Computerized Bibliographic Retrieval Services

FRANK B. ROGERS

> I take it for granted that you have everything in your great Library in Washington and that Dr. Billings knows all that has been written since Chiron first took a pen in his hoof.
> (Letter of 7 April 1876, Oliver Wendell Holmes to Joseph M. Toner).[1]

SINCE CHIRON FIRST took pen in hoof, a very large amount of medical literature has been produced. When John Shaw Billings retired, after thirty years of prodigious acquisitions activity, from the directorship of the National Library of Medicine in 1895, the number of volumes in the collection was 117,000. At present, it takes only five years to acquire that amount of current material. (Comparisons are difficult. The collection total in 1895 was 117,000 "volumes" and 192,000 "pamphlets." For comparisons with the present only "bound post-1914 monographs" and "bound journal volumes" were counted and pamphlets, theses, microforms, etc., were omitted.)

In the sixteen volumes of the *Index Catalogue of the Library of the Surgeon General's Office* published between 1880 and 1895, some 511,000 journal articles were indexed. That is slightly less than the number of journal article citations added to the MEDLARS data base in the most recent 2.33 years for which figures are available—516,653 citations were added from July 1971 to October 1973. It is unnecessary to belabor the point; everyone knows that the growth of scientific literature since the end of World War II has been enormous. Today, even Billings would need a few computers to handle it.

Over the last decade, the use of computers for bibliographic retrieval in medical libraries has come of age. Beginning with tape-oriented files, progressing to decentralized service bureaus for searching these files, and moving recently into on-line systems, computerized bibliographic retrieval in biomedicine has undergone an astonishingly rapid

Frank B. Rogers is Librarian, University of Colorado Medical Center, Denver, Colorado.

development. Similar developments have taken place outside the biomedical area, and to the extent that they impinge strongly on the health sciences they are noted here, but no attempt is made to cover all retrieval systems.[2] This paper also does not concern computer applications in library housekeeping tasks, nor computer bibliography in individual local libraries, as in the production of book catalogs. It is solely concerned with national systems, and mainly with such systems as offer subject access to the periodical literature, which comprises more than half of the stock of the average medical library and presents by far the most difficult problem of bibliographic control.

DEVELOPMENT OF TAPE FILES

MEDLARS began operation at the National Library of Medicine in January 1964. It was the first large-scale computerized retrieval system to be available to the general public. The story of this system has been detailed elsewhere.[3]

MEDLARS is a term that is used in several different ways: (1) it means the mechanized data base from which its major published products—*Index Medicus, Index to Dental Literature,* and *International Nursing Index,* and many subsidiary publications—are derived. In this article, it is always referred to in this sense as the "MEDLARS data base"; (2) it embraces the computer machinery and photocomposition devices used for forwarding the publications. The constellation of machines and methods used keeps changing, and there is currently underway a transition to a system known as MEDLARS II, which should be viable in 1974; (3) it refers to the original system of performing demand search bibliographies to individual request specifications, which flourished from 1964 through 1972 (the last revision of the *Guide to MEDLARS Services* appeared in August 1971). It is in this sense that the term will be used in the first part of this paper.

When a request for a MEDLARS search was received at NLM, an analyst formulated the search in terms of Boolean coordination of subject terms (the other searchable items were largely used for sorting, and for major exclusions, as by language fields). The formulation was fed to the computer, through which the entire MEDLARS file was then passed, comparing each citation against the criteria set forth by the search formulation. The output was a printed list of citations sent to the requester.

In this way, NLM completed 1,800 searches in fiscal 1965. The demand rose from 62 in July 1964 to 276 in June 1965. At this time there was one file and one search center, at NLM. Any medical library in the country could avail itself of MEDLARS on behalf of its clients; access was by mail, to the centralized source.

DECENTRALIZATION OF MEDLARS

In 1965, NLM began to move toward a decentralization of MEDLARS search services. Tapes could be replicated cheaply, and duplicate files could be built up at regional centers. Within a few years, twelve regional MEDLARS centers were established, each serving specified areas which in time were rationalized to coincide with the RML areas then developing. In addition, eight centers were established in countries throughout the world.

As it turned out, only one-half of the domestic centers were processing centers, i.e., performed their own computer operations. The rest of the MEDLARS regional centers accepted requests, formulated them, and shipped the formulations to one or another of the processing centers for machine processing.

