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ABSTRACT

This memorandum is the result of an investigation into the three existing biomedical information services; MEDLARS (Medical Literature Analysis and Retrieval System), the interlibrary loan (ILL) service, and the network of Poison Control Centers. This research is intended to provide an understanding of the structure, quality, and coverage of these services, prior to the conceptualization and design of systems that may provide similar types of information. In addition, an attempt is made to design a computer-based system that could provide the services investigated. This treatment is stylized and functional rather than operational: the primary objective is to determine how the various functions may be automated, rather than to define specific hardware, communications systems, and manpower resources are necessary for implementation. The cost data included are thus superficial and are included only to provide a basis for comparing various means of dissemination. (Author)

MEMORANDUM
RM-6129-NLM
MARCH 1970

BIOMEDICAL INFORMATION DISSEMINATION: ALTERNATIVE SYSTEMS

J. A. Farquhar

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PREFACE

This Memorandum is the result of an investigation into the three existing biomedical information services: MEDLARS (Medical Literature Analysis and Retrieval System), the interlibrary loan (ILL) service, and the network of Poison Control Centers. This research is intended to provide an understanding of the structure, quality, and coverage of these services, prior to the conceptualization and design of systems that may provide similar types of information.

In addition, an attempt is made to design a computer-based system that could provide the services investigated. This treatment is stylized and functional rather than operational: the primary objective is to determine *how* the various functions may be automated, rather than to define what specific hardware, communications systems, and manpower resources are necessary for implementation. The cost data included are thus superficial, as are treatments of consideration external to the design system. Cost figures are included only to provide a basis for comparing various means of dissemination.

SUMMARY

This Memorandum describes three services currently providing information to the biomedical community: MEDLARS, the interlibrary loan service, and the network of Poison Control Centers. Each of these services is discussed in terms of 1) current configuration and capability (Sec. II); 2) current and projected demand (Sec. III); and 3) an automated system that would provide similar services (Sec. IV).

In Sec. V, an approximation is made of the capabilities and costs accruing from three modes of dissemination: a single national center, three regional centers, and seven regional centers. Costs for the single center and three-center systems are quite similar. While the use of a seven-center system represents a considerable increase in cost, it might also offer an increased capability and opportunity for provision of other biomedical information services.

CONTENTS

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I. INTRODUCTION

The body of printed information in medicine as well as in other areas is growing rapidly. One authority states that the world's total information store adds 2.5×10^6 bits (over 400,000 printed characters) per second [1]. Though this approximation is arguable, massive effort must be devoted to the structuring, storage, and dissemination of this information for it to be of use.

Medical information systems must provide an effective solution to this dilemma. In perhaps no other field is information dissemination so critical. However, it seems that in medicine the information explosion has been unchecked, even though the information problem within medical specialties may affect, at its extreme, a "life or death" situation.

Investigation of the information needs and resources of the biomedical community has shown that structured sources of such information are scarce and widely scattered. Moreover, sources that do exist do not appear to be utilized to the extent that might be expected or desired. With the possible exception of the National Library of Medicine (NLM), no institution, foundation, or other agency serves as a central source for collection, coordination, and dissemination of biomedical information. The researcher or physician must, therefore, elicit required facts from a paucity of formal systems and a multiplicity of informal sources; though assessing the consequences of this is difficult (in lost time, incorrect information, mistaken diagnoses), one may safely assume that the degradative effect on medical service is large indeed.

This Memorandum describes the three major formalized services available to the biomedical community. The following discussions postulate possible configurations that might better meet biomedical information needs, as demonstrated by

response to other services. The configurations presented are not wholly intended as recommendations for specific action; rather, they are hypothesized as possible nodes for inclusion within the Biomedical Communications Network. In addition, they suggest that medical information should be reposited and retrieved, whenever possible, in a highly centralized information base. Such a configuration should eliminate much of the guesswork involved in eliciting medical information, and should provide a number of dependable and standardized sources for the exclusive use of the biomedical community.

II. EXISTING BIOMEDICAL INFORMATION SERVICES

Though many other means of disseminating similar information exist, the three services described below are the most widely used; the nature of the information they disseminate varies greatly. The Poison Control Centers, for example, dispense a relatively small volume of information; yet the rapidity with which such information is delivered is most critical. The opposite is true of the interlibrary loan (ILL); it handles an extremely large volume of information, and the dissemination involved proceeds at a more leisurely pace. Thus, any central service capable of handling the three functions described should be well equipped to dispatch a broad spectrum of related services with ease.

MEDLARS (Medical Literature Analysis and Retrieval System)

MEDLARS, implemented in January 1964, serves as the computer-based "central librarian" in the National Library of Medicine (NLM). Its function may be split, for descriptive purposes, into two general areas. The first area involves the publication of approximately sixteen recurring bibliographies, indexes, and catalogs, extracted at regular intervals from the MEDLARS data base. Typical of these documents, and most notable, is *Index Medicus* [2]. All recurring documents published through MEDLARS are composed by computer-driven photocomposition equipment. This hardware, GRACE (Graphic Arts Composing Equipment), produces negatives for printing by photo-offset.

The second function of MEDLARS is the production of demand-search bibliographies. These are created in response to requests by biomedical personnel for pertinent references to a particular medical topic. Requests for MEDLARS' services are made to one of six regional centers within the continental United States. Each center interfaces only with the "customer" and the NLM. The centers perform the following functions in the demand-bibliography procedure:

1) They receive search requests from interested parties (anyone having a pertinent requirement for medical information);
2) They formulate search requests into search parameters for processing by NLM;
3) They prepare the formulated search requests in punched card form and forward to NLM;
4) They receive the completed bibliographies from NLM and disseminate them to requesters.

In some cases, the regional centers also perform the MEDLARS search.

All communication with NLM concerning routine search formulations and bibliographies is done by mail. A teletype link between NLM and its regional centers is used when a center becomes overloaded with search requests. Should this occur, the concerned center forwards its surplus search requests (unformulated) to NLM, which subsequently distributes them via TWX to less busy centers.

The MEDLARS data base, approximately 750,000 bibliographic citations of medical literature in June 1968 [3], exists currently on magnetic tape. These citations refer to and are indexed from 2400 biomedical periodicals. All citations in the MEDLARS file refer to articles published subsequent to mid-1963. The MEDLARS file is accumulating new citations, in an apparently linear fashion, at the rate of 200,000 per year. Approximately 45 percent of the extant citations reference non-English-language papers.

INTERLIBRARY LOAN

Interlibrary loans, transmissions of printed information between libraries, are initiated in response to a user request for an article, journal, or monograph not held by the library in question. The 1964 volume of such loans has been estimated to include over 500,000 entries; the predicted

1965 volume has been estimated at close to one million [4]. Because of the UCLA figures enumerated below, accepting this projection is difficult. A more reasonable approximation would show the volume of biomedical interlibrary loans currently approaching one million annually. The work cited above [4] further states that (in 1964) "Current signs of strain indicate that the system, as presently operated and financed, has reached its maximal capacity to meet the demand for interlibrary loans and is critically unstable."†

Although this declaration might have been somewhat premature, it does seem to be an adequate characterization of the interlibrary loan service. The ILL mechanism forces a hardship both on the requester, who must generally wait an extended period of time (estimated to average between three and fourteen days) for his information, and on the better biomedical libraries, which of necessity must satisfy the majority of requests. Moreover, it is expensive: The cost of biomedical interlibrary loans has been estimated at around $2,000,000 for 1964. This figure is based on the volume previously mentioned, and on an average cost of $2.00 to lend a document and $2.00 to borrow it, creating a total unit loan cost of $4.00.

A subjective picture of the interlibrary loan can be gained from a discussion of the UCLA Biomedical Library. In the calendar year 1967, UCLA received 19,271 loan requests from other libraries. Of these, 16,370 (85 percent) were filled. The remaining requests were not filled for the following reasons:

1) 1400--requested material not in library.
2) 292--incorrect citation or reference.
3) 375--noncirculating book or journal. All journals printed after 1960 are considered noncirculating. A request falling into this category indicates that the requester is not willing to pay for photocopy.

4) 150--lost, stolen, or otherwise missing.

5) 684--other reasons; e.g., duplication of earlier request, request for copy of more than 20 pages, specific issue of journal not received, noncirculating rare book.

Of the requests filled, 5402 were for hard-bound material: books or bound journals dating prior to 1960. The remaining requests were filled by reproducing the requested material. Such reproduction is billed to the requester at the rate of 15 cents per page. Diverse rate schedules and sources of funding must be considered: reproductions made for other state institutions are free, paid for by state money. The regional medical program absorbs the cost of some service. Other libraries vary as widely in their sources. The NLM, however, is bound by law to offer this service free.

In the same year (1967), UCLA initiated requests for only 488 documents. These needs were met by the following sources:

University of California, Berkeley	34%
Library of Congress	11%
National Library of Medicine	41%
Other	14%

The interlibrary loan requests place little strain on UCLA; probably less than 10 percent of human and material resources are used to meet these demands.† The real strain of interlibrary loan is placed on the requester, who must wait what seems an untoward amount of time for the information he needs. Fortunately, the libraries supporting the heaviest demand for loans seem most capable of bearing it.

