

Division uses our list of basic-research papers published each year as the basis for preparing digests for inclusion in a magazine entitled *Search*; this is distributed throughout the scientific community and also serves as an important aid to recruiters visiting university campuses.

A Scientific Liaison Group in our company also makes use of these lists to provide information to universities or consulting groups.

It may be seen, then, that well prepared lists of company publications, classified as needed, can be useful tools in a variety of ways in an industrial organization.

- (1) "Publication of Basic Research Findings in Industry, 1957-1959." NSF61-62 National Science Foundation, Washington, D. C., 1961.
- (2) R. F. Marschner, and J. O. Howe, "Better Written Reports," *Res. Management*, 3, No. 3, 147-155 (1960).
- (3) B. H. Weil, "What Organizations Are Doing to Improve Papers," *Chem. Lit.*, 7, No. 2, 3 (1955).
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Government-Sponsored Research Reports in Three Areas of Physical Chemistry*

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In the last five or six years, there has been much discussion regarding the value of the unpublished government-sponsored research report as a medium of scientific communication.¹⁻⁶ As a result of interest stimulated by the Humphrey Committee investigations of problems on coordinating government research information,^{7,8} and through the leadership of the National Science Foundation, great strides have been made in recent months toward wider dissemination of information gathered in research under government sponsorship, not only to persons performing this research, but to the members of the scientific community at large.

As a first step in exploring the use of these unpublished technical reports by physicists and chemists in the Los Angeles area, the present study was undertaken to examine in some depth just what is available in this literature in three areas of physical chemistry and to note some of the characteristics of the reports and some problems associated with searching for this type of information. The case histories which we shall present originated as requests for open literature surveys and were conducted by members of the Literature Research Group at Aerospace Corporation.

As our company is a relatively new one, it might be of interest to interpose here a brief description of Aerospace Corporation and its mission.

At the request of the U. S. Air Force, and with its support, Aerospace Corporation was established in June, 1960, to perform research, development, and advisory services for the U. S. Government and to contribute to the support of scientific activities and projects for the Government. One major mission of the Corporation is to serve the Air Force in the management of space systems

and advanced ballistic missiles. Members of the Laboratories Division, where both basic and applied research are conducted, requested the literature surveys which we have selected as case studies for this paper. We wish to emphasize at this point that we do not propose to draw any generalizations from these studies. Being user-oriented, our approach has been 100% pragmatic, and the observations which we shall make are purely subjective.

To paraphrase a hyperbole which is original with a well known experimental psychologist, searching the report literature is like poking a haystack with a needle. Approaches are diffuse, and once a search has been made, there is no way of estimating its completeness. The chief source of report literature covering a wide range of subject fields is the *Technical Abstract Bulletin* of the Armed Services Technical Information Agency, issued primarily for the use of Department of Defense contractors. The unclassified section of the *Technical Abstract Bulletin* is made available to the general public by duplicate publication in *U. S. Government Research Reports*, issued by the Office of Technical Services. Ideally, ASTIA's collection should include all of the reports generated by recipients of about 75% of the Government's research and development dollars. ASTIA officials, however, have stated that ASTIA now receives, and lists in its Bulletin, about one-tenth of the reports which defense contractors have produced.

One of the major handicaps of the report literature indexes is that none of them has had a sufficiently long period of development for indexing policies and practices to be crystallized to some degree of consistency. Inconsistencies in quality of abstracts complicate the problem. *Nuclear Science Abstracts*, which aims at complete coverage of report as well as journal literature in its field, is a notable exception. Its subject indexing, though broad, is consistent and prompt. *International Aerospace Ab-*

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stracts, now in its second year of publication, is also a well organized source of unclassified report literature; subject indexes have not yet appeared. In January, 1960, *Chemical Abstracts* began coverage of *U. S. Government Research Reports*. A minor criticism may be made of CA's citation of these reports, which is by PB number, with no indication of the precise number of the report as assigned by its issuing or sponsoring organization.