The MEDLARS files were serially ordered. Citations for about one month of indexing would just about fill one reel of tape (the tapes were named for the monthly issue of *Index Medicus* with which they corresponded). If one wished to search the most recent 750,000 citations in the file, one had to pass the forty tapes which held them. At about 3 minutes per tape, this process of reading took 2 hours, followed by another period of logical comparisons, formatting, and printing. At a computer cost of $250 per hour, it is obvious that the economics of doing searches one at a time is not favorable. The solution was, of course, to batch—to collect some optimum number of searches and to process them all at once against one reading of the entire tape file.

This was what was done. The process of collecting an adequate-size batch involved delays in turn-around time. For the nonprocessing centers, additional delays were involved in mailing time. One center (Colorado) achieved a turn-around time of less than ten days for 67 percent of its searches when it was processing the searches for itself; when it became nonprocessing, due to cheaper computing being available elsewhere, the turn-around time was increased by an additional five to ten days.

This delayed response time, of one degree or another, is characteristic of all tape-oriented retrieval systems. Clients were receiving a marvelous bibliographic service where next to nothing had existed before, and they were not complaining about the delay. One can see, however, that the system favored the researcher, the expert who needed an exhaustive search, the person who had been commissioned to do a review article. To help the clinician with a problem case, we scanned the printed bibliographies as we had always done; when someone wanted to write up a series of cases, he or she asked for a MEDLARS search.

MEDLARS services peaked in fiscal 1971, when 18,000 searches were performed in the United States—4,000 at NLM, 14,000 at other U.S. centers—and an additional 5,600 at foreign centers.[4]

There were no "average" MEDLARS searches, but the statistically average search at the Colorado station covered three years of the data base (about 665,000 citations) and retrieved an average 160 citations per search, i.e., one out of every 4,150 citations was selected. The great majority of clients were pleased with the results. Lancaster, in a very stringent examination, found that MEDLARS achieved a recall ratio of 58 percent and a precision ratio of 50 percent.[5] A survey of NASA/RECON performance in 1970-71 produced about the same ratios.[6]

DEVELOPMENT OF OTHER BASES AND SERVICE CENTERS

Biomedical libraries employ many bibliographic tools covering areas of interest beyond the central core of *Index Medicus.* Some of the most important are mentioned below.

Chemical Abstracts Service, a division of the American Chemical Society, brings out *Chemical Abstracts* and other related publications of particular interest to medical school-based biochemists and pharmacologists. The various services provide enormous coverage of the literature, and are furnished with detailed indexes. Most of them are available in the form of computer-readable tapes.[7] One of the most popular services is CA Condensates, furnished weekly, giving authors, titles, source data, and keyword phrases (no abstracts) to an estimated 360,000 journal articles and patents in 1973. CAS leases these tapes to users, but does not provide search services from its own shop.

The BioSciences Information Service, publisher of *Biological Abstracts* and related items, offers BA Previews on computer tapes, covering 240,000 reports each year. The cost of these tapes is $5,000 per year. BA also offers individual retrospective searches through this file at a price of $150.

The Institute for Scientific Information, publishers of *Science Citation Index* and related items, leases computer tape data bases. This is an interesting instance since ISI, by the nature of its compilations, has been a computer-based operation from the beginning. For years ISI has offered its ASCA (Automatic Subject Citation Alert) current awareness service through searching its tapes.

There are other such computer-tape bibliographical data bases, of both governmental and commercial origin, available: CAIN, from the National Agricultural Library; ERIC, from the U.S. Office of Education; PANDEX, from CCM Information Sciences, Inc.; and many more.

What has developed over the last few years is a distinct trend away from single-institution proprietorship of these tape data bases and toward a grouping of several data bases in what amount to regional processing centers, supported by NSF grants. These centers are typically located at universities; in some cases, the center reorganizes the multiple data bases into a single new format, in effect permitting driving a search through all files on a single pass. Since search vocabularies differ from service to service, it is clear that search formulation in such cases is not a trivial problem.

Table 1 shows a representative sampling of some of these centers, with some of the data bases held by them.