†This estimate and the above figures were supplied by Nelson Gilman, Assistant Biomedical Librarian, UCLA.

THE POISON CONTROL CENTERS

Approximately 558 Poison Control Centers currently exist. One should note immediately that this appellation is misleading: in nearly all cases, the centers serve only passively by providing poison information. Any hospital or professional organization may establish a center; therefore, the centers vary greatly in size and affiliation--from the Los Angeles Center, which employs a full-time staff of five at Childrens Hospital, to the L & K Professional Pharmacy in Aurora, Colorado. The areas of responsibility also vary; e.g., over 100 of the 558 centers are in Illinois.

Each center maintains information, on 5 × 8 cards, concerning approximately 20,000 toxic household products, agricultural chemicals, and flora. The centers combined receive over 200,000 calls annually, with the greatest burden concentrated in the large metropolitan areas. A majority of the calls received are from professional personnel; most centers will not accept calls from the general public, as the legal implications are immense and still must be clearly defined. Some centers, however, are more than happy to dispense advice at this level: telephone directories in Philadelphia, New York, and Washington, D.C. have Poison Control Center numbers prominently displayed on the first page. Understandably, though perhaps lamentably, no two Poison Control Centers are similar. This disparity results primarily from the absence of: 1) any genuine central authority to define the role; 2) demographic coverage; and 3) responsibility of the various centers. The National Clearinghouse for Poison Control Centers, located in Alexandria, Virginia, oversees the Poison Control Centers, to the extent indicated above. The Clearinghouse, which was established originally under the aegis of the Public Health Service, is now an agent of the Food and Drug Administration and is responsible only for providing poison information (on the aforementioned 5 × 8 cards) to any

center that requests it. They are also charged with extracting from manufacturers the chemical makeup of the various toxic household products (estimated as some 250,000 in number) and disseminating that information to the centers. The Clearinghouse distributes a "standard file" of about 3000 cards; in addition, it maintains a secondary file of 45,000 cards, carrying information that is too specialized to file with each individual center. Any center unable to satisfy a request from its own file can call the National Clearinghouse to gain additional information. Should this fail, a call may be placed to a manufacturer, as detailed below.

The Los Angeles Center is considered by many to be the best in the country. This status has been achieved, in part, because the center is privately endowed, operating on an annual budget of fifty to sixty thousand dollars. A more important reason for the Los Angeles Center's quality is perhaps its ingenious and dynamic staff, headed by Mrs. Claire Barton, R.N.

The center, located in Childrens Hospital, maintains information on over 60,000 toxic products, well in excess of the usual amount of data held by a Poison Control Center. The information is stored on Visirecord cards, making any item easily accessible in seconds. This system seems the exception rather than the rule among Poison Centers: some must store their information in shoe boxes, using highly questionable and inefficient filing and indexing systems. The Los Angeles Center operates, with a staff of five nurses and two rotating resident physicians, twenty-four hours a day and seven days a week. This again is an exception: many centers are not sufficiently funded to operate continuously.

For more difficult calls, the Los Angeles Center has available approximately twenty consultant toxicologists, botanists, chemists, cosmetologists, herpetologists, and

pharmacologists. When this source is unable to fill a need, collect calls are placed to the manufacturer of the toxic product. Manufacturers are apparently most willing to assist and are concerned about possible overdoses of their products. The larger pharmaceutical manufacturers, which all publish handbooks containing overdose remediation for their products, have medical personnel on call at all hours to discuss problems.

III. THE CURRENT AND PROJECTED DEMAND FOR MEDICAL INFORMATION

In view of the many circuitous routes already used by the biomedical community for information gathering, the projected demand for any newly structured service must be considered highly tenuous. The difficulty in projecting is also complicated by the belief that the quality of service offered will markedly affect the demand. Since all services included herein should be, to some degree, improved by that inclusion, one cannot easily derive the volume of expected requests from existing statistics.

Nevertheless, some gross demand estimates based on existing data can be made; these are advanced below.

MEDLARS

MEDLARS' demand seems most unstable. Its usage is rather low compared to the number of biomedical personnel. In the first quarter of fiscal year 1968, MEDLARS performed 1700 bibliographic searches [5]. Research personnel appear to use MEDLARS almost exclusively. Should its user community be expanded (due to some change in the nature or rapidity of the service provided), MEDLARS' demand might be expected to increase spectacularly.

For the purposes of this Memorandum, however, demand for bibliographic searches will exhibit linear increase, which one might postulate to be of a magnitude of about 14 percent per year. This figure is similar to that stated by Orr and Pings [4] as characterizing the rate of increase of medical information.

Several caveats should accompany this projection. Although the number of physicians remains relatively constant, the boundaries of medical research are expanding rapidly; medicine now includes legitimately many aspects of chemistry, physics, and engineering, which a few years ago were not

within its purview. Hence, though the "classic" medical-user group and related body of knowledge do not exhibit a rapid growth rate, these annexation processes may cause a great increase in the growth of both the MEDLARS file and the user set.

INTERLIBRARY LOAN

The prediction of interlibrary loan volume is considerably simpler than the previous speculation. This service, unlike MEDLARS, has existed in various forms for some time; hence it has achieved an approximation of "steady state." In addition, some speculation and analysis have been undertaken by other parties.

Orr and Pings arrive at what seems to be a rather reliable characterization of interlibrary loan volume [4], despite an absence of definitive and comprehensive data. They accomplish this by scrutinizing the data on NLM loans, coupled with arriving (through questionnaire analysis) at a ratio of NLM loans to loans from other biomedical institutions. The authors display two curves as the result of their analysis (Fig. 1). The upper curve represents the estimated volume if NLM loans comprise 15 percent of total flow. The lower line is based upon the hypothesis that NLM loans are increasing more rapidly than the overall volume (as they appear to be). Figure 2 represents the extension of this approximation using the same rationale. This characterization is considered adequate for the purposes of this study.

Note again that interlibrary loan is a relatively slow service. Similarly, the impact on the curves depicted in Fig. 2 is difficult to envision if either of the following should occur:

1) A radical change in the pricing structure (primarily, cost of reproduction);
2) A similar alteration in the "turnaround" time, or time delay from request to receipt.

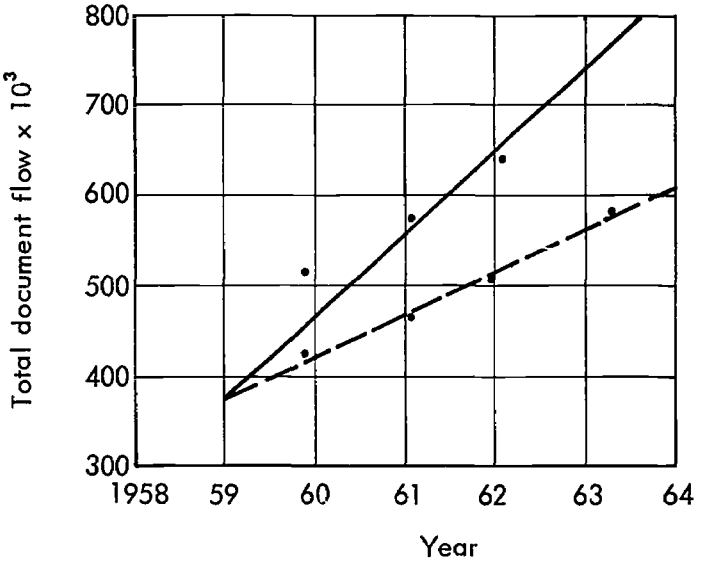

Fig. 1--Biomedical Interlibrary Loans 1959-1963

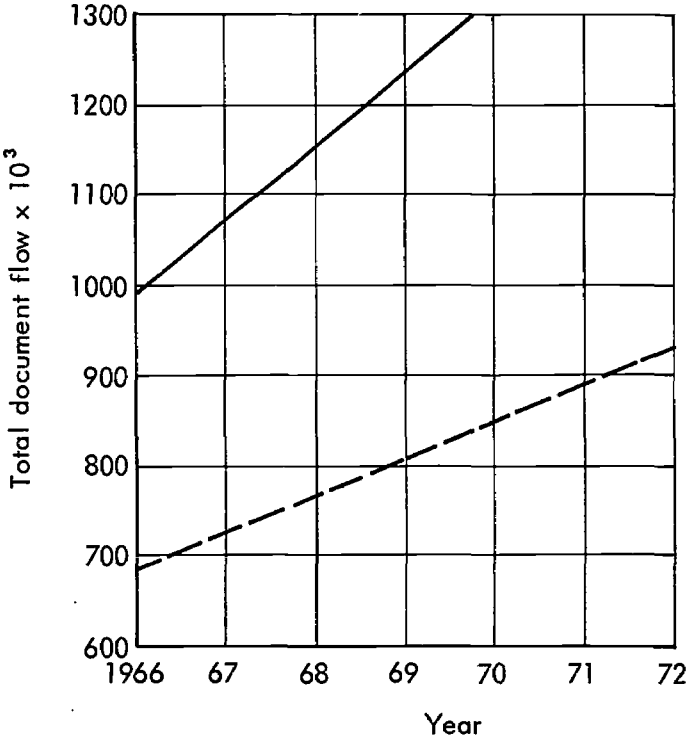

Fig. 2--Biomedical Interlibrary Loans 1966-1970

POISON CONTROL INFORMATION

A demand analysis of poison information may be based on one of two groups of statistics:

1) Data on the number of poison ingestions within the United States;
2) Data on the number of calls placed to various Poison Control Centers.

