Crisis in Libraries of Science and Technology

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THE ROOT of most difficulties in libraries of science and technology lies in the extraordinary increase in the volume of scientific literature. This is not, of course, the exclusive problem of scientific libraries. The Librarian of Congress called attention to the general problem in his annual report for 1940–41 with quotations from the words of Ortega y Gasset. "The book, wrote Ortega y Gasset in 1936, is an instrument to facilitate the conservation of ideas. At first it was a pure facility 'and had in our life only a positive significance.' Now, however, it has 'turned against man' and its relation to us is complicated by a negative significance. 'In all Europe there exists the impression, the reverse of that in the Renaissance, that there are too many books.' 'The man of science himself warns that one of the greatest difficulties of his work is to orient himself in the tremendous bibliography of his subject.' 'We are in danger of living to study instead of studying to live.' " [1]

This concern is certainly more than a century old. In the *American Eclectic* for September 1841, a German writer was quoted in protest against the increasing number of scientific periodicals in Germany. "Most of the natural sciences," he wrote, "have some great journal of undisputed authority, which is conducted by the ablest men in that department, and sought by their fellow-laborers in the same department. . . . Of *medical* journals there are forty-three in Germany. It must be granted that different modes of practice require different periodicals . . . But forty-three journals are an astonishing number. What physician who practices daily can read them all, and to what physician who does not practice can they be useful? The number of journals in natural science can be justified only by the number of particular departments, which are sufficiently important to have a separate periodical devoted to them." [2]

This mid-nineteenth century writer would hardly believe the fantastic increase in the number of medical periodicals in the one hundred years since he expressed his concern for *forty-three* medical periodicals in Germany. An area of the world far less productive, proportionately, of scientific literature than Germany, the countries of Latin America, are producing now some sixteen hundred medical periodicals.[3] He would be equally distressed, as he probably should be, at the large numbers of periodicals which have been published even in some of the medical specialties. There have been recorded, for example, more than three hundred periodicals and other serial publications in the field of pediatrics; [4] fortunately, not all of them are being published currently.

Rough measures of the rate of increase in the number of scientific periodicals are provided by two examples. In 1895, Bolton [5] listed some 8,600 scientific periodicals, exclusive of medicine and exclusive of the transactions of learned societies, which are devoted primarily to the proceedings of the societies by which they were issued. The preface to the third edition of the *World List of Scientific Periodicals* [6] points out that "the number of periodicals to be included [in this] proved to be of the order of 50,000." The number of periodicals indexed by *Chemical Abstracts* has shown equally phenomenal increases. The first volumes indexed approximately 650 periodicals; the current volumes index more than 5,000 titles; and if the rate continues, the number of periodicals indexed may well have increased more than ten-fold by 1957, only fifty years from the founding of this abstract journal.

The interpretation by the Librarian of Congress of the words of Ortega y Gasset included a strongly expressed belief that a primary problem of librarians is to bring the great mass of the world's books under catalog control. This requirement applies to the literature of science with perhaps more force than to the literatures of other disciplines, primarily because of the progressive character of scientific knowledge. Harvard's President Conant emphasizes this fact when he states "that science emerges from the other progressive activities of man to the extent that new concepts arise from experiments and observations, and that the new concepts in turn lead to further experiments and observations." [7] The practical aspects of this statement are of the greatest significance to libraries of science and technology, not only in the relation of library service to basic research, but particularly in its relation to industrial research and development in both peace time economy and national defense.

In the area of industrial research, served primarily by special librar-

ies, there are certain characteristic demands which must be met by the technical library. For the most part their roots are economic; but they draw heavily, also, on the cumulative character of science. In the first place, industry is constantly alert to the practical possibilities of new basic discoveries in chemistry, physics, biology, and related sciences. There is an urgent interest, therefore, in prompt and full reports in the indexing and abstracting journals of research results in all periodicals and separate reports in the basic sciences. For many companies these secondary publications are neither full enough nor prompt enough to serve company interests, and large expenditures are undertaken privately to review current journals and to extract information pertinent to the manufacturing interests of the company concerned.

Similarly, industry is interested in new technological applications of science accomplished throughout the world. For every company with an active development program, it is vital to be kept informed of new products and new techniques that may affect the competitive position of the company either in products to be marketed or in costs of production and distribution. A special aspect of this economic interest is found in the field of patents. Quite apart from reference to patent literature, on which many companies spend large sums of money, there are problems relating to preparation of specifications for new patent applications, and review of prior art in connection with litigation on infringement of patents. In this complex of problems, there is need not only for prompt access to the content of new technological publications but need for thorough record of all such publications issued in the past.

Fortunately, the literature of science, technology, and medicine is more fully covered by abstracting and indexing journals than are the literatures of the social sciences and the humanities; otherwise the situation would be one of much chaos and little progress. As it is, there are elements inherent in the present situation which contribute to a degree of chaos and an obstruction to progress. The principal elements are inadequacy in fullness of coverage and inadequacy in quality of coverage.