TABLE 1

REPRESENTATIVE TAPE FILE HOLDINGS OF REPRESENTATIVE INFORMATION CENTERS

Information Centers	Data Bases					
	CA	BA	ERIC	PANDEX	CAIN	ISI
University of California, Los Angeles	X	X	X		X	
University of Georgia	X	X	X		X	
Illinois Institute of Technology Research Institute	X	X				X
Ohio State University	X			X		X

Each of these tape data bases is large; any grouping of them is very large. As a consequence, these centers place most of their emphasis on SDI-type searches, i.e., searches run on a recurring basis, as each new increment of the data base is received, against a user profile, a search formulation embodying a delineation of the client's field of interest. Retrospective searches are possible, and they are performed; in these instances the data base is, so to speak, waiting for the accumulation of enough search formulations to make a batch run economically viable. In SDI searching, on the other hand, the batch of user profiles has already been accumulated, and is just awaiting arrival of the next increment of the data base. It is significant that the association formed by these search centers is called the Association of Scientific Information Dissemination Centers. ASIDIC has about thirty full members, and about a dozen of these offer services to the general public.[8]

There are differing pricing schedules among the various centers, depending on many variables—the number of data bases being searched, subscription fees, number of "hits," changes in profiles, format of output, and others. About $100 per year per SDI search might be a representative cost figure.

DEVELOPMENT OF ON-LINE SYSTEMS

The batch mode of searching tapes in serial order involves delays in delivery of results; it also demands that search strategy be totally foreseen in advance, with no possibility of modification during the course of search. If results are poor, the only remedy is to reformulate and rerun. But if the files are inverted (i.e., citations posted to terms), and if these files are placed in large direct access storage devices, such as disks, then the files can be examined directly and on-line. This mode has not only the advantage of immediacy, but also makes available the ability to modify search strategy in course.[9]

The technological advances which have made on-line searching feasible on a grand scale are: (1) third-generation computers; (2) the advent of very large and fast disk drives such as the IBM 3330, with a capacity of 100 million characters for each drive; (3) the availability of cheap terminals, with hard-copy printout to speeds of thirty characters per second, which now cost about $2,800; and (4) the creation of reliable long-line communication networks with reasonable tariffs.[10] While on-line systems can exist with none of these features, it is true that it is the presence of all of them that makes large networked on-line bibliographic retrieval systems operationally and economically feasible.

Bibliographic Retrieval Services

One of the pioneering on-line retrieval systems was that organized by Irwin Pizer at the SUNY Upstate Medical Center Library in Syracuse. When this system became operational in the fall of 1968 it had nine nodes covering medical libraries from Boston to New York to Rochester. (It now connects twenty-five institutions, reaching as far west as Chicago and Minneapolis.) The system had multiple purposes—union lists of serials and union catalogs of books, interlibrary loan transactions, and other library housekeeping functions. What is of interest in the present context is the fact that the largest component of the SUNY data bases was a five-year file of MEDLARS citations obtained from NLM.[11]

In 1970 NLM began publishing the *Abridged Index Medicus,* which covered 100 high-quality, widely held English-language journals in clinical medicine. Shortly thereafter NLM established an experimental on-line service called AIM-TWX. The data base was a five-year coverage of the AIM journals, comprising about 100,000 citations. The file was stored in a computer at the System Development Corporation in Santa Monica, and used a software package which SDC had developed, called ORBIT. The system was accessed via TWX terminals (10 cps), already available in most large medical libraries as an adjunct to interlibrary loan operations.

In October 1971 NLM brought up the MEDLINE (MEDLARS on-line) system on the NLM computer in Bethesda, Maryland. By February 1972 the system had matured to its full data base consisting of the indexing of 1,200 journals, worldwide in scope, selected from the larger MEDLARS data base, and covering the current year plus the three most recent years; the data base was incremented monthly. At the same time, a long-line communication network was established through rental agreements with the TYMSHARE Corporation, which furnished forty nodes in major metropolitan areas throughout the United States, by which MEDLINE could be accessed through a local telephone call. Originally established in all of the eleven Regional Medical Libraries and MEDLARS centers, MEDLINE quickly spread to medical school and other major medical libraries across the country. By July 1973 there were 163 operational MEDLINE units in the United States in addition to those at NLM, and another ten were about to become operational. In addition, there were ten units in Canada and three in England and France, using the TYMNET node in Paris.