Some evidence exists to indicate that calculations based upon the latter statistics will give a truer picture of expected demand upon any poison information system. One source states that "In reviewing the PCC [Poison Control Center] data, it was evident that much ingestion by children was reported but little in adults" [6]. This assumption seems reasonable, since much adult ingestion of toxic products is voluntary, and usually confined to overdoses of rather well-known agents. Children, however, are prone to swallow the toxic esoterica, which demand a request for additional information. These requests are usually directed to a Poison Control Center.

The second statistical base, the number of calls received, seems more feasible for demand prediction since it represents demand for a similar service. However, reconciling the volume differences among centers is difficult. The Los Angeles Center now receives about 24,000 calls per year, 80 percent of which originate within Los Angeles County [7]. This represents about 2.7 calls per thousand population per year against the U.S. average of one call per thousand calculated from Clearinghouse figures [8]. That Los Angeles County has 2.7 times as many poisonings as the rest of the nation seems highly unlikely. A more plausible answer may lie in the widely known efficiency and ability of the Los Angeles Center personnel, as well as their aggressiveness in making the service known. The 2.7 calls per thousand figure would probably typify the demand for a national service, were it made as effective and as well publicized

as that offered by the Los Angeles Center. Thus, annual demand on an effective Poison Information Service may be expected to approximate

(population in thousands) × 2.7

or about 540,000 calls per year.

Seasonal Variation

Though thorough statistics are unavailable, marked seasonal variations in poison information demand do not seem to exist. Figure 3 shows the 1967 and the 1968 fluctuation for the Los Angeles Centers. Only the "first quarter" national figures are inconsistent with the demand pattern depicted for Los Angeles County. This might result because children tend to play inside during this quarter due to unfavorable weather. This constraint, however, is not particularly common to the Los Angeles area. It seems acceptable nationally, moreover, that the summer quarter (July-September) will show some increase in reported ingestions because of the school recess and the increased use of pesticides.

Variation with Time of Day

The curve depicted in Fig. 4 represents the only data available on this subject. Its national applicability seems believable since the major variations in the graph can be explained: one such explanation might note that peaks occur at those hours when parents tending children are most occupied with other matters, such as preparing meals or readying other children for bed. The demand peaks are explained plausibly by the director of the Los Angeles Poison Control Center as also corresponding closely to those hours when children are most hungry [9].

Therefore, the peak demand for poison information will probably occur in the late morning hours of the summer months.

