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ABSTRACT

In simple terms, the scientist's problem with respect to information is: How can the present volume of research results be published promptly? What is being published now? Where is it? and How can I get at it? The purpose of this paper is to examine these problems and to suggest possible ways in which they can be solved. In regard to what the Federal Government responsibilities should be two alternatives are stated: (1) establishment of a large, highly centralized scientific information agency financed by the Federal Government or by government and private industry and (2) establishment of a science information service of the coordinating type which would strengthen rather than supplant existing systems. The second alternative is advocated with the establishment of a Science Information Service within the National Science Foundation as an extension of the Foundation's present scientific information program. The White House press release announcing the establishment of a Science Information Service in the National Science Foundation is appended. (This is considered to be one of the basic papers of government interest in the field of information science.) (NH)

THE WHITE HOUSE

December 7, 1958

A REPORT OF
THE PRESIDENT'S SCIENCE ADVISORY COMMITTEE

IMPROVING THE AVAILABILITY OF SCIENTIFIC AND TECHNICAL INFORMATION IN THE UNITED STATES

WHAT THE PROBLEM IS AND WHY IT IS SERIOUS

The long, hard look we have recently taken at the state of science and technology in this country has brought to light several areas that need to be strengthened and improved. Some of these, notably in the field of education, have aroused nation-wide concern. But another area--also in great need of attention--has attracted little or no public interest. This is the matter of scientific information--the technical data that a scientist needs in order to do his job. Yet our progress in science may very well depend upon the intelligent solution of problems in that area.

All of us use a wide variety of information every day of our lives. We glean it from newspapers, conversation, radio and television, magazines, clocks, books, meters, mail, maps and so on. The scientist, however, is interested in the specialized information that results from scientific research. The publication of research information is absolutely essential to every working scientist for two reasons: (1) It is the means by which he announces significant results in his own work, establishes priority where appropriate and invites the evaluation of other scientists; (2) It is also the means by which he keeps abreast of what others are doing in his field.

The extent to which the working scientist depends upon the work of others has been clearly stated by one of the greatest of all scientists, the nuclic physicist, Ernest Rutherford. As quoted by James Newman in a recent issue of The Scientific American, Lord Rutherford said:

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The extent to which the working scientist depends upon the work of others has been clearly stated by one of the greatest of all scientists, the atomic physicist, Ernest Rutherford. As quoted by James Newman in a recent issue of The Scientific American, Lord Rutherford said:

> I have also tried to show you that it is not in the nature of things for any one man to make a sudden violent discovery; science goes step by step, and every man depends on the work of his predecessors. When you hear of a sudden unexpected discovery--a bolt from the blue as it were--you can always be sure that it has grown up by the influence of one man on another, and it is this mutual influence which makes the enormous possibility of scientific advance. Scientists are not dependent on the ideas of a single man, but on the combined wisdom of thousands of men, all thinking the same problem, and each doing his little bit to add to the great structure of knowledge which is gradually being erected.

The reason scientific information has become a major problem, particularly since World War II, is that the rapid rate of scientific progress has multiplied the volume of scientific information to a point where it can no longer be published and handled within the framework of existing methods. When one considers, too, that much of what is significant in science is being published in unfamiliar languages, it is clear that the working scientist is faced with almost insuperable problems in attempting to keep himself informed on what he needs to know.

Some idea of the volume of increase may be had from the fact that the science and technology periodical collections of the Library of Congress have doubled approximately every 20 years for the past century and now contain approximately a million and a half volumes, a significant fraction of the

Library's total bound collections. The Library is receiving journals in science and technology at the rate of about 15,000 annually, and 1,200 to 1,500 new periodicals are appearing each year. Yet the Library receives less than a third of the 50,000 scientific periodicals that appear in the world list of 1952 and it is expected that by 1979 the total world output will reach 100,000 journals.

The language difficulty is reflected in the fact that Russian-language publications are estimated to account for a tenth or more of all the scientific literature being published in the world today. This Russian total is second only to English.

Reduced to simple terms, the scientist's problem with respect to information is: How can the present volume of research results be published promptly? What is being published now? Where is it? and How can I get at it? The purpose of this paper is to examine these problems and to suggest possible ways in which they can be solved. In particular, it will consider the question of what should be the responsibility of the Federal Government in meeting this crisis.