As of September 1973, there were 509,396 citations in MEDLINE, covering indexing from January 1970 through October 1973. The system was available 13 hours a day, 5 days a week—8 hours a day from the NLM computer, and an overlapping 9 hours a day from a duplicate file on a computer at SUNY-Albany. Another file, called COMPFILE, was a complement of MEDLINE, the remainder of the MEDLARS data base. As of September 1973 this file held 336,989 citations, and was available on the NLM computer two days a week. SDILINE was the current month of the entire MEDLARS data base. In September 1973 this increment was 18,765 citations, and was available on both computers; it was available for carrying out current awareness (SDI) searches. BACKFILE, previous years of the MEDLARS data base, was up experimentally (available Saturdays only) for several months in the spring of 1973. It remains to be seen whether this segment will be reinstated when the reworked software package for MEDLINE, a part of the on-going MEDLARS II effort, becomes fully operational by the middle of 1974.

Besides these riches, there were also available on-line from the NLM computer two additional files: SERLINE, a union list of some 5,600 primary substantive serial titles in the life sciences, with holdings information for 100 regional and resource medical libraries; and CATLINE, a file containing full bibliographic data for all items published in the *NLM Current Catalog* from 1965 to the present.

By June 1972, MEDLINE searches were being performed at an *annual* rate of 70,000. In May 1973, 17,024 searches were performed by U.S. MEDLINE centers, for an *annual* rate of more than 200,000 searches. Those 17,000 searches required 3,169 connect hours, or an average of 11.2 minutes per search.

OTHER ON-LINE DATA BASES

The National Aeronautics and Space Administration brought up its RECON network in 1970. Lockheed Missiles and Space Company had brought up some internal data bases onto its DIALOG system (prototype for RECON) in 1967. System Development Corporation's ORBIT was in use at the Department of Defense in 1965. Battelle Columbus Laboratories began operating its BASIS-70 system in 1970 for certain defense-related contractors.

But of more interest to biomedical librarians is what has transpired more recently. Several health and allied sciences data bases are now available on-line via the TYMSHARE network, and are offered by "centers," in this case commercial companies, in a

TABLE 2

REPRESENTATIVE ON-LINE DATA BASES
OF REPRESENTATIVE COMPANY CENTERS

	Data Bases				
Companies	CA Condensates	NTIS (U.S. Govt. R & D Reports)	PANDEX	Psychological Abstracts	CAIN
Lockheed		X	X	X	X
System Development Corp.	X				X
Informatics				X	
Science Information Assn. (via Battelle)	X	X			

manner analogous to the tape data bases offered by the several university centers. Table 2 below may be compared to Table 1.

DATA FROM AN AVERAGE MEDLINE STATION

The MEDLINE station at the University of Colorado Medical Center Library produced 1,237 MEDLINE searches (1,147 one-shot demand searches plus 90 SDI increments) during fiscal 1973, the first complete July through June period in which the full MEDLINE data base was available. If all MEDLINE stations were producing at a similar rate, then the annual production for all domestic MEDLINE stations would be just above the 200,000 figure previously posited.

The 1,147 one-shot searches produced 51,319 citations, an average of 45 citations per search. This may be compared with the average 160 citations produced by a MEDLARS search.

Printouts were performed on-line for 837 searches, off-line for 98 searches, and both on-line and off-line for 212 searches. The total number of searches having some on-line printout component was 1,049, with an average of 18 citations printed on-line. The total number of searches having some off-line printout component was 310, with an average of 105 citations printed off-line. The average number of terminal minutes required per search was 13. The total of connect hours for the year was 272.

The number of MEDLINE searches predicted for fiscal 1974 is 1,620. Adding to this, searches of the CATLINE and SERLINE files will probably raise the total to 2,000 searches. (At Colorado, when a search is pushed through both MEDLINE and COMPFILE data bases, it is counted as one MEDLINE search.) It remains to be seen what effect the imposition of fee-for-service charges will have. At the time of writing, data are too sparse for prediction; for what it is worth, in October 1973 MEDLINE searches were running at the full predicted annual rate.