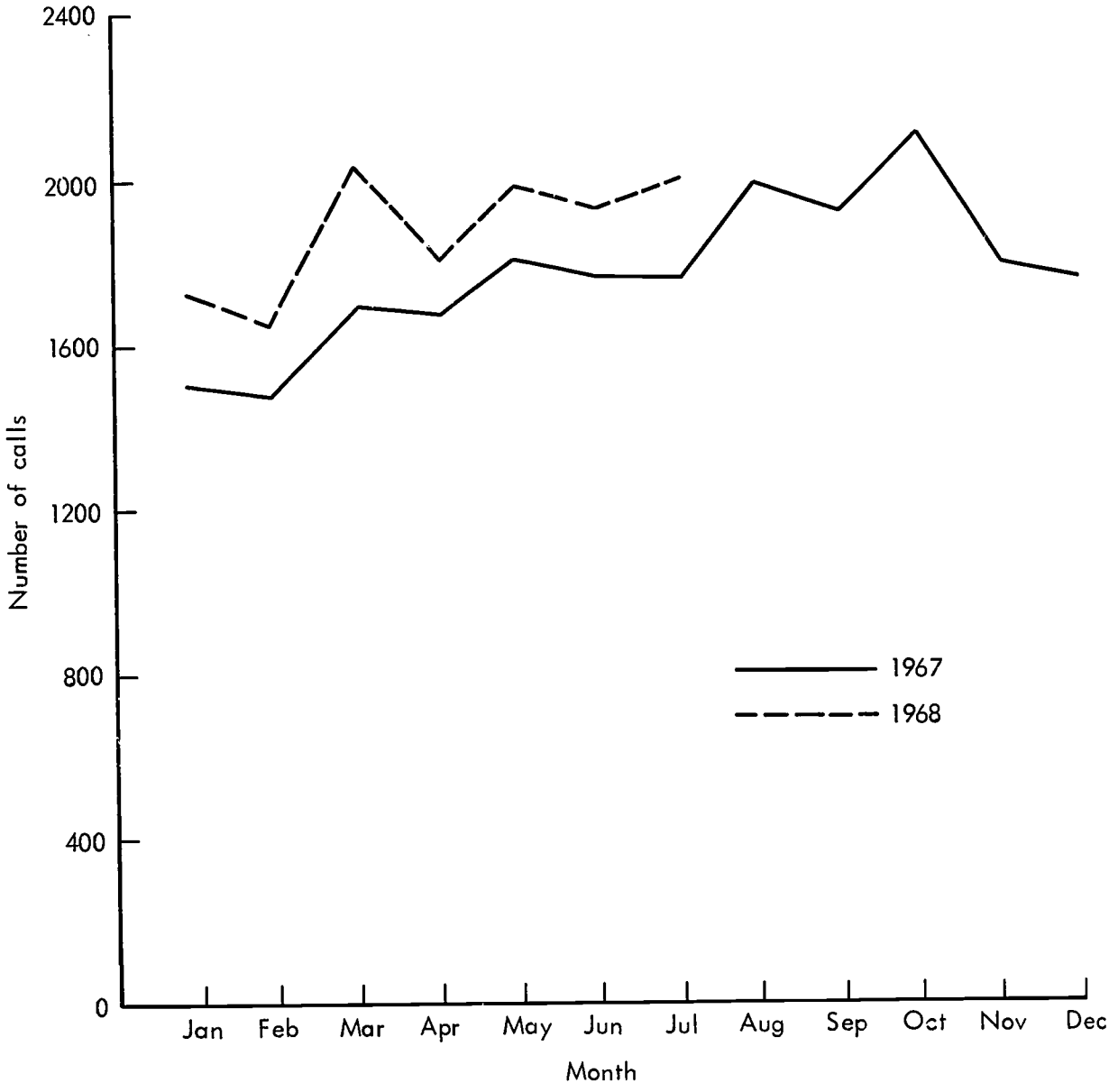

Fig. 3--Calls per Month: 1967, 1968 Los Angeles Poison Control Center

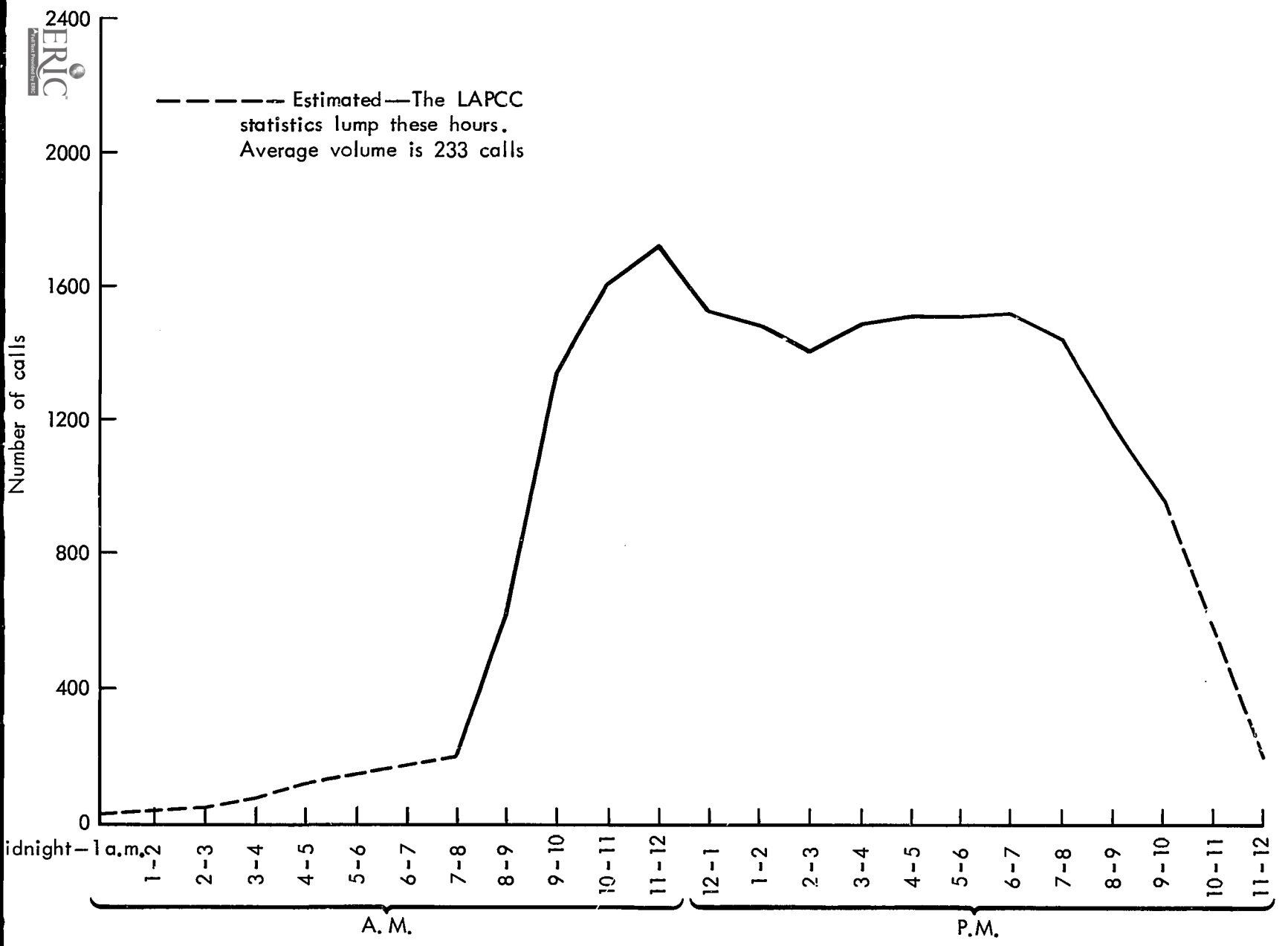

Fig. 4--Calls per Hourly Interval: Total 1967 Los Angeles Poison Control Center

The extrapolation of the Los Angeles Center data prescribes a mean demand for these peak hours of approximately 144 calls per hour.

IV. AUTOMATION OF SERVICES

An alternate system is the automation of present services. This system would provide the three services previously described, at the stated demand levels; and would be a "short-term alternative," i.e.:

1) It could be implemented at a cost less than or similar to that of the current system;
2) It utilizes existing and well-proven technology;
3) It provides those services included with some measurable increase in quality and effectiveness.

No attempt is made in this system to alter the service as it appears to the user. Thus, the physician must still telephone for poison information, and contact a library to receive a loan. This is done partly because of the large expense involved in the methods of communication, but primarily because experience has shown that a massive acclimation and re-education effort must accompany any radical restructuring of services to insure their usefulness.

MEDLARS

MEDLARS' internal as well as external operations would probably remain much the same. The data collection scheme mentioned above might also be used to record MEDLARS requests, though the received requests would not be used as immediate input to any computer program; they would be forwarded to search analysts for formulation into MEDLARS search parameters. The computer is beneficial, if only for rather trivial record keeping, since it structures procedure for a smooth transition to a fully automated system, should it become feasible.

INTERLIBRARY LOAN

When confronted by a system that "has reached its maximal capacity . . . and is critically unstable,"† one faces the choice of either reinforcing that system, or totally eliminating and replacing it. The second alternative is recommended in this case, for the following reasons:

1) The current system is rather slow and will continue to be so, barring massive infusion of new money;
2) It may be argued that the function of interlibrary loan is not really a responsibility of the medical library, and merely constitutes an aggravation of it;
3) The current service is much more expensive than it might be were it handled by an organization specifically designed for that purpose;
4) When MEDLARS and other bibliographic services attain an accuracy and specificity currently impossible, a direct link between these services and the interlibrary loan can drastically reduce the elapsed time of the medical information "loop."

In the configuration described for poison information, the user (clinician or researcher) telephones his inquiry to a regional information center. An operator formats the user's query for machine ingestion, receives an answer, and gives it verbally to the user. When the user wishes to receive a particular *document*, the system action would be essentially the same, though the input media would be directed through a library as a written rather than a spoken request. The request would inform the center of the title,

†Ref. 4, p. 45.

the author, and the location of the document, and would in turn be keypunched, toward initiating mechanized retrieval. Also entered would be the name and address of the requesting physician. The punched information would be transmitted through the computer to an attached storage device, which could be either serial (tape) or random access (disk).

When the requests for time-critical information fall to a certain level, a "background" program (should all services be provided by a single machine) would begin processing the ILL requests. This program would first sort all requests in the following sequence:

Major -- Journal Name
Minor -- Journal Date

Next, the program would process the sorted requests against the MEDLARS file, or an abstract of it. From this file, the number of pages in the article would be extracted as well as certain keying information for the devices that produce the hard copy of the required documents. The outputs of this processing phase would be:

1) A machine-printed bill (calculated from the number of pages to be reproduced), containing the name of the article, the price, and the requester's name and address. This address would also be printed on a detachable gummed address label, which would be removed from the bill later.
2) A magnetic tape containing the indexing information. This tape is used in keying the reproducing devices.
3) A "schedule" of the reproduction process to aid the operators of devices.

The magnetic tape used to key the reproducing devices is then rewound. Figure 5 illustrates the system's operation, to this point. The Houston-Fearless (H-F) CARD system will be the output medium to allow the making of a later cost-estimate, and to allow further definition of the capabilities

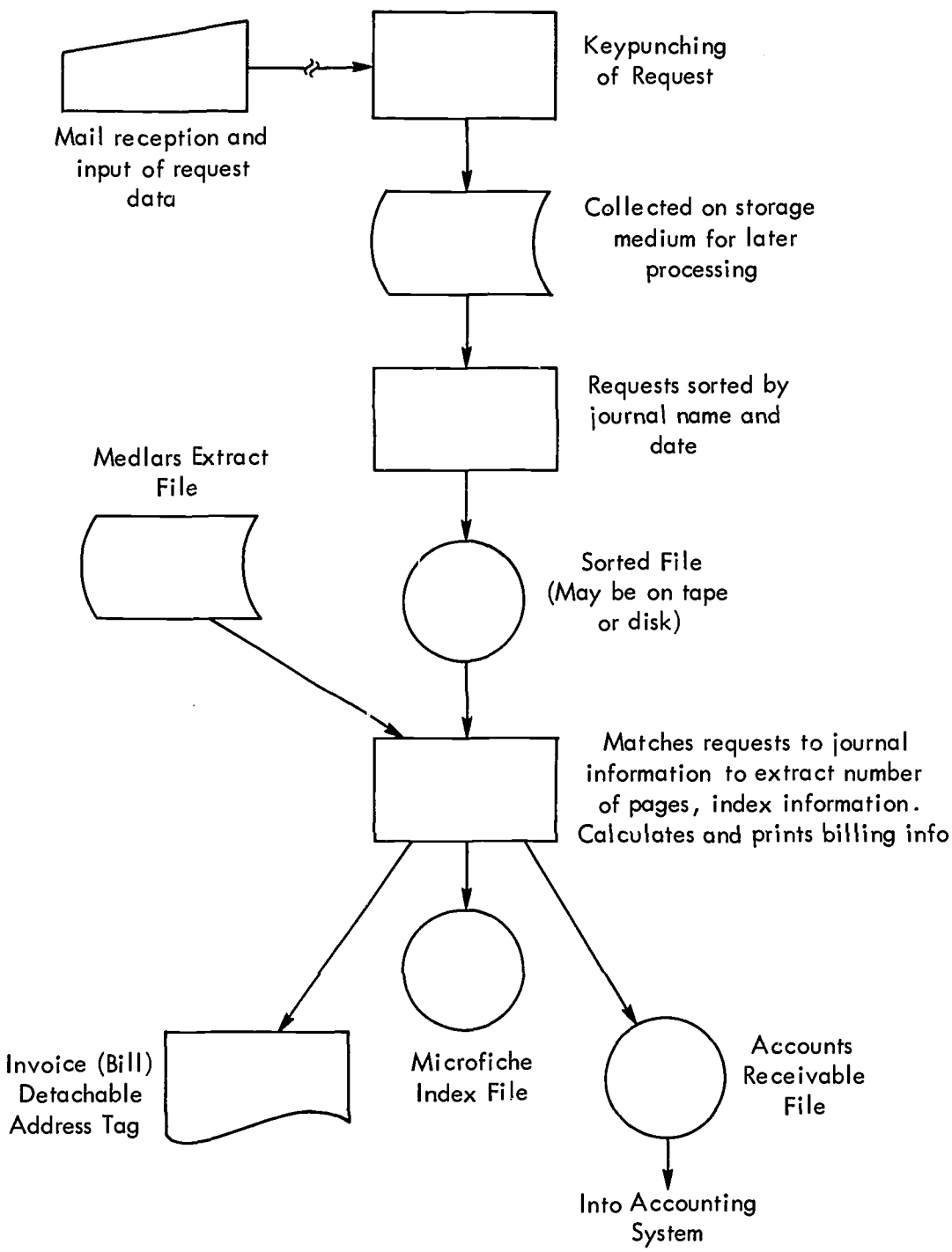

Fig. 5--Document Loan System--Part 1
Processing of Loan Request

and limitations of such a system. This is a computer-actuated microfiche retrieval system that allows computer access to any of 75,000 images within four seconds. The microfiches are stored on a carousel about twelve inches in diameter, and the carousels on a given machine may be changed within a matter of seconds. The computer transmits an index number (earlier retrieved from the MEDLARS File) to the device; the particular fiche and image are displayed and an attached reproduction device makes a hard copy. With appropriate file organization to insure minimization of access time, the average time for retrieval and printing should be approximately nine seconds per page. Figure 6 shows a schematic of this portion of the inter-library loan.