General approaches to the chemical information in Government publications are ably discussed elsewhere.⁹⁻¹² As an appendix, we have listed some sources which are useful for searching the report literature. Indexes which cover only classified literature are not included. Applicable sources were consulted in each of the examples to be presented. We should like, however, to mention a little publicized approach to government research information, namely the Department of Defense Project Card, commonly known as DD-613. We wish also, in presenting two of our case histories, to discuss some experiences in using the facilities of the Armed Services Technical Information Agency.

The Department of Defense file on 613's represents the one single source where all research and development undertakings of military departments and other Department of Defense agencies are reported. The project card contains descriptive and administrative type information, a background history of the project, and lists the technical reports which have been issued, or a specific organization, with address and telephone extension, from which additional information on the project may be obtained.

The only complete file of 613's is maintained in the Office of Directory Defense Research and Engineering.* It has recently been reported, however, that plans are underway to extend the availability of this information from the management level down to the level of the project engineer and officer.⁸ Stern has also reported that the information on the basic research section of the 613's has now been put on magnetic tape for electronic data processing.⁸ It is not yet known how accessible this facility will be to other echelons of government research activity.

Aerospace Library is fortunate in having a complete file of the Air Force component of the 613's. The major breakdown is by Research Planning Objective, 800 being the designation for basic research. Searching for references to technical reports which have been issued under current tasks is accomplished by laborious page-by-page examination of the project cards of interest. Two retrospective approaches to basic research sponsored by the Air Force Office of Scientific Research are: *Air Force Scientific Research Bibliography, 1950-1956*, published in 1961 by the Library of Congress, and *Basic Research Resumes, 1959 and 1960*, compiled and indexed by Herner and Company. The Library of Congress compilation lists publications issued by AFOSR contributors, while the Herner compilation abstracts and indexes project cards only.

The first case history, one which we elected to study in most detail, represents an area of research for which there is a sizable journal literature. It is a continuing

search on *Dissociation and Recombination Kinetics of Hydrogen, the Halogens, and the Hydrogen Halides*. We also wanted to find information on the inhibition of these reactions by oxygen, water, acetylene and similar compounds, vibrational relaxation times, as well as optical properties of the species. The open literature was searched from 1900 to the present, using *Chemical Abstracts*, *Physics Abstracts*, *Chemical Titles*, and other conventional indexes. Concurrently with the open literature search, for the purposes of our present study, we made an intensive effort to locate unpublished research reports on these subjects. This example was selected because it is an area of research which meets the requirements of being basic, in that few firm theories exist on non-equilibrium phenomena and irreversible thermodynamics, and because of its possible propellant applications.

In addition to the subject files of the Aerospace Technical Documents Collection, the applicable report sources listed in the Appendix were consulted. Machine searches of the ASTIA collection were conducted by personnel at ASTIA Headquarters in Arlington, Va. A manual search was made of the subject files in the ASTIA Los Angeles Regional Office, covering reports in the AD series from 1953 to the end of 1959. Sections 4, 9, 10, 25, and 30 of the *Technical Abstract Bulletins* from July, 1959, through Dec. 15, 1961, were examined page by page. For comparison, the cumulated indexes of descriptors were also consulted. In the cumulations, the long lists of AD numbers under essentially unmodified descriptors present a problem in searching. In some cases, correlation of AD numbers under related descriptors was facilitated by photocopying the columns of numbers and cutting them into strips for ease of manipulation. In other cases, it was preferable to select from the limiting or distinguishing facet of retrieval terminology, usually what would be a modifier or subheading in traditional indexes.

Another problem in using the cumulated indexes arises because only the descriptors which the subject analyst considers significant are included in the cumulation. It is perhaps a truism to say that too frequently the subject analyst's conception of what is significant does not coincide with what users of the information consider to be important. Nevertheless, this is a vexing problem. For example, in the present study, several instances were found where the recombination reaction constituted a significant portion of the research report (in more than one instance the word recombination was used in the actual title of the document), yet Recombination was not asterisked for inclusion in the index, though it was used as a descriptor.