SOME PROBLEMS

A good summary of some problems is provided by Cuadra.[12] One of these is the question of search vocabulary. Some systems use a controlled vocabulary, as in the familiar MeSH of MEDLINE and of the printed *Index Medicus.* Some systems increasingly lean toward what is called "full text" indexing, a terrible misnomer; what is meant is free indexing on significant words of title and short abstract. It would be nice to have both, and some systems do, but that is costly. There can be no doubt that full text indexing increases the precision of a search—at the expense of recall; but precision alone is easy to achieve, as, for example, in the almost certain way one can find *one* pertinent citation by eye-balling a likely segment of *Index Medicus,* thus achieving 100 percent precision. Free indexing will often adequately serve the client who wants "a few recent references on the relation of X to Y," and that type of client is in the majority; in this kind of situation the on-line data base is simply a much more sophisticated version of the printed KWIC index. But the client who wants an exhaustive search is better served by the system using a controlled vocabulary, which performs much better at the recall end of the spectrum. This type of client may be in the minority, but the ultimate payoff of his search, in terms of social value, may often be quite large. The system used in MEDLINE, requiring first a squeezing down on the pertinent subject area by means of combinations of MeSH terms, and then permitting a title-word search of the citations in the identified area, seems to be a reasonable compromise.

There is also the question of mediation or nonmediation of the search request by reference librarians (search analysts). When searches are being done on tape files, there is an absolute need for mediation; somebody who knows the intricacies of the system must formulate the search request and prepare it in a form acceptable to the computer. It must be asked whether the same conditions apply in on-line searching. In one most obvious way they certainly do not. The ease of operating a terminal in an interactive system is simplicity itself compared to the complex rigamarole required for inputting a search into a tape system. Anyone can learn to operate a terminal, under the general rules of a particular system, in half an hour.

A further consideration is the fact that the average client has a much more profound knowledge and understanding of the subject area he wishes to explore than does any librarian mediator. If the client must express his search request through a mediator, inevitably something is lost in the process; the librarian may not understand fully the real dimensions of the request, or worse, the librarian may unwittingly, in difficult cases, shift the emphasis from the question put by the client to some penumbral question that the system can answer more easily.

These two considerations—ease of terminal operation, and superiority of the client's subject knowledge—have persuaded many designers and proprietors of on-line systems that direct client operation of the terminal, without mediation, is a necessary criterion for any on-line system to be declared successful in operation. To these major considerations other arguments are added: since librarians allow and even urge direct use of the card catalog, why should they not allow and urge direct use of the terminal in an on-line system? Studies are performed which "prove" that such direct use is desirable.[13]

This writer remains profoundly skeptical of the validity of such a position. There are too many inarticulate clients, too many clients with only the vaguest notions of what they are after, too many clients with too much impatience and greater exasperation when confronted with a system conceived as having magical properties, but which cannot respond to "you know what I mean." There is also the fact that a majority of clients prefer not to be involved in the actual searching process, as well as the fact that queuing problems inevitably develop when there is free access to the terminal, and this is accentuated by the slow speeds of search formulation and modification characteristic of persons who, unlike the librarian search-analyst, do not have daily practice and familiarity with the system. Perhaps one-third of the clients will wish to look over the shoulder of the analyst during the course of search, largely because of the novelty factor, and there is nothing wrong with that. But most clients will be content to come back or be called when the search is completed. Many search questions are received by telephone, from various parts of the metropolitan area; as many are mailed, at the request of the client, as are marked "hold for pick-up."

This is not to say that search strategies and performance of all search analysts are automatically optimal. They are not. The worst mistakes are made through impatience, through a desire to get on with it, through a failure to think for a few minutes before sitting down at the terminal and opening the line. Some search analysts sit down, open the line, log into the system, get the indication that a search statement may be entered, and only then turn to the client and ask what it is that he is interested in; the analyst may not know even the client's name, in what department he is working (which is often crucial to success, and which rarely is made explicit without prompting), or at what level he is working (student, resident, technician, chief of division). In such circumstances a successful result is likely to depend on pure luck, on the naiveté of the client, on the simplistic nature of the question, or on all three.