POISON INFORMATION SERVICE

Automation of the poison information service, though difficult and time-consuming, would be a relatively straightforward task. The inputs to such a system are known and finite: when someone has ingested a toxic product, the treating physician is generally able to supply a brand name or the actual name of the compound. If this is not known, symptoms and a partial hypothesis may be supplied. This input structure makes the problem of indexing rather trivial, in the case of the first two inputs. In the case of the third--symptoms--the indexing task is decidedly non-trivial. As this is not formally (or actually, in most cases) a function of the Poison Control Centers now, inclusion of any services beyond recommendations of the most basic type seems unnecessary.

Initial input to the system is made when a physician calls the Poison Information Center. Although various schemes could be used to handle such calls, this study suggests that they be received by telephone operators having access to a central computer through remote consoles.

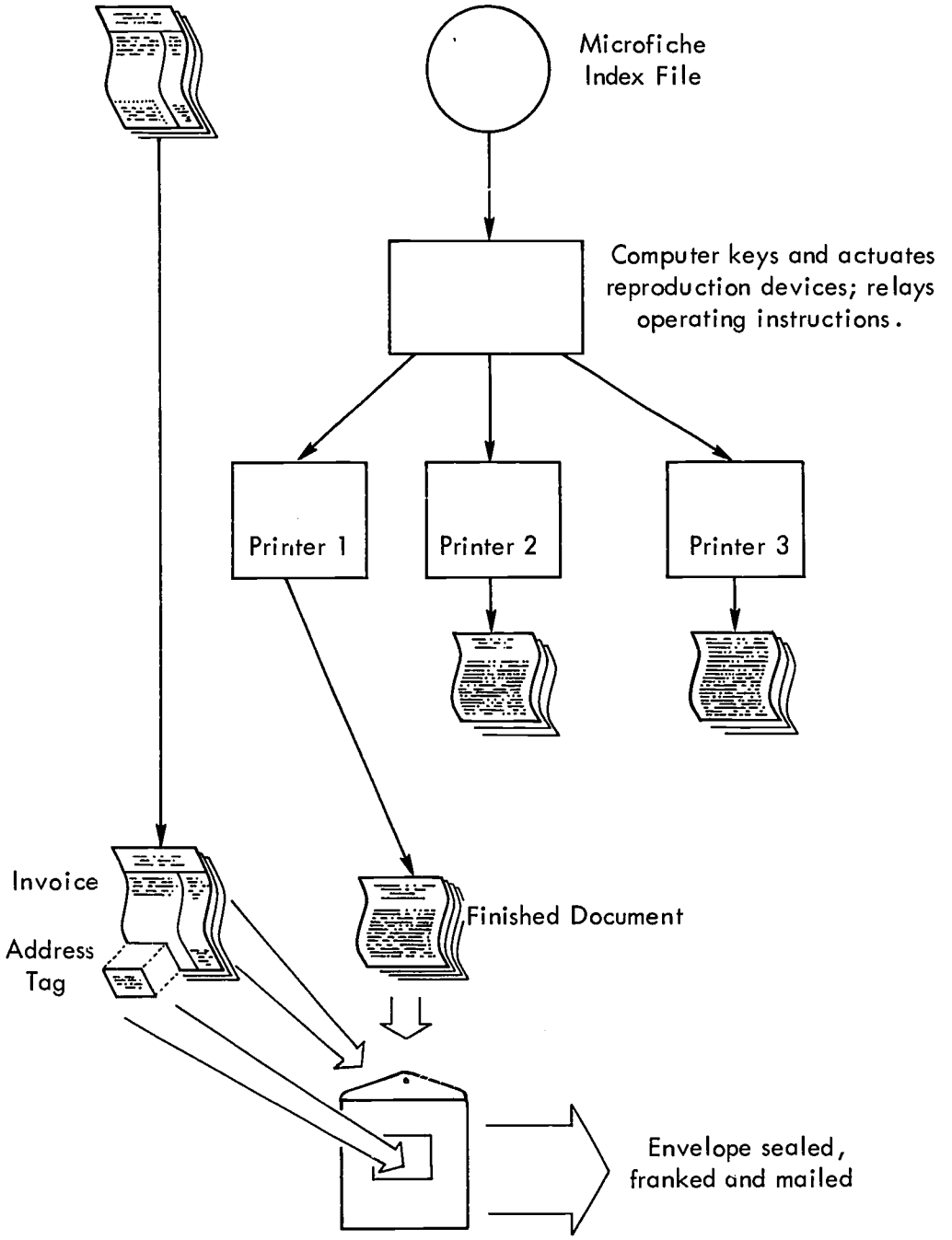

Fig. 6--Document Loan System--Parts Production and Mailing of Finished Documents

In turn, the console operator would request the desired information by keying the brand name, chemical name, or common name of the toxic product into the computer. When no information is available or when the ingested product is an unknown (e.g., small green berries), the physician concerned could be given the names and telephone numbers of the nearest competent specialists immediately by inputting his zipcode and problem code. This is a relatively simple matter for the computer, assuming a reasonable number of consulting specialists exist (under 1000).

Output of such a system would be a two-hundred-word abstract (maximum) on the symptoms, treatment, and side-effects of such poison as was ingested. This abstract, or the most pertinent segments of it, would be relayed by telephone to the requesting physician.

V. HYPOTHETICAL CONFIGURATIONS

The following are actual configurations that may provide the services described. Discussion of three alternative systems will offer a basic appreciation of the costs and benefits accruing from various types of service. In the cases described, International Business Machines and Houston-Fearless hardware are used as examples.†

Appendices A through C (p. 37 ff.) provide approximate cost data on the systems described. They include data only on the operating costs of such centers as are discussed below. No attempt is made to estimate the true expense involved in facility rental, maintenance, or personnel as this will vary widely depending upon the location and the affiliation of the facility. The cost picture, a *comparative* measure, is included only to indicate grossly the financial benefits of centralization and decentralization.

No costs are given for software production, maintenance, or implementation. Production costs should be similar regardless of the number of centers employed. Maintenance and implementation costs will reflect the number of centers, in that personnel will be required at each location for monitoring and implementation. In any event, software costs will be substantial. The cost of software preparation often equals hardware rental expense [10]; software maintenance may exceed the preparation cost [11].

SINGLE NATIONAL CENTER

The single hardware configuration shown in Fig. 7 is considered capable of providing the poison information

†No implication is intended that these manufacturers provide unique or superior equipment. Their products are described only because such hardware is familiar to the author, and because cost data are close at hand.

