedreaming? I do not think so. We are already blasé about demonstrations of on-line, direct-access retrieval stations. Moreover, MIT's Project Intrex is already operating in the MIT Library a multi-purpose terminal which, after the user has identified a document, will also display its full text on pushbutton command, will enlarge portions of the document for easier viewing on pushing another button, and will deliver microfilm-strip copies on pushing still another button.[10, 11] Bell Telephone's Touch-Tone dialing already permits remote data input, and its Picturephone is almost certainly a forerunner of much-more-versatile equipment. Competition will assure that. Moreover, Bell and others have long been experimenting with the fundamentals and practice of computer identification of voice patterns.

Much is already going on in data/document transmission.[34-40] For facsimile, in the future, digital instead of analog transmission, bandwidth compression, and selective scanning (in which blank spaces are skipped) will combine to use a combination of leased wide-band telephone lines, coaxial cables, microwave or even laser relay, and/or a complex network of communication satellites. Perhaps slow-scan video transmission will have taken over (the difference will have become largely moot), using videotape buffers or video records at the receiving end to eliminate line

tieups. Hard-copy electrostatic prints will be easily produced, on demand.

Document storage may depend heavily on microfilm, much of it computer-produced in or as a by-product of computer typesetting, and some of it deliberately produced to place at least the most important documents in accessible form. Alternatively, storage may be based on videotape, on laser-scanable holograms, or on some (yet to be conceived) vast but inexpensive memory devices for computers.

For the most recent documents, recall will be by something like an International Document Number (IDN), such as (or based on) Standard Book Numbers (SBN's), Standard Report Numbers, derivatives of Standard Serial Numbers (SSN's), patent numbers, etc. Where an IDN is not available or known, the requester will ask for documents by a combination of titles, SSN's, report numbers, patent numbers, authors, dates, etc.—information with enough specificity or redundancy to cue the controlling computers to determine what document is wanted and where and how it is available for call up. Where necessary, central-exchange operators (librarians) will cut in to ask for further information.

When the documents are not in automatic-access storage, facsimile or video relay will be called into use. For the latter, bound publications in central libraries will be placed in front of TV cameras and transmitted either to video buffers, for user viewing, or directly to hard-copy printers at the users' stations. Where this would yield too many single sheets or an unwieldy roll, some of all user stations will be equipped to produce high-reduction microfiche or microfilm rolls for use in reader-printers.

In this mechanized Utopia, publishers, equipment manufacturers, librarians, and other information workers will concentrate on creating the alerting and storage media and tools that will still be needed, on making them accurately accessible, on providing the human assistance that will always be needed, and on developing new and better systems. Information engineers will also be called on to develop or to specify new equipment, and otherwise to help to cope with the information explosion that will still be continuing.

In the intervening years, of course, we will be hearing much about research and development on the aforementioned use of lasers, holograms, and the like. We will also see vastly greater use of library networks based on printed documents and on the present and near-future generations of technology. We will see local collections (libraries) shift only gradually toward becoming alerting and searching centers before they eventually become information-system expediters. We will see even slower changes in file rooms and archives, for economic reasons.

Indeed, for some years we will probably see relatively few changes in most locations. But "it must follow as the night the day" that what lies ahead is a real revolution in document access, as part of the revolution in total communications.

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The What and How of Computers for Chemical Information Systems*

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Received March 1, 1971

What literature chemists need to understand and to do to use computers efficiently and productively is discussed in terms of when a computer is needed, which computer, what a computer is and how it works, computer logic, and designing a chemical information system for computer processing.

The computer has a long past but a very short history. Its antecedents are the abacus of the ancient orient and various calculating devices of ancient Greece, the mechanical digital calculator made by Blaise Pascal in the 17th century, and the mechanical calculator designed by Charles Babbage early in the 19th century and from which evolved the electromechanical accounting machines of the early 20th century. The real beginning of the history of the computer was probably in the late 1930's when Howard H. Aiken of Harvard University and George R. Stibitz of Bell Telephone Laboratories introduced automatic calculators with relays. This was closely followed by the work of J. Presper Eckert and John W. Mauchly, at the University of Pennsylvania, during the early 1940's which resulted in ENIAC, the first electronic computer.

Computers of the 1940's and early 1950's were vacuum tube based. For example, ENIAC contained 18,000 vacuum tubes. These vacuum tube computers are now called first generation computers. They performed arithmetic (addition, subtraction, multiplication, etc.) and logical operations (comparison, selection, and rejection) in a thousandth of a second or less. Magnetic tapes were the primary mass storage devices and, consequently, data could be processed only sequentially and by batching techniques, very much like, but faster than, the electric accounting machines of the 1930's and 1940's.

The first generation computers evolved into what are now called second generation computers. These computers of the 1950's and early 1960's used magnetic core working storage with transistors and diodes replacing the vacuum tubes of the first generation computers. They performed the same arithmetic and logical operations as the first generation computers, but at speeds of microseconds, or millionths of a second, and with the added advantage of direct access to mass storage—i.e., many thousands of stored records, any one of which could be retrieved in a fractional part of a second.

During the 1960's, the third generation computer was introduced with speeds of nanoseconds or billionths of a second. These computers were characterized by integrated microcircuitry.

At the beginning of 1970, the number of computer installations—viz., second and third generations—totaled about 70,000 in the United States. This growth of the computer industry over the past 25 years is without equal among technological developments. Its glamor and impact have been unique, by any standard, and today computers are a pervasive part of daily living of practically everyone in the United States.

Computers are very much present in the chemical industry for mathematical and accounting applications. I know of no chemical company which has a technical library or a

*Presented before the Division of Chemical Literature, 161st Meeting, ACS, Los Angeles, Calif., March 29, 1971.
Hercules Research Center Contribution No. 1552.