Chemistry is the only subject field of primary interest to industry for which fullness of coverage can be considered reasonably complete. Physics and engineering, including such currently important fields as metallurgy and electronics are much less fully treated; and the coverage would be even less complete if it were not for the large amount of literature of interest to these subjects now being included by *Chemical Abstracts*. An important exception to this general statement is nuclear

physics, in *Nuclear Science Abstracts.* This exception is due in part to the cooperation given to the Atomic Energy Commission by the Department of Agriculture Library, the Armed Forces Medical Library, the Bureau of Standards Library, and libraries of other federal agencies in covering published literature of the world. The exception is due, also in part, to the fact that *Nuclear Science Abstracts* covers the unclassified report literature issued by the government.

This last point, namely the record of separate government research reports, may have bearing, of increasing importance, on the problem of fullness of coverage of scientific literature in the future. Not only is there an increasing amount of report literature being produced by government agencies and by contractors doing research for the government, but there appears to be a growing number of advocates of separate reports *versus* publication of research literature in the form of periodicals. If this movement succeeds, it will increase the problems of bibliographical coverage. The problem of covering fifty thousand papers each year from some five thousand different periodical and other serial publications is fraught with difficulties. To be faced with fifty thousand separate publications, with all the problems of acquisition and distribution for abstracting, might prove too much for even the highly organized machinery of *Chemical Abstracts.* The present system, illogical as it is in some important respects, offers, at least, some continuity in the source of publications and a measure of assurance of completeness of coverage. Both of these advantages would be lost if the periodical form of publication were to disappear. The minimum requirement to offset these losses would be the publication of the separate reports in series.

Some of the administrative problems of technical libraries would be greatly increased if the separate report were to replace completely the periodical. Even assuming adequate subject cataloging and indexing coverage of reports by the abstracting journals, which is quite an assumption, there would still remain the mountainous problem of locating these reports for users of the library. No library in the world contains all of the periodicals; all libraries must depend in part, most often in large part, on the content of other collections. While the equipment for this purpose is far from adequate at the present time, the problem of location is solved in large degree by the *Union List of Serials,* the check lists of holdings published from time to time by *Chemical Abstracts,* the National Union Catalog at the Library of Congress, and special subject and local union lists and catalogs.

This does not mean that the need of the individual scientist for per-

sonal copies of the papers he requires for his own research should be ignored. It might, however, be effectively met by other means than by the wrecking of a publishing device which has many merits, both in the intellectual life of scientists and in the practical machinery of collecting and supplying scientific and technical literature through libraries. Experimentation with one possible solution is already in progress at the Library of Congress in the program of the Technical Information Division. This includes publication of bibliographical information and abstracts in card form, with full microprint text of the indexed paper on the back of the catalog or index card. It does not seem unreasonable to hope that the modern scientist will be willing to accept this or some other practical publishing device which utilizes the technical methods and equipment for the development of which he has been personally responsible.

To return to the problem of bibliographical coverage of scientific literature. Reference has been made above not only to "fullness" of coverage, but also to "quality" of coverage. The latter is related to what Dyson calls the "chain of inquiry" [8] between the original publication and the user of the publication. The importance of quality of coverage is made strikingly clear. "To arrive at one end of this chain from the other all the links must be in order. The probability that this will be so depends on the efficiency with which each link operator works; if searcher, indexer, and abstractor are all 90% efficient, the over-all efficiency is 72.9% and the chance that a given piece of original information will reach the searcher is approximately 3 in 4." [9] For this chance to be even as good as "3 in 4" depends on the unstated assumption that *all* relevant literature has been covered by the abstracting journal. The implications of this analysis are made even more crucial by the fact that few other abstracting journals are the equal of *Chemical Abstracts* in fullness of coverage and quality of abstracting.

Enough has been said here to demonstrate that one of the most serious problems with which the technical library must deal is the economics of utilization. The first element in high costs is the inadequacy of distribution. As already stated, no library acquires all of the literature of science and technology; and great dependence must rest on union lists, union catalogs, and other sources of more random search to locate items for the clientele of the individual library. A second element is the inadequacy of coverage, both quantitative and qualitative, by the indexing and abstracting journals. A third element is insufficient knowledge of the techniques of searching. And all of these contribute

to a fourth, and sometimes very serious, element of high cost in the economics of utilization, namely, delays in the availability of scientific and technical information necessary to the progress of scientific research and development. These delays are always undesirable and in instances when they relate to research bearing on national defense they are potentially disastrous.