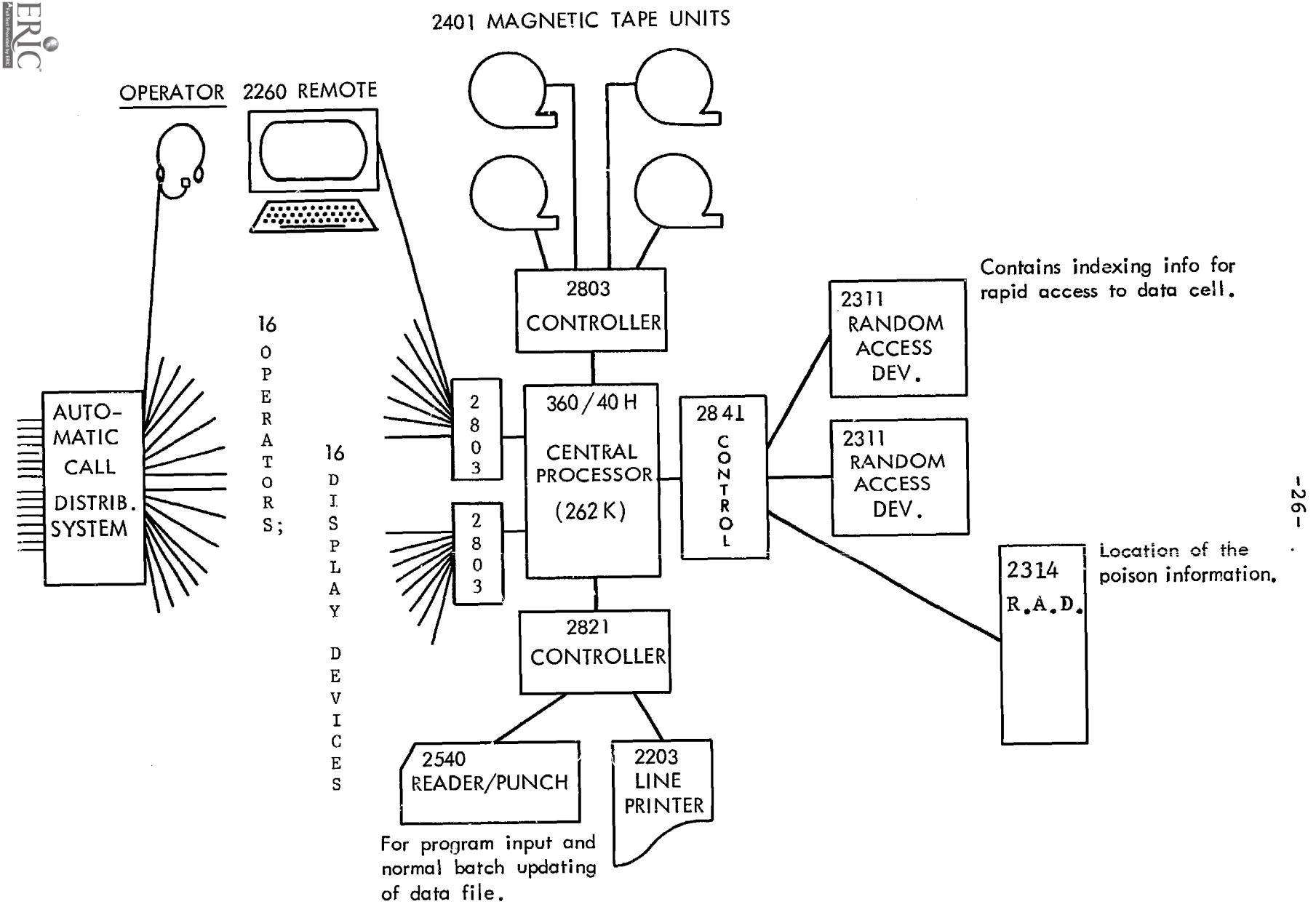

Fig. 7--Proposed Configuration--Poison Information Center

service described in Sec. III. It consists of an IBM 360/40 Data Processing System to be used as an on-line information repository. A 360/50, similar to that now used by MEDLARS, handles bibliographic searches and automated document retrieval and reproductions.

Poison Information Service

Telephone service to the Poison Information Center may best be provided through a system known as INWATS [12]. This system allows any individual to direct-dial a toll-free call to a select number. The area code "800" denotes this service and all numbers connected with it. The subscriber using INWATS may select any number of "lines" for reception of inquiries. These lines are designated as "Zone" 1 through 6, depending upon the reach of their coverage; they are priced accordingly. Thus, national service from a single point may utilize a mixed grade of INWATS lines, according to population distribution around that point. Appendix A (p. 37) describes the combination chosen for a center in Washington, D.C., and the attendant cost. Charges for INWATS service are a flat fee per line, regardless of the volume of calls received.

Observation of the Los Angeles Poison Control Center's operations showed that no call was longer than two minutes. Retrieving information with the computer should not affect this appreciably; therefore, three minutes per call might be a realistic yet safe estimate. Standard queueing tables [13] indicate that in such a situation fourteen stations are needed to handle 95 percent of the calls without delay. Thus, each "prime" shift (8:00 a.m. - 4:00 p.m. and 4:00 p.m. - midnight) will require a total of 98 (14 × 7) operator-shifts per week. A doubling of this yields 196 operator-shifts, to which must be added the six operators required for the midnight to 8:00 a.m. shift, yielding a final total of 240 man-shifts per week.

The critical nature of poison information demands a high reliability. The telephone system can be reasonably expected to meet these standards. This is not necessarily so, however, for the computer. The main frame and most peripherals are reasonably reliable, but the heart of the system--the data cell--is not. It needs much preventive maintenance to remain in operating order. For this reason, having an identical system as backup to the single configuration is most advantageous. This extra machine would allow the preventive maintenance necessary to the successful and reliable operation of the Poison Information Center. In addition, it would furnish a substitute when the primary system failed to function.

Document Retrieval and Reproduction

The ILL portion of the system might receive input in one of three ways:

1) Telephone operators could take calls, much the same as with poison information. Such a capability, however, would require hundreds of telephone operators--an expensive commodity.
2) An alternative system might use a tape recording of the telephone request for subsequent keypunching. The possibility, however, of receiving garbled, insufficient, and unintelligible information makes the efficiency of this alternative questionable.
3) The third alternative is the reception and keypunching of written requests, either from individual physicians or from libraries. These would be keypunched easily, and the use of a standard form (as in MEDLARS) would help to insure that all information is present and correct.

In keeping with the stated desire to maintain the external appearance of the current system, the third approach seems most feasible.

Since the annual estimated volume of requests is approximately one million, a maximum daily figure of 5000 requests does not appear unreasonable. This estimate accounts for most ILL requests being received during the nine-month academic year. Since punching is from a standard form, each keypunch operator might be expected to process about 100 requests per hour. Thus, eight keypunch-shifts should be more than sufficient to provide all necessary service.

Each H-F CARD system is capable of producing one page of hard copy every eight seconds. A survey and sampling of 1000 *Index Medicus* articles reveals that the mean article length is slightly over seven pages. The stated demand thus requires the production of approximately 40,000 pages per day. Assuming that each CARD system will operate 18 hours per day, calculations show that six such systems will handle the necessary demand.

THREE REGIONAL CENTERS

A logical alternative to the single center described above is a system of three regional centers, located in and serving the areas depicted in Fig. 8. As illustrated in Appendix B (p. 40), the triple-center complex requires a hardware, staffing, and communications expenditure only slightly greater than the single center because the reduced demand per center allows *all the functions described in Sec. IV* to be performed by a single computer. In addition, a full backup configuration is not necessary since a malfunction will divert calls to the other two centers.

SEVEN REGIONAL CENTERS

Another conceivable configuration for providing biomedical information services is the system of seven regional