THE PRESENT SYSTEM

The system by which scientific information is disseminated is the result of evolution rather than any preconceived system or plan. Its defects stem largely from its inability to keep pace with the increasing volume of scientific results and literature and the absence of techniques geared to the newer forms of scientific information, such as Government reports. The situation is further complicated by the fact that a large and important proportion of the world's scientific literature appears in languages unknown to the majority of American scientists, such as Russian and Japanese.

Scientific information appears in several forms. Most significant are the highly specialized technical periodicals, called primary journals, because it is in these that new scientific results are first published. The Physical Review, Journal of the American Chemical Society, and the Aeronautical Engineering Review are examples.

Another important primary source is the monograph, an exhaustive study of some highly specialized phase of science. Because it is of interest to only a limited number of scientists, and because it often includes elaborate charts and plates, the monograph is almost prohibitively expensive to publish. The result is a lack in this country of monographs on many exceptionally important scientific subjects that should be so covered.

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A second important category is the abstracting journals, such as Biological Abstracts and Chemical Abstracts. These contain summaries of synopses of papers that originally appeared in primary journals. When adequately indexed, they permit a searcher to locate previously published papers on any given subject. If an abstract is sufficiently informative, it may serve the scientist in lieu of the complete paper. It should be noted parenthetically, however, that the 14 major scientific abstracting services in the United States recently indicated that the almost half a million abstracts that they issue annually constitute only about 55 per cent of what they should be publishing in order to cover the literature in their combined fields reasonably well. Other important secondary sources include critical reviews, special indexes and indexing services, bibliographies, title lists, collected tables of contents, handbooks of data, and compendia of various kinds.

A recent trend of special interest is the establishment of Data Centers. When the quantity of research data in a given field becomes too great for book publication to be practical, the Data Center offers a solution. Such centers

compile, correlate, standardize, and organize numerically, data representing the properties of materials or the characteristics of phenomena. Examples of such centers include the Thermophysical Properties Research Center at Purdue University; American Petroleum Institute Research Project 44 at the Carnegie Institute of Technology, which is concerned with the physical properties of hydrocarbons; the Nuclear Data Project of the National Research Council; and the National Bureau of Standards Center on Selected Values of Chemical Thermodynamic Properties.

Falling outside scientific information that is published, cataloged, and indexed in the normal way, is a steadily mounting volume of Government research reports. It is conservatively estimated that upwards of 50,000 scientific reports (at least half of which bear no security classification) are issued annually by the private and Government laboratories that conduct Federally-sponsored research. Many of the newest and most significant scientific data are to be found in these reports.

A smaller body of scientific information not covered by the normal processes is to be found in such material as research findings submitted in satisfaction of Ph.D. thesis requirements, industrial reports and papers presented at scientific meetings and symposia.

At the present time it is not even possible to answer the question with any degree of completeness, "What is being published now?" One would assume that, somewhere in the world, there must be a composite listing of the world's scientific--publications--perhaps even arranged by subject fields--but no such compilation exists. The establishment of such a list and its maintenance on a current basis obviously would be a very expensive undertaking, and this is one reason why it has never been done.

The basic answer to "Where can I find it?"--as far as journals are concerned--is the "Union List of Serials," in the libraries of United States and Canada. Such a compilation lists periodicals alphabetically and names the libraries where each can be found. But no such union list of scientific journals now exists. A Joint Committee on a Union List of Serials covering all fields has estimated that the science and technology portion of a new union list would cost approximately three-quarters of a million dollars. It could be kept up to date only in a relative sense, since such a list is constantly changing. It follows, of course, that no comprehensive listing of the principal secondary publications is in existence either.

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Then there is the problem of "How can I get it?" The scientist who needs a particular journal may find himself (if the journal is rare) far distant from the location of the nearest copy as indicated by the union list; or he may find that the article he is seeking is in a language he does not read.

In summation, then, it may be said that both inside and outside the normal channels of scientific communication a mounting flood of scientific data threatens to swamp even the most zealous research investigator. The implications go far beyond the inability of one man, or even a group of men, to keep abreast of developments in their field. Our very progress in science is dependent upon the free flow of scientific information, for the rate of scientific advance is determined in large measure by the speed with which research findings are disseminated among scientists who can use them in further research.

HOW ARE WE GOING TO MEET THIS PROBLEM?

The situation has evolved over a lengthy period of time, during which the developing problems not only have been recognized, but have been the subject of attack on a number of separate fronts. These efforts have been

handicapped, however, by the lack of over-all coordination and sufficient funds with which to support really effective remedies.

What is Already Being Done?

