documents with the aid of computers. Consequently, it does not appear that skilled human abstractors and indexers are likely to be displaced by machines in the near future.

To summarize, we have shown that abstractors and indexers are needed to make industrial research and development work more effective by helping to avoid unnecessary duplication and by making maximum use of research results obtained elsewhere. We have discussed the work that abstractors and indexers do and lastly we have explored briefly some of the tools and types of literature that they work with.

The Literature Research Chemist*

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Much has been said and written of the literature explosion which faces today's scientist. It is not at all difficult to see why this situation should exist: it has been estimated that, of all scientists who ever lived, some 80-90% are living today.[1] This army of scientists has nourished a rapidly growing literature, and helped to give prominence to a relatively new type of chemical specialist—the literature research chemist.

Ample evidence documenting this literature explosion is readily available. Price has noted the exponential growth in the number of scientific journals over the past 200 years.[2] The size of *Chemical Abstracts* has grown, over a relatively short period, from 42,000 abstracts in 1948 to 145,000 in 1961. The technical library at Esso Research and Engineering Co. now contains approximately 2,000,000 literature and patent reference cards (representing about 500,000 documents), and this number is growing at a rate of about 100,000 cards per year.

As this flood of information continues unabated, the total of all information, past and current, contained in in the literature mounts to increasingly staggering proportions. The job of the literature research chemist—or, more broadly, the Information Research Chemist—is to stimulate increased and more effective use of this vast store of available data.

The Information Research Chemist is not really a new phenomenon. The laboratory chemist has always doubled as an information research chemist. Today's laboratory chemist may seriously intend to keep up with a number of journals which are likely to contain information related to his interests. However, these journals may easily total several dozens. In practice adequate coverage becomes impossible, as the pressures of achieving and reporting experimental results lead to an encroachment on time set aside for reading. Apparently most chemists feel that they are only being productive when they are in the laboratory. In a recent study conducted by Case Institute, the chemists in several representative groups reported that, on the average, they spend only two hours per week reading the literature.[3]

The adverse consequences of being able to devote so little time to reading are manifold. First, there is a strong inclination to avoid spending time with material not directly connected with immediate interests. Thus, there is little opportunity for the scientist's ideas to be stimulated by work done in more or less closely related fields. Material in foreign languages tends to be ignored. Coverage tends to be superficial. The Case study indicates that frequently the scientist is content to read an abstract or digest, without consulting the original article. Coverage tends to be inaccurate. Obviously, the less time devoted to a job, the greater the possibility of carelessness and error. Finally, it is evident that, as the amount of time allotted to reading diminishes, the chance of overlooking information directly connected with one's interests increases correspondingly.

It must be kept in mind that this discussion so far has referred only to journal literature, and not to patents. In fact, a great deal of significant information first appears in published patents and patent applications—in particular those from such fast-publishing countries as Belgium, Portugal, and the Republic of South Africa. Failure to cover the patent literature often leads to a serious information gap.

The significance of an information gap bears emphasis. It can lead to the unnecessary duplication of effort already expended and documented by others, with a serious waste of time and money. It can result in the chemist's failure to solve his own problems, through ignorance of available ideas, techniques, and results. For the individual chemist, concentration in too narrow an area can lead to serious deficiencies in background when he finds himself working in a new area. Finally, an information gap can cause an organization to miss an important competitive advantage in capitalizing promptly on new trends and ideas.

More and more organizations have recognized the need for technical information groups to cope with the flood of information. A 1959 survey showed close to 100 industrial organizations which had set up technical information groups. These groups range in scope from special libraries which may, in addition, be responsible for literature searching and the publication of abstract bulletins, to integrated multifunctional groups such as the Technical Information Division (TID) at Esso Research.

Three Information Research sections in TID are devoted to Chemicals, Petroleum Products, and Petroleum

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Processes and Engineering. These sections play an important part in the operation of the division. What is more important, they have developed, in the five years of TID's existence, into an integral part of Esso's research team.

Each Information Research group is made up of both senior and junior scientists whose *full time* is occupied in Information Research work. Their aim may be summarized in a few words: to turn facts into actions. The literature is a repository for countless facts. The Information Research chemist assembles and organizes these facts, analyzes them, and attaches to them an expert opinion—for opinions are essential in making the decisions which are required if one is to convert facts into actions. He then communicates facts and opinion to those in a position to make the necessary decisions—to the laboratory chemist prosecuting a research program, or to management, which must select entirely new areas of research.

How does the Information Researcher go about accomplishing his objectives? The broad areas of his operation include current literature review, use of stored information, maintaining technical expertness, and communication of research results. Let us consider each of these in more detail.

Current literature review involves selection and interpretation of important current items. Each week the Information Researcher considers a large number of literature and patent abstracts, supplied by TID's Information Processing group, in addition to material he encounters in his own independent reading of the current literature. From these he selects the most significant items, which are treated in a variety of ways. An item of interest to individuals or small groups is informally directed to their attention. Items of more general interest may be highlighted on the front pages of the abstract bulletins published by the Division. These highlight pages are regularly read by virtually all research management and laboratory personnel. The most significant items may be called directly to the attention of management *via* detailed letters or special reports.

Another and highly important aspect of current literature review involves keeping the abstracters and librarians aware of changing areas of company interest. This serves the dual purposes of insuring that abstracting coverage is adequate and of preventing the abstract bulletins and files from becoming cluttered with material which is no longer of company interest.

The second broad area of operation is use of stored information. Stored information—literature, patents, and company reports,—is brought to light by searches. A search may be carried out by an Information Researcher on his own initiative, or it may be requested by groups or individuals in other divisions. A frequent preface to the start of a requested search is the reformulation of the request so that the aims and scope of the search are more clearly defined. A search request often can be rephrased to answer a broader question, or several questions at once.