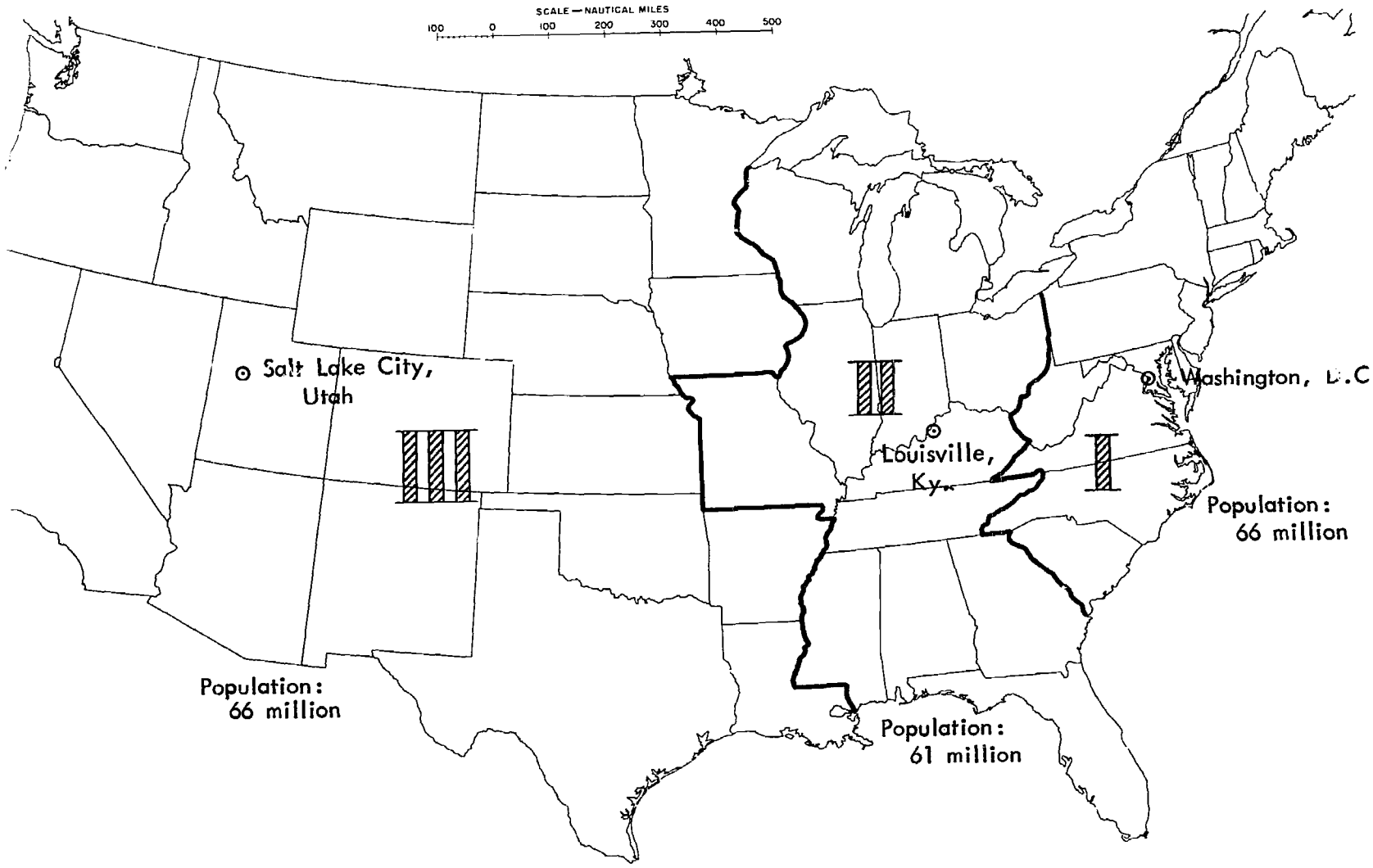

Fig. 8--Geographical Divisions: Three Center System

centers detailed in Fig. 9. The primary object in defining regional boundaries is to insure equal population distribution. This is done because the critical load placed on the computer will come from requests for poison information: the demand for such information seems general population-dependent, rather than physician population-dependent. Since this is not true of such services as MEDLARS and ILL, the hardware associated with these two services should probably vary according to physician population within the particular region.

Hardware and associated costs are detailed in Appendix C (p. 42). Note that unlike the single center, the seven-center system may have all services provided by a single computer. In addition, the seven-center structure offers a more efficient remedy for the reliability problem; i.e., a malfunction in one center can be programmed to transfer demand to another or to several others. Center locations are based on: 1) minimizing communications costs, and 2) having educated work forces available. In addition, each hypothetical location already boasts a medical school and a relatively large biomedical population.

Appendix C (p. 42) shows that the seven-center system is much more expensive than either the single center or the three-center complex. When one considers only present needs, services, and expenses, the system is in no way cost-effective. The plan for seven centers is included, however, because it offers certain unique, and mainly subjective, advantages, particularly when considered from a standpoint of long-term possibilities.

Many services not currently offered to the biomedical community may become feasible under the regional plan described. Each regional center could well become, in the long term, the genuine focal point within each region. Biomedical personnel may look to these centers in the future for all facets of information and educational services. Each

REGION	COVERAGE	CENTER LOCATION	MILLION POPULATION (1965)	CLINICAL	RESEARCH & FACULTY
1	New England & New York	Boston, Mass.	29.2	53,940	3644
2	Pa., N.J., Del., Md., Va., W.Va., D.C.	Washington, D.C.	29.4	38,806	2549
3	N.C., S.C., Ga., Fla., Ala., Miss., Tenn.	Atlanta, Ga.	27.2	29,598	1507
4	Mich., Ohio, Ind., Ky.	Columbus, Ohio	26.5	29,440	1477
5	Ill., Wis., Iowa, Minn., N.D., S.D., Nebr.	Minneapolis, Minn.	23.9	27,737	1492
6	Mo., Ark., La., Kans., Okla., Texas, Colo., N.M.	Oklahoma City, Okla.	28.3	29,152	1740
7	Mont., Wyo., Utah, Ariz., Idaho, Nev., Wash., Ore., Calif., Hawaii, Alaska	Palo Alto, Calif.	29.2	42,624	1962

Fig. 9--Biomedical Population for Seven Regional Centers (Non-Federal)

center may become the nucleus for construction of a Biomedical Information and Education Facility, a university-sized complex charged with the responsibility for providing all medical information and education. Under a unified control (e.g., the Lister Hill National Center for Biomedical Communications), the system of centers might develop tools for insuring that all providers of medical care are educated to a similar level of competence.

Section VI describes additional services that may move the centers toward this role. Although the systems described seem most desirable within the regional context, they could easily be provided by any single center or combination of centers.

VI. ADDITIONAL SERVICES

SELECTIVE DISSEMINATION OF INFORMATION

Selective Dissemination of Information (SDI) is a service that, in effect, would provide a MEDLARS-type bibliography to an interested individual on a regular basis. When the MEDLARS file receives a new citation, it is checked with an "interest profile" of customers. If the two match, a copy of the citation is sent to the interested party.

Such a service could be considerably worthwhile to the medical community, if it could provide the requisite level of precision and relevance. Nearly all previous efforts at SDI have fallen far short of expectations because the indexing of pertinent citations has been shallow and poor in quality.

The MEDLARS file, however, is indexed exhaustively. In addition, all index terms are coded, allowing the construction of more sophisticated Boolean relationships. Most currently operational SDI efforts are dependent on a "keyword" scheme; consequently, they provide no real sophistication. Moreover, an SDI system tied to MEDLARS could form its "interest profiles" based on, among other things, historical data: a machine-generated and analyzed record of the types of information a researcher requested previously.

Given the immensity of the volume of biomedical literature, yet noting that an SDI run would be time consuming, one month seems a reasonable interval between such runs. Hopefully, SDI operations could be staggered, as opposed to the alternative of running bibliographies for all physicians at one particular time of the month. An alternative approach is making the SDI service a by-product of the updating of the MEDLARS file, screening each citation for possible interest before extering it into the data base. This procedure, however, seems somewhat incompatible with a desire for rapid updating of the MEDLARS file: either the new

citations would have to be withheld until a sizeable number were accumulated, or the risk would be run of inundating researchers with sheafs of one-citation bibliographies.

The major role of SDI is, in fact, one of "preventive maintenance." The physician or researcher at present seems to utilize MEDLARS primarily as a remedy for a serious information deficiency. SDI provides a means of preventing such a deficiency, and should bring about a gradual attenuation in the volume of MEDLARS searches. A truly viable SDI system should require an interested party to run a MEDLARS search only when he first changes or expands his stated areas of interest.

DIRECTORY OF CONTINUING EDUCATION

If the physician and researcher can call on one source for information on poisons, bibliographic information, and specific documents, they will probably begin to depend upon that number as a central information source. Because of this dependence, the center should possibly become a clearinghouse for continuing education. The vast number of courses taught make it difficult for a physician to keep abreast of those that might be beneficial to him. A single call to the center periodically might be a giant step toward alleviating this difficulty. A directory of all courses being offered in the near future would occupy only a small part of any random-access device within the center.

In addition, the center might utilize the "interest profile" information to inform interested parties directly of future courses and seminars that might concern them. This service would be provided in the same program and time cycle as the SDI, and would merely form an addendum to its list of pertinent publications.

Figure 10 illustrates the inputs, outputs, and processing steps involved in maintaining a viable SDI-Educational Directory system.