All along the line there have been sincere efforts to cope with the problems. Primary journals have expanded substantially in recent years and the scientific societies have helped to cover the increased costs by raising dues and subscription prices. In an effort to conserve space, greater and greater condensation of papers is being required, with the result that there is danger of few people besides the author and his immediate colleagues being able to understand a paper. There is constant search for cheaper production methods and many journals levy page costs upon the authors, so that scientists must pay for the privilege of having their research findings published. Such financial help as the Government has given has been limited, consisting largely of short-term emergency grants made to tide a particular journal over a rough spot or to launch a new journal that is badly needed in order to fill a gap. Some agencies pay page costs for their employees and their contractors' employees when they publish.

Federal aid has also been provided in the form of temporary assistance to commercial abstracting and indexing services, including funds to support the establishment of a National Federation of Science Abstracting and Indexing Services, designed to bring cooperative efforts to bear upon mutual problems. A few Government agencies publish or partially support certain secondary publications in subject fields of particular interest to them.

It is generally agreed, however, that the magnitude and seriousness of the problem are such that a long-term solution requires fundamental research into the problem and widespread application of machine methods and techniques. In other words, science must look within itself for a new system that will meet present-day requirements for the location, storage, and retrieval of scientific informatio..

A number of industrial firms have developed, and are using successfully, mechanized storage and retrieval systems tailored to their own needs. Large manufacturers of business machines and computers are becoming increasingly interested in the application of their equipment to information-processing problems. A dozen or more universities are carrying on research in the information-handling field, including studies of existing patterns of scientific communication in various subject fields, research in mechanical translation, development of procedures for determining how scientists use technical information, and research on actual mechanical systems for information rage and retrieval. Within the Government, the National Science Foundation supported research on scientific information problems to the extent that available funds have permitted.

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Efforts are also being made to improve the availability of foreign scientific information. The emphasis is on Russian research results because Soviet scientific publications are second only to our own in number, and because so few scientists in this country read Russian. Of the 61 Soviet journals available here on subscription in cover-to-cover translation, about 34 are being supported principally by the National Science Foundation, with assistance from the Atomic Energy Commission and the Office of Naval Research. Nine are supported by the National Institutes of Health; the rest are issued commercially.

In the field of unpublished documents the Office of Technical Services, Department of Commerce, lists some 7,500 such documents each year in its abstracting journal, U. S. Government Research Reports. Copies of all items so announced can be obtained in original form or in photoreproduction. The Library of Congress is building in its Science and Technology Division

an open reference collection of unclassified reports. The National Science Foundation maintains a clearinghouse for Government research information to provide scientists information on Government-supported research in their fields and the reports that are available.

Thus a considerable amount of work is being done on serious scientific information problems. From the standpoint of national welfare, however, these efforts are on far too small a scale to deal with the over-all problem. The question then remains as to how it can be met.

What Should be done for the Future?

Two alternative possibilities have been advanced. One would be the establishment of a large and highly centralized scientific information agency, financed by the Federal Government or by government and private industry. A second would be the establishment of a science information service of the coordinating type, which would strengthen and improve the present system by taking full advantage of existing organizations and the specialized skills of persons with long experience in the field. Let us examine the respective merits of these alternatives.

A Single Large Operating Center? The proposal to solve existing problems in the field of scientific information by the establishment of a single large operating center, financed wholly or in part by the Federal Government, may have been suggested by the experience of the Soviet Union with its All-Union Institute of Scientific Information. The organization and operation of the Institute implies that the Russians recognize the magnitude and importance of the problem by their decisive and aggressive attempts to meet it. Available evidence indicates that the Institute operates effectively in meeting the needs of Russian science. But, it must not be overlooked that in planning the establishment and operations of the Institute, the Russians could not call upon the services of scientific information organizations such as we find already in existence in the private enterprise structure of our country, and which have

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The solution the Russians have developed for meeting their own problems in our judgment would not be equally effective in meeting ours. The Russian Institute is organized along the lines that are basically compatible with the organization and administration of research in the Soviet Union, which, of course, is controlled by the Central Government. Our own research efforts are organized and administered very differently, and it is illogical to suppose that a highly centralized organization for the dissemination of research information would serve our purposes equally well. Whatever its faults may be, our present system has developed along the lines of individual initiative and private enterprise that are very basic to our institutions.