Many agencies are engaged in the study of these problems, including libraries and organizations of librarians. The broad issues were on the agenda of the Scientific Information Conference sponsored by the Royal Society in London in 1948.[10] They have also received attention internationally in the program of Unesco. Some of these activities have been described by Collison and Carter, respectively, elsewhere in this issue of *Library Trends*. They have been on the agenda of the American Chemical Society, the American Institute of Physics and other scientific societies which have been working to improve the quality of abstracting services. A major attack was made on the problem of techniques of searching in the Symposium on Searching the Chemical Literature held by the Division of Chemical Literature of the American Chemical Society in Detroit in April 1950.[11]

A promising experiment has been tried by the Committee on Periodicals and Serial Publications of the Medical Library Association in the evaluation of medical periodicals to aid in determining priorities in acquisition and indexing literature in this field. *A Selective List of Latin-American Serials* has resulted from "an attempt to provide an evaluative guide through the bewildering profusion of medical serials published in the countries of Latin America." [12] A review of some 1,600 serial titles resulted in four categories, as follows: (1) essential in any comprehensive collection (66 titles); (2) essential only in a research collection, but useful in any medical library (169 titles); (3) useful only in large research collection (666 titles); and (4) of little or no usefulness (the remainder). Although there is some confusion in use of the terms, "comprehensive," "research," and "large research," there is obvious merit in grading periodicals for determining relative values for indexing by the Armed Forces Medical Library and for acquisition by the various medical libraries of the country. Widespread use of this evaluating technique would improve the quality of indexing and abstracting coverage not only in medicine but in all other scientific and technical fields as well.

In terms of potential for the future, by far the most important development in recent years has been extensive experimentation with

machines for the storing and searching of information. The Symposium on Machine Techniques for Information Selection, held at the Massachusetts Institute of Technology in June 1952 was devoted to a review of progress in this field. The announcement of the symposium opened with the statement: "The quickened pace of research during recent decades has been paralleled by rapid expansion in the volume of recorded knowledge. Its use in planning and conducting research and development often requires professionally trained experts to devote many hours to scanning indexes and to selecting needed items from classified collections. Such tasks consist mostly of routine operations that can be performed by suitably designed machines." [13]

The use of machines for bibliographical and informational searching has now received extensive study, and the M.I.T. symposium represented only another gathering of scientists and scientific bibliographers to evaluate progress and further lines of research. Experimentation with punched cards has been sponsored by the American Chemical Society since 1946; and an account of this work was given in the March 3, 1952, issue of *Chemical and Engineering News*.[14] The rapid selector, using film, has been frequently in the news. The electronic digital scanner, using magnetic tape, and the IBM electronic card scanning system were reviewed at the M.I.T. symposium. The problems of terminology, information analysis and methods of coding and indexing have all been, and are being, studied for use in the several machines. The significance of all this experimentation is of the greatest interest to the technical library. An evaluation of the potential significance was given in a paper by Shera, on the "Effect of Machine Methods on the Organization of Knowledge." The following quotation from Shera has a high degree of relevance to the crisis in libraries of science and technology.

> One can argue with a reasonable degree of credibility that we do not as yet know enough about the precise nature of these new mechanisms, and that our perspective is as yet inadequate for a dispassionate appraisal of the effect of machine methods on the organization of knowledge. However, it is not excessive to maintain that we can even now envisage the general characteristics of these mechanisms with sufficient clarity to enable us to hypothesize certain conservative estimates of their effects upon traditional bibliographic procedures and operations, especially as these relate to bibliographic classification.

What, then, are the characteristics of these mechanisms that one may assume without too much fear of contradiction? (1) They will

probably be electronic rather than mechanical. (2) They will doubtless make use of photographic techniques in one or more forms. (3) They will be capable of storing large masses of bibliographic data in their "memories." (4) Through the operation of a coding system they will be able to sort this stored data in a variety of ways so that the user receives only those materials relevant to his purpose. (5) They can be designed to manipulate complete bibliographic units (i.e., complete photographic copies of entire monographs or other documents); abstracts of these units; bibliographic information only; or fragmented segments of information (i.e., units of information or units of thought.) (6) They will operate at speeds far in excess of the human. (7) Negatively, they will not be mechanical substitutes for human intelligence. Hence, (8) their use seems likely to be limited to the more complex problems of bibliographic searching, and therefore, they may not be applicable to the entire range of bibliothecal operations. This brief capitulation emphasizes the enormous potential inherent in these machines, and the difficulties encountered when one attempts to discuss them with restraint. Even a conservative view must acknowledge that here are latent forces that could revolutionize, not only traditional library and bibliographic operations, but the very pattern of scholarship itself.[15]

It is probably too early to judge whether a turning point has been reached in the bibliographic organization of scientific literature and information, and in the techniques for utilization. The massive volume of publications, the crucial relation of scientific literature to progress in scientific research, and the need for effective chains of inquiry in our system of scientific communication, will all continue to be vital factors in library service even after the crisis is past. A great deal is at stake: the alternatives of experiments and observations, recorded in the literature, leading on to new experiments and observations in ever widening circles—the normal process of scientific research—or intellectual strangulation. The possibilities of the latter seem quite remote, but the former, too, is far from being realized to its full potentialities. The costliness of the horse-and-buggy techniques being used for the collection, organization and utilization of scientific literature is now realized, however, and this fact alone is a harbinger of better days ahead.

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