There is also the question of machine capacity. On-line computer systems, just like tape-oriented computer systems, have finite limits; a communications link can cope with just so many messages using a certain band-width. Davis McCarn has addressed some comments to the problems of on-line system performance. He says that "characteristic of all these systems . . . looked at is that they have performance curves that, at some level of usage, curve up sharply toward very slow responses."[14] The greater the number of simultaneous users, the longer the response time interval becomes—the time between inputting a search term and getting the computer to send back a reply.

It is easy to talk about adding complex user-guidance displays, to consider how to allow free-language phrases on input to be mapped automatically into complicated searching strategies, to attach subsidiary files (e.g., CATLINE) to a main file (e.g., MEDLINE), thus bringing a whole new class of users (catalogers) to the system, to develop greater decentralization of the system by adding more and more terminals, or to offer an increasing variety of output formats with citations ordered by complex criteria. And it can all be done, but it is done at a price; there is always a limit, a point at which the average system response time becomes degraded to an unacceptable level. Some human judgments have to be made on how much is enough; the system's clientele will ultimately vote on this with their pocketbooks.

A DAY IN THE LIFE OF A SEARCH-ANALYST

Recently, when the two search-analysts at the University of Colorado Medical Center were absent, I temporarily covered the MEDLINE operation. I have been much involved as a search-analyst in the past and I welcomed the chance to get back into harness, if only for one day. I had hardly cleared my desk when the first client walked in. I was still negotiating his search when the second client walked in. As I handed her a search request form, the telephone rang with a call from a third. In the course of the first two hours I talked with six clients who brought me ten searches.

My first client was a medical student working on a special laboratory investigation in anatomy. He had one question about the passage of a particular enzyme through the blood-brain barrier, especially of rodents; another question involved the choice of suitable media for the culture of ganglionic cells—"just spinal ganglia, not autonomic ganglia." The second walk-in client was a graduate nursing student whose search was to be on psychological and sociological aspects of smoking. She could give no examples of what she meant by sociological and finally left me to do the search on a "best effort" basis—whatever I thought psychological and sociological might signify. It took me at least half an hour to figure out a reasonable skeletal strategy.

The third client came via a telephone call from a doctor's office seven miles across town. The doctor's nurse said a search on "dorsal column electrode implants" was desired. I had never heard the phrase before; the dorsal column tipped me off to what the general area of discourse was, and the nurse verified the fact that the doctor was a neurosurgeon and that the context of the request was the relief of intractable pain.

The fourth client was another walk-in, a student in a course for health administrators. He wanted a search on regional emergency health services. By regional I eventually gathered that he meant citywide, or metropolitan areawide. One word he used two or three times was "categorization"; this later proved to be helpful.

The fifth client, a physician from an independent research hospital only a few blocks away, brought me what could have been considered three searches or five searches; I eventually logged them in as three. She was doing a review article on several drugs. The concepts were not difficult, and translated into easy searches. For the three searches I eventually printed 882 citations off-line.

My sixth client and last two searches come via telephone from the biology department at the main university campus thirty miles away. One question was on olfactory neoplasms and retinoblastoma in humans, and was straightforward. The other question was vast; it concerned carcinogenesis in rodents, either by chemical or viral means, but only in cases of tumors of the nervous system. When I asked this biologist how many articles he thought I might find, he said he could not believe that more than 100 had appeared in the last three years; I eventually delivered ninety-six citations.

I spent the rest of the day completing these ten searches. The time I actually spent at the terminal was 142 minutes; the rest of the time was spent exploring in various tools, and plotting strategy. When I went to the terminal at the end of the day to put in the last search I was worn out, fatigue causing me to make a number of input errors, which then required repeated corrections.

The other analyst and I had put in a total of about 11 man-hours to perform 14 searches for 10 clients. We had retrieved 1,564 citations, of which 347 were printed on-line and the rest off-line. We had spent 220 minutes, just one-third of our time, at the terminal, and the rest of the time in preparation for searching. In this small sample, the average time spent per search was 47 minutes, of which 15.7 minutes was terminal time.

If all other MEDLINE terminals in the United States were used at the same rate on that day, the number of connect hours was 600. The number of CPU hours available was 17; the average load in any hour would therefore be 35 terminals on-line. At peak-load times, the number of terminals on-line at any one time would approach 70; that is close to saturation in the afternoon period when both the NLM computer and the SUNY computer are available.

This case history is presented in the hope that it will illuminate some of the realities of on-line searching and to show that there is a lot going on around those terminals even while they are not turned on.