Three separate machine searches were conducted at ASTIA Headquarters, using three different sets of descriptors. The number of pertinent AD reports found by machine searching was 82, in comparison to the 242 found by manual searching. The disparity of numbers was caused principally by three circumstances: (1) inaccuracies and insufficient depth of indexing at ASTIA; (2) manual location of relevant reports which we had not anticipated finding and which we had not asked the machine to find; (3) less than optimum prescription of retrieval terms on our part. In our searches of the conventional literature, we are accustomed to employ a certain amount of redundancy in selecting searching points to ensure as complete retrieval as possible. It is doubtful that this

* ASTIA now maintains a complete file on DD 613's, indexed and on computer tapes for searching. To obtain searching service, all organizations other than the military must request approval of Dr. Robert Stegmaier, Office of Defense Research and Engineering, The Pentagon, Washington 25, D. C.

is a good approach to retrieval from manipulative correlative indexes. In fact, our experiences with prescribing descriptors for machine searches at ASTIA during the past 18 months tend to bear out Bernier's statement that though selectivity increases with the number of terms used simultaneously in searching correlative indexes, this selectivity is gained at the risk of losing part or all of the information desired.²⁰ On the other hand, when too few terms are used, the retrieval of large amounts of unwanted material reduces the search to a predominantly manual operation.

Table I summarizes some of the characteristics of the reports found on Dissociation and Recombination Kinetics, in comparison with the characteristics of journal articles published during the same period, 1952-1959.

Our second example, "Vacuum Ultraviolet Photolysis of Organic Compounds," illustrates further the problem of deciding the most efficient way to prescribe descriptors for machine searching at ASTIA Headquarters. First of all, there is the problem that there is no provision for distinguishing between different wave lengths of the ultraviolet spectrum. It is accepted that coding for numerical ranges presents more difficulties than gains. The fact, however, that relatively little research has been performed in the vacuum ultraviolet makes the screening process all the more important. An uninitiated person might make the assumption that he would retrieve the wanted reports by asking the machine for only those reports where the three following descriptors were used in combination: Ultraviolet radiation, Photolysis, Organic compounds. Examination of descriptors listed with abstracts on this subject in 1960 and 1961 TAB's reveals that such a prescription would produce no reports at all. It seems unreasonable to require that each specific compound be posted under its ultimate generic class (Inorganic, Organic), as well as the functional groups to which it belongs. Yet, retrieval by listing all relevant groups of compounds, even when they are known, would be a tremendous operation. Obviously, then, a search for reports on vacuum ultraviolet photolysis of organic compounds can be accomplished only through manual screening, by wave length and by class of compounds, of

Table II. Descriptors Common to Reports on Ultraviolet Photolysis of Organic Compounds Listed in Technical Abstract Bulletin, 1960-1961

Photolysis (112) ^a	Ultraviolet radiation (193) ^a	Decomposition (914) ^a	Photochemical reactions (169) ^a
X	X	O	X
O	O	O	X
X	O	X	O
X	O	X	O
X	X	O	X
X	O	X	O
O	X	O	O
O	O	O	X
X	O	X	X
X	X	O	X
X	O	X	X
X	X	X	X
X	X	O	X
X	X	X	X
X	O	O	X
X	O	O	X
X	X	X	O
X	X	O	O
X	O	X	O
X	O	X	O
O	X	X	X
X	O	O	O
X	O	X	X

^a Frequency of assignment as of June, 1961. X, assigned to report; O, not assigned.

Results of Correlating Some of the Above Descriptors

Correlations	Hits	Misses
Photolysis	19	4 ^a
(Ultraviolet radiation) (photolysis)	8	15
(Ultraviolet radiation) (decomposition)	4	19
(Ultraviolet radiation) (decomposition) (photochemical reactions)	2	21

^a Underassignment.

the results of the machine search, and the chief function which the computer has served is one of filing and storage.

Manual searching of the ASTIA TAB's, 1960-1961, produced 23 reports on vacuum ultraviolet photolysis of various compounds. Table II lists some descriptors common to the 23 reports. It is immediately apparent that the easiest way to assuring nearly complete retrieval of these reports would be to prescribe one descriptor only, Photolysis, requiring manual screening of at least 112 cards or examination of at least four times as many cards as those found pertinent. Because of underassignment of terms, complete retrieval of these 23 reports would require programming for all reports assigned Photolysis, plus all of the reports assigned Ultraviolet radiation but not Photolysis, plus all of the reports assigned Photochemical reactions but not Photolysis or Ultraviolet radiation. The percentage of irrelevant information would be quite high.