It is important to recognize that these searches go beyond the mere collection of references to form bibliographies. The Information Researcher brings his experience and knowledge to bear in analyzing these references, so that they may be used to best advantage. Where a prospective search concerns a narrow area primarily of interest to one individual, the Information Researcher may guide the individual in carrying out the search himself, by suggesting how and where to look for the desired information.

The third area of operation involves maintaining expertness. This takes the form of developing and keeping up a broad familiarity with the chemical literature, attending professional meetings, attending classes which help to develop new areas of competence, and maintaining a thorough knowledge of company programs, interests, and needs. While all of these activities are important to any chemist, they are particularly important to the Information Research Chemist, since he is called on to deal with problems in a much wider area than is the average lab chemist.

Fourth, and perhaps most essential, is the communication of results. No evaluation of current literature, no search—no matter how thoroughly and expertly performed—can be of any value unless the results are communicated to those who are in a position to turn them into action. This may mean a bench chemist or it may mean top management, depending on the nature of the material involved. It may mean a single individual or a large number of individuals, who may, moreover, be scattered at various geographical locations in a large operation such as that of Esso Research. A thorough knowledge of company interests pays off here, helping the Information Researcher to direct his report to those who can use it most effectively. Information must be communicated precisely and lucidly, in a form appropriate to the problem at hand. Thus, the style of two reports, one aimed at solving a current company problem and the other proposing a new area of research, will necessarily be quite different, if each is to produce the optimum result.

At present, each of the Information Research sections of TID is headed by a senior Ph.D with extensive company experience who must possess certain indispensable attributes: he must have a sound technical background, as well as a thorough knowledge of company problems; he must have the confidence of top management, in order that his evaluations may bear weight; he must possess initiative and imagination, for he is generally operating very much on his own initiative, in new and challenging areas; he must be able to communicate his findings effectively, both orally and in writing; and, finally, he must be enthusiastic about his work, and believe fully in the importance of Information Research.

Each Information Research section is staffed with additional senior and junior men who must possess in great measure the same attributes as described above, though they may lack some of the years of experience.

It is frequently difficult to assess the accomplishments of an information group, but TID can point to a number of areas in which its influence has been felt. One such area is the increased use of the literature by laboratory personnel, a prime aim of TID's philosophy. This is reflected by greater use of the library, and by a rise in journal circulation. Another indication of the value of TID activities is in the new research programs TID has been instrumental in developing. One of the most dramatic of these reached fruition last year when the Jersey organization announced the development of a new process which will make it possible to use petroleum products as fuel in steel industry blast furnaces. This is one example out of many in which Information Researchers worked as an integral part of the research team.

As the need for Information Researchers continues to grow, the questions arise, "Where does one find an Information Researcher? How are Information Researchers trained?"

Information groups at Esso and elsewhere have found that new Information Researchers are often hard to find. This frequently reflects a general lack of knowledge about the operations and rewards of what is still a very young and not well known field. At present, no academic program for the training of Information Researchers is available. The Information Research personnel of TID were either selected from within the company or hired direct from school. None have had previous training in the information field. There is a good deal that can be done to stimulate topnotch young scientists to turn to Information Research as a career.

Academic institutions can go a long way toward instilling in the student an appreciation for the importance of the literature. They must emphasize the value of making full use of the literature—including abstract journals and patents—and must further teach how to use this literature most effectively. They must promote the precise communication of information. They must encourage the student to develop and make use of a reading knowledge of foreign languages, particularly Russian. One excellent way of accomplishing these objectives would be the widespread establishment of Chemical Literature courses such as that described by Dermer in the ACS monograph, "Training of Literature Chemists."[4]

The industrial organization itself can help greatly by emphasizing to educators and students the importance which it attaches to the work of Information Research Chemists. It can explain its needs for such men to campus contacts, placement officers, and potential new employees, in promotional literature and in job interviews. The Esso Speakers' Bureau has prepared a talk on Information Research Careers, for presentation to interested student groups.[5]

Today's deluge of information can be of enormous value if adequate techniques are developed to use it. Experience at Esso has shown that Information Research can contribute greatly to the effective use of the literature, thereby increasing the productivity of current research efforts and stimulating the creativity of the entire research organization.

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The Documentation Research Chemist[1]

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The dictionary defines a document as a means of storing information. Documentation chemists prefer to be much more positive and, in a broader sense, we interpret chemical documentation work to include both the storage and retrieval of chemical information; also we like to include in the definition any necessary interpretation of such information when retrieved. The handling of large numbers of documents usually requires special equipment such as punched card machines or computers. The term "Chemical Documentation" should not convey merely the special techniques, but rather the whole process of storage, retrieval, and interpretation of chemical information.

What do we include in the term "chemical information"? The three major types of chemical information to be considered in this paper are:

(A) structures of compounds;
(B) properties of compounds or mixtures thereof;
(C) chemical processes, reaction conditions, *etc.*

Structures indicate how atoms are joined to form molecules. The structure is the basic information which is conveyed best from chemist to chemist by a structural formula; it may be most easily printed in form of a name (although several names may represent the same compound) or may be represented unambiguously by means of a linear chemical notation system, often called a cipher.[2,3] A cipher would place every compound in one definite position in an index. A translation step is required to regenerate the structural formula from a name or a linear notation. This is critical, because the average chemist, especially one dealing with organic compounds, wants to use the structural formula rather than a name, number, or notation.

The problems of indexing are important, since the hundreds of thousands of known compounds require organization in indexes for retrieval. The subject and molecular formula indexes of *Chemical Abstracts* enable retrieval of information pertaining to a single compound or closely related compounds, but it is almost impossible to run a truly generic search with *Chemical Abstracts*.