IMPACT ON LIBRARIES

On-line bibliographic searching is here to stay. In less than a decade of phenomenal development,[15] it has demonstrated its great power and its cost effectiveness when delivered through national networks. One of the supreme merits of on-line bibliographic searching is that it permits very wide dispersion of service centers, thus bringing them closer to clients. And the immediacy of the service offered provides remarkable reinforcement to its impact on all other service aspects.

The increased volume of reference work which this new technology permits and encourages has suddenly leapt forward by a factor of 10. The challenge to effective use that this presents to biomedical librarians will, when met, embrace a whole new dimension of library service.

References

1. Quoted in: Bell, Whitfield J., Jr. "Joseph M. Toner as a Medical Historian," *Bulletin of the History of Medicine,* 47:1-24, Jan.-Feb. 1973.

2. For broader surveys, see for example: Carroll, Kenneth D., ed. *Survey of Scientific-Technical Tape Services.* New York, American Institute of Physics and American Society for Information Science, 1970; and Williams, Martha E., and Stewart, Alan K., eds. *ASIDIC Survey of Information Center Services.* Chicago, IIT Research Institute, June 1972.

3. Austin, Charles J. *MEDLARS 1963-1967.* Bethesda, Md., NLM, 1968; *The Principles of MEDLARS.* Washington, D.C., U.S.G.P.O., 1970; McCarn, Davis B., and Leiter, Joseph. "On-Line Services in Medicine and Beyond," *Science,* 181:318-24, July 27, 1973.

4. Corning, Mary E. "The U.S. National Library of Medicine and International MEDLARS Cooperation," *Information Storage and Retrieval,* 8:255-64, Dec. 1972.

5. Lancaster, F. Wilfrid. *Evaluation of the MEDLARS Demand Search Service.* Washington, D.C., U.S. Dept. of Health, Education, and Welfare, Public Health Service, 1968.

6. Coles, Victor L. "Remote Evaluation of a Remote-Console Information-Retrieval System (NASA/RECON)." In *Interactive Bibliographic Systems; Proceedings of a Forum. . . .* U.S. AEC Office of Information Systems, 1973, pp. 133-42.

7. For a catalog of these, see *CAS Information Services, 1973.* Available from Chemical Abstracts Service, Marketing Department, The Ohio State University, Columbus, Ohio 43210.

8. For a good perspective on the problems faced by these centers, see: Park, Margaret K. "Computer-Based Bibliographic Retrieval Services; The View from the Center," *Special Libraries,* 64:187-92, April 1973.

9. Warheit, I.A. "On-Line Interactive Systems in Libraries, Now and in the Future." *In* F. Wilfrid Lancaster, ed. *Proceedings of the 1972 Clinic on Library Applications of Data Processing; Application of On-Line Computers to Library Problems.* Urbana-Champaign, University of Illinois Graduate School of Library Science, 1972, pp. 3-21.

10. Walker, Donald E., ed. *Interactive Bibliographic Search: The User/Computer Interface.* Montvale, N.J., AFIPS Press, 1971. See especially: Katter, Robert V., and McCarn, Davis B. "AIM-TWX: An Experimental On-Line Bibliographic Retrieval System," pp. 121-41; and Egeland, Janet.

"User-Interaction in the State University of New York (SUNY) Biomedical Communication Network," pp. 105-20. The extensive discussions, pp. 233-311, are rewarding.

11. Pizer, Irwin H. "A Regional Medical Library Network," *Bulletin of the Medical Library Association,* 57:101-15, April 1969.

12. Cuadra, Carlos A. "On-Line Systems: Problems and Pitfalls," *Journal of the American Society for Information Science,* 22:107-14, March-April 1971.

13. See for example: Lancaster, F. Wilfrid. *Evaluation of On-Line Searching in MEDLARS (AIM-TWX) by Biomedical Practitioners* (University of Illinois Graduate School of Library Science Occasional Papers, no. 101). Urbana-Champaign, Feb. 1972.

14. [Remarks in the discussion following the paper of] Coles, *op. cit.,* pp. 143-44.

15. Brodman, Estelle, and Ohta, Miwa. "Medicine," *Library Trends,* 15:896-908, April 1967.