Going a few steps further into specificity, if we are interested in photolysis of ketones, is it necessary to list the "also sees" under Ketones as retrieval terms in order to be assured of obtaining information about photolysis of all ketones? If this is desirable, and manipulation of sets of descriptors from the 1960 and 1961 cumulative indexes indicates that it is, will users normally remember

Table I. Characteristics of Publications on Dissociation and Recombination Kinetics, 1952-1959

	Unpublished govt. research reports		Journal articles	
	No.	Per cent	No.	Per cent
Performers of research				
Government laboratories	42	14.1	60	8.5
Industries	51	17.2	55	7.7
Universities	149	50.3	240	33.8
Other nonprofit institutions	9	3.0	14	2.0
Foreign institutions				
Universities	29	9.7	238	33.5
Other	17	5.7	103	14.5
Total	297	100.0	710	100.0
Research approach				
Theoretical	98	33	120	17
Experimental	166	56	525	74
Reviews and compilations	33	11	65	9
Total	297	100	710	100

to suggest all of these terms? I think it is not unreasonable to urge that pyramiding be raised at least to this level of generic posting.

We recognize that failure to provide for generic searching is an inherent deficiency of traditional indexes also. Though *Chemical Abstracts*, for example, treats the subject of our search generically under Light, ultraviolet, additional references are scattered under names of specific compounds. It seems, however, since bulkiness is not a major problem in mechanized systems, that generic searching is the area in which these systems can be of greatest value to organizations such as ours.

These are some of the problems which will have to be worked out if users of ASTIA are to obtain satisfactory results from the bibliographic services available. Users will need to gain a clear understanding of the principles of correlative indexing and of the policies and procedures connected with mechanized information retrieval at ASTIA Headquarters. It is expected that the revision of the *Thesaurus of ASTIA Descriptors* and accompanying explanatory material will eliminate some of these problems.

"Thermodynamic Properties of Lithium and Kinetics of Reaction with other Metals" represents a search for which the requester specified summary reports containing, among other things, phase equilibria diagrams. His requirements had not been met with information from standard, conventional sources such as *Gmelin* and the NBS published Circulars nor from journal references found in *CA*. The desired information was found in unpublished reports issued chiefly by the Oak Ridge National Laboratory and by the Naval Ordnance Test Station, China Lake, California, and in preliminary reports issued, but not published in conventional media, by the National Bureau of Standards. The security classification of all reports located was Unclassified, some having been declassified since initial issuance. Some of the summary reports located contained extensive tabular material and are illustrative of the type of data mentioned by Gray² which frequently escapes publication because it exceeds journal space requirements. This example has been presented because compilations of physical properties and the like represent a segment of the report literature which is frequently overlooked, though it is of great potential value to the working scientist. Authors of an article in the February, 1962, issue of *Physics Today*²³ also mention the elusiveness of this type of information: "Compilations have a tendency to get published in peculiar or obscure places. In the literature of science they are the stepchildren." And here the authors cite three compilations of nuclear data which had been issued as unpublished research reports.

We have presented case studies of government-sponsored research reports in three areas of physical chemistry. As our work was carried out at the request of physicists and chemists conducting basic research, and in close consultation with them, it is assumed that their needs and problems are reflected in the observations we have made. Some of the comments made by these men are

2. Some of the reports located, such as progress reports, are repetitive and would not be adaptable to journal publication.
3. The fact that technical reports are not monitored by one's scientific peers results in the publication of information which authors would dare not submit for publication in conventional media.
4. To avoid some of the inaccuracies in indexing technical reports, it is recommended that authors of government research reports be required to submit indexing terms together with their abstracts. (This suggestion will receive some implementation in one phase of the program now proposed for improving the capabilities and services of ASTIA.)

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APPENDIX

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DIRECTORIES

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* Subject files of the ASTIA Los Angeles Regional Office, covering reports in the AD series from 1953-1959, were searched in lieu of the *Title Announcement Bulletin*.