The primary journals, as well as the abstracting services, are published under the benign auspices of the scientific societies who are in a better position than anyone else to appreciate the information problems of scientists. Existing services, moreover, represent a considerable investment of private capital. Chemical Abstracts, for example, which has operated without Government subsidy, had a 1957 budget of approximately $1.5 million. Although most of the journals and services have smaller budgets and many do receive some Government support, the total private investment in the publication and dissemination of results of scientific research runs into many millions of dollars. The mere mechanics of transforming the existing decentralized system of private enterprise into a strong central agency are enough to stagger the imagination.

From a purely practical point of view, it must be remembered that much of the day-to-day work involved in the dissemination of scientific information--that is, the writing, editing, abstracting, translating, and so on--is

done either by scientists or people with technical skills of a very high order. Many of these people perform such chores in addition to their regular scientific work and it is quite inconceivable that they could be induced to affiliate themselves on a full-time basis with a centralized agency. Put the matter another way: The case for a Government-operated, highly centralized type of center can be no better defended for scientific information services than it could be for automobile agencies, delicatessens, or barber shops.

A Science Information Service? The second alternative, however, could lead to an integrated, efficient and comprehensive scientific information service that would take advantage of privately supported programs as well as the very extensive work being done by the Federal agencies--that is, it would strengthen rather than supplant them. Specifically, this solution calls for the establishment within the Government of an organization that might be called a Science Information Service. Such a Service would assist, cooperate with, and supplement the many existing scientific information programs but would "take over" none of them. It would retain the benefits of the existing complex of scientific information services while working at the same time toward remedying its defects. Such a program would be in the best American tradition of private enterprise and Government working together voluntarily for the national good.

The Service would have two important functions: (1) through effective coordination and cooperative effort of public agencies and private organizations to capitalize upon and improve existing facilities and techniques in such a way as to afford immediate relief to short-term problems of a pressing nature; and (2) to encourage and support a fundamental, long-term program of research and development, looking to the application of modern scientific knowledge to the over-all problem through the application of machine techniques and through yet-undiscovered methods.

Under the first category the Service would help to answer the scientist's fundamental questions: How can the present volume of research results be published promptly? What is being published now? Where is it? and How can I get it?

In the area of primary publication, the Service would provide financial assistance where needed for the publication of journals and monographs. It would encourage publishers and scientific societies to experiment with new and streamlined methods of publication designed to increase efficiency, improve services, and decrease costs. Similar cooperation would be encouraged among the producers of secondary publications and financial

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The Service would provide the answer to "What is being published now?" by sponsoring, and if necessary supporting, the immediate preparation of world-wide lists of both primary and secondary scientific research publications, subject-classified and indexed. It would perform a similar task with reference to a union list of scientific and technical periodicals and provide a clearinghouse of information on abstracting and indexing services throughout the world. It would review the newly developing field of Data Centers, compiling information on those that now exist, analyzing overlaps and duplications, and defining areas where new centers are needed.

The whole area of foreign scientific information would be scrutinized and the translation of Russian science expanded to the extent needed to provide full coverage. Additional translation programs in Japanese and other languages would be initiated as needed.

The Service would give special attention to the area of Government scientific reports by expanding the existing announcement system to include every significant unclassified report. It would also expand and improve

facilities for making copies of these reports available upon request. It would foster cooperative projects among the agencies to promote greater efficiency in the preparation, processing, and dissemination of Government reports.

It would seek to expand and improve inter-library exchange agreements throughout the world, photocopying processes, and other ways and means of bringing to the scientist copies of items unattainable through normal channels.

All of these things, the Service, with sufficient funds and backing, could proceed to do at once. For the longer term, the Service should support a continuing program of research and development through grants and contracts, looking to the widespread application of machine techniques to such problems as storage, retrieval, indexing, and on a higher plane, to such problems as translation and abstracting.

CONCLUSION

It is clear that in the realm of scientific information, the scientist has neglected his own needs. As a nation we have readily applied modern scientific knowledge to the solution of much more difficult problems. If the Federal Government will establish a national coordinating service of the type that has been described, we can move toward solution of a problem that is vital to our progress in science.

Fortunately a new agency will not be required to meet this need. The National Science Foundation, whose enabling Act charges it with specific responsibilities for scientific information, already has a pilot program in this field and hence useful experience and special competence. The Foundation plays a coordinating role with respect to basic research and policy matters within the Federal Government. The establishment of the Science Information Service within the Foundation could be easily achieved by the extension of the Foundation's present program.

The Committee therefore recommends that the National Science ıdation expand its scientific information program to constitute a Science rmation Service that would serve to aid and coordinate existing governmental and private efforts.

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