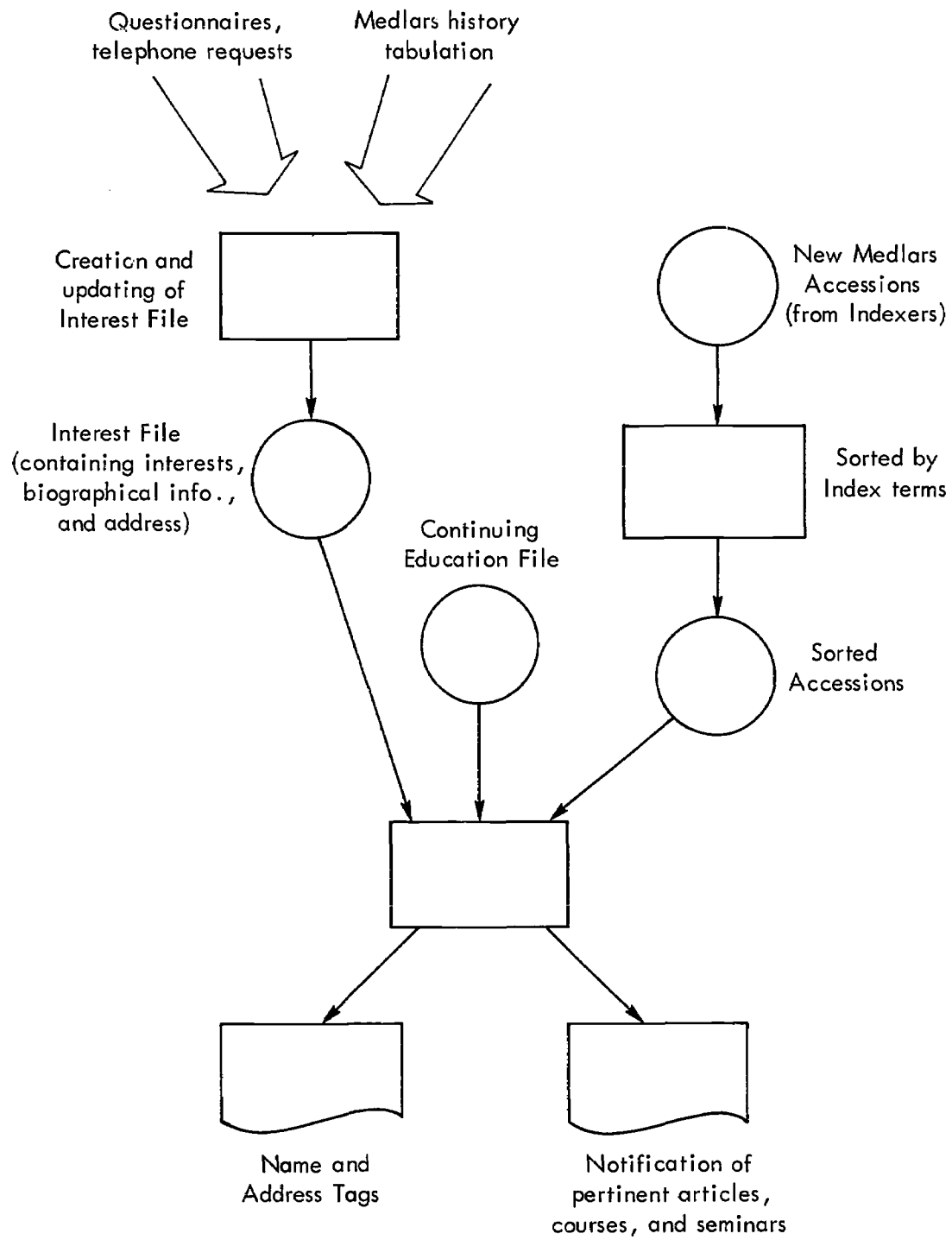

Fig. 10--Selective Dissemination of Information--
File Preparation and Systems Flow

Appendix A

SINGLE NATIONAL CENTER

COMMUNICATIONS COSTS (MONTHLY)

INWATS Lines -	2 Zone 1	@	$ 500	= $	1,000
	3 Zone 2	@	800	=	2,400
	2 Zone 3	@	1,100	=	2,200
	2 Zone 4	@	1,500	=	3,000
	2 Zone 5	@	1,850	=	3,700
	3 Zone 6	@	2,250	=	6,750
	Total Monthly Cost			= $	18,850
	Total Yearly Cost			= $	226,200

COMPUTER AND PERIPHERAL RENTAL (MONTHLY)

Poison Information System

Qty	Unit	Description	Unit Rental-Mo.	Total Rental-Mo.
14	2260	Remote Terminal	$ 51	$ 714
2	2848	Controller	800	1,600
1	360/40H	CPU	10,500	10,500
	Extra	Features	1,500	1,500
1	2803	Tape Controller	700	700
4	2401	Tape Transport	800	3,200
1	2821	Controller	1,000	1,000
1	2203	High-Speed Printer	900	900
1	2540	Reader/Punch	675	675
1	2841	Controller	720	720
2	2311	Disk Storage	590	1,180
1	2314	Disk Storage	5,500	5,500
1	1052	Console	65	65
		Total Monthly Rental		$ 30,661
		Total Yearly Rental		$368,032

Document Dissemination System

Qty	Unit	Description	Unit Rental-Mo.	Total Rental-Mo.
1	360/50H	CPU	$14,165	$ 14,165
	Extra Features		1,700	1,700
1	2803	Tape Controller	700	700
4	2401	Tape Transport	800	3,200
1	2203	High-Speed Printer	900	900
1	2540	Reader/Punch	675	675
1	2841	Controller	720	720
4	2311	Disk Storage	590	2,360
1	1052	Console	65	65
6	H-F	CARD Systems	207	1,242
		Total Monthly Rental		$ 25,527
		Total Yearly Rental		$287,871

STAFFING

Console-Telephone Operators

Assuming that each operator receives $3.50 per hour, an annual salary figure of:

$3.50 * 8 (Hours in Shift) * 52 (Weeks) * 240 (Shifts/Week) = $355,040

Machine Operators

2 Operators/shift, 3 shifts/day, 7 days/week, @ $4.50 hr = $1,512 per week.

Yearly total = $78,624.

Card-System Operators (to monitor hard copy output, collate and mail documents)

5 Operators/shift, 3 shifts/day, 7 days/week, @ $3.00/hr = $2,520 per week.

Yearly total = $131,040.

Keypunch Support

8 Keypunchers/shift, 1 shift/day, 5 days/week, @ $3.00/hr = $960 per week.

Yearly total = $49,920.

TOTAL

Communications	$ 196,800
Hardware--	
Poison Information	368,032
Document Dissemination	287,871
Space	337,692
Staffing--	
Console Operators	355,040
Machine Operators	131,040
Keypunch	49,920
TOTAL	$1,549,595

Appendix B

THREE REGIONAL CENTERS

COMMUNICATION COSTS (MONTHLY)

Region	INWATS Lines	Unit Cost	Total Cost
1	2 Zone 1	$ 500	$ 1,000
	1 Zone 2	800	800
	2 Zone 3	1,100	2,200
2	2 Zone 1	700	1,400
	1 Zone 3	1,100	1,100
	2 Zone 4	1,300	2,600
3	1 Zone 1	1,000	1,000
	1 Zone 2	1,100	1,100
	1 Zone 3	1,400	1,400
	2 Zone 4	1,750	3,500
		Total Monthly Cost	$ 16,100
		Total Yearly Cost	$193,200

COMPUTER AND PERIPHERAL RENTAL (MONTHLY)

Poison Information and Document Dissemination System

Qty	Unit	Description	Unit Rental-Mo.	Total Rental-Mo.
5	2260	Remote Terminal	$ 51	$ 255
1	2848	Controller	800	800
1	360/50H	CPU	14,165	14,165
	Extra Features		1,700	1,700
1	2803	Tape Controller	700	700
4	2401	Tape Transport	800	3,200
1	2203	High-Speed Printer	900	900
1	2540	Reader/Punch	675	675
1	2841	Controller	720	720
5	2311	Disk Storage	590	2,950
1	2314	Disk Storage	5,500	5,500
1	1052	Console	65	65
3	H-F	CARD Systems	207	621
		Total Monthly Cost		$ 32,252
		Total Yearly Cost (per center)		$ 287,024
		Total Yearly Cost (all centers)		$1,160,072

STAFFING

Console-Telephone Operators

Total cost for three centers, six operators per center (prime) - $455,516.

Machine Operators (per center)

1 Operator, 3 shifts/day, 7 days/week @ $4.50/hr = $756 per week.

Yearly total (single center) = $ 39,312.

Yearly total (three centers) = $117,936.

Card-System Operators

Total cost should approximate that of single national center - $131,040.

Keypunch Support

Same as national center - $49,920.

TOTAL

Communications	$ 193,200
Hardware	1,160,072
Staffing--	
Console Operators	455,516
Machine Operators	117,936
Keypunch	49,920
TOTAL	$1,976,644

Appendix C

SEVEN REGIONAL CENTERS

COMMUNICATIONS COSTS (MONTHLY)

Region	INWATS Lines	Unit Cost	Total Cost
1	1 "Zone 1"	$ 500	$ 500
	2 Zone 2	900	900
2	3 Zone 1	500	1,800
3	3 Zone 1	800	1,600
4	1 Zone 1	700	700
	1 Zone 2	900	900
	1 Zone 3	1,100	1,100
5	1 Zone 1	800	800
	2 Zone 2	1,100	2,200
6	1 Zone 1	900	900
	2 Zone 2	1,100	2,200
7	1 Zone 1	1,100	1,100
	2 Zone 2	1,400	2,800
		Total Monthly Cost	$ 18,900
		Total Yearly Cost	$226,800

COMPUTER AND PERIPHERAL RENTAL (MONTHLY)

Poison Information and Document Dissemination System

Qty	Unit	Description	Unit Rental-Mo.	Total Rental-Mo.
3	2260	Remote Terminal	$ 51	$ 153
1	2848	Controller	800	800
1	360/50H	CPU	14,165	14,165
	Extra	Features	1,700	1,700
1	2803	Tape Controller	700	700
4	2401	Tape Transport	800	3,200
1	2203	High-Speed Printer	900	900
1	2540	Reader/Punch	675	675
1	2841	Controller	720	720
5	2311	Disk Storage	590	2,950
1	2314	Disk Storage	5,500	5,500
1	1052	Console	65	65
3	H-F	CARD Systems	207	621
		Total Monthly Cost		$ 32,149
		Total Yearly Cost (per center)		$ 385,788
		Total Yearly Cost (all centers)		$2,700,516

STAFFING

Console-Telephone Operators

Total cost for seven centers, three operators per center (prime) - $512,450.

Computer Operators

Per center - $39,312 per year (see Appendix B).
Total (7 centers) - $275,184.

Keypunch Support

Same as national center - $49,920.

CARD-System Operators

Same as national center - $131,040.

TOTAL

Communication	$ 226,800
Hardware	2,700,516
Staffing--	
Console Operators	512,450
Machine Operators	275,184
Keypunch	49,920
CARD Operators	131,040
TOTAL	$3,895,910

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