SEARCHING THE CHEMICAL LITERATURE

A collection of the papers presented at the Symposium on Searching the Chemical Literature held by the Division of Chemical Literature of the American Chemical Society at the 117th national meeting in Detroit, April 16 to 21, 1950. Also included are four revised papers from the Symposium on the Preparation of Literature and Patent Surveys held by the Division of Chemical Education at the 111th national meeting in Atlantic City, April 14 to 18, 1947.

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The Use of Chemical Abstracts

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Chemical Abstracts' editorial policies, adopted to meet the wishes of its users, have given this journal certain emphasized properties. These properties are described and discussed, because a knowledge of what to expect in a publication is essential to its most effective use. The scope of *Chemical Abstracts* is outlined, the three essentials for complete coverage within this scope are described, the efforts for quality in abstracts and for promptness in their appearance are discussed, form and arrangement are mentioned, and the five kinds of indexes published are given consideration, with the emphasis on subject and formula indexing. In the interest of growth in the service rendered by *Chemical Abstracts,* the editor offers an attentive ear to users of this journal.

An editor needs ears more than he needs a pen when the use of his journal is discussed. It is better for him to listen to users than to try to tell them how to proceed. It is only because this editor has done a lot of listening and has tried to build his journal accordingly that he has consented to discuss the use of *Chemical Abstracts.*

Chemical Abstracts has a large staff of abstractors, about 700 altogether, and these constitute a representative group, because all kinds of chemists are needed in approximate proportion to the research activities in the various branches or fields of chemistry. Each of the 33 sections and 9 subsections of *Chemical Abstracts* is in charge of one or more section editors well informed in the field of the section. The abstractors and section editors, active in many kinds of chemical work, are often consulted as to matters of policy, so that the editor does have good and regularly available contact with users of *Chemical Abstracts* right in the *C.A.* family. In addition, many others are consulted and many write to tell of their needs. Listening is a source of growth.

Chemical Abstracts' editorial policies, adopted to meet the wishes of its users, have given this journal certain emphasized properties. These properties are discussed briefly here, because a knowledge of what to expect in a publication is essential to its most effective use.

Coverage

Complete coverage of chemistry and chemical engineering has long been attempted, so that a searcher can use *Chemical Abstracts* with a feeling of reasonable confidence that he will not miss important contributions if his search is careful and thorough. The publication of adequate abstracts and of full, well-constructed indexes is a factor in completeness as well as is the reporting of all suitable papers and patents that appear.

The words defining limitations in the coverage by *Chemical Abstracts* are "chemical" and "new." A paper to be covered must contain new information (the results of experiment or experience) which is of chemical interest, except that good reviews, those

accompanied by references, and papers of biographical or historical interest are briefly reported. Users of *Chemical Abstracts* sometimes expect to find nonchemical information therein. The scope of *Chemical Abstracts* is determined by a broad and generous interpretation of what is of chemical and chemical engineering interest and considerable nonchemical information gets into the journal in the brief abstracting of papers only partially of chemical interest, but no user of *Chemical Abstracts* should count on this journal for complete coverage of any nonchemical subject.

It is not easy to define the borderline between chemistry and other sciences. This borderline is often indefinite and indistinct. In general, the policy is to abstract a paper in case of doubt as to its chemical nature. In particular, it is difficult to draw a line between the various branches of biology and chemistry. In this effort the abstractors and editors are guided by a six-page statement entitled "Biochemical Borderline and the Classification of Biochemical Abstracts in *Chemical Abstracts*." Copies of this will be sent to interested users of *Chemical Abstracts* on request. Clinical papers involving the use of chemical compounds in the treatment of disease, but with no chemical results reported, are counted as being outside of our chemical field.

Chemical Abstracts now systematically covers over 5000 journals. It is sometimes asked what determines whether or not a journal is covered. The answer is that a journal is placed on the list for coverage as soon as it is discovered that at least occasionally it contains new information of chemical interest. Coverage, of course, does not mean the abstracting of all papers in a journal. As a matter of fact, all papers are abstracted in only a comparatively small percentage of the journals in the "List of Periodicals Abstracted by *Chemical Abstracts*." The above-mentioned criteria for inclusion are applied to individual papers, not to journals. Many trade journals are covered as well as scientific and technical publications. House organs are occasionally the source of abstracts suitably published in *Chemical Abstracts*, but articles in these are not abstracted when they have an advertising flavor. *Chemical Abstracts* rarely abstracts anonymous articles, as experience has taught that they seldom contain information not already published elsewhere in signed articles. Published miscellaneous bulletins, circulars, and the like, such as those issued by government agencies, are abstracted, but mimeographed or otherwise unpublished governmental reports and documents are not covered. Books are not usually a source of new information, but when they do report for the first time the results of experimental investigation they are abstracted. Otherwise new books are merely announced.

Sometimes we are asked whether or not the possessor of a file of *Chemical Abstracts* needs also to turn to *British Abstracts* and to *Chemisches Zentralblatt* to make chemical searches complete. This is difficult to answer categorically. The abstracts in these European abstract journals are systematically checked against our record of abstracts after a period of time and when they have covered a paper of chemical interest which *Chemical Abstracts* has missed we proceed in one way or another to get an abstract. *British Abstracts* is no longer strictly a chemical abstract journal and *Chemisches Zentralblatt* covers some papers which we regard as clinical or otherwise not chemical. As far as chemical papers are concerned, it is our belief that *Chemical Abstracts* covers everything which these other two abstract journals cover, but does so in certain instances with less promptness. It should be borne in mind, however, that there is a human element in abstracting and indexing and that no two abstractors will report a paper exactly alike nor will two indexers always select exactly the same information to record. There was a time when *Chemisches Zentralblatt*, which has always emphasized the organic side of chemistry, was more complete in its organic reporting and indexing (in particular, it published fuller patent abstracts) than was *Chemical Abstracts*. This is no longer true, but it is true that owing to the human element there is an advantage in having access to more than one chemical abstract journal in making the most thorough kind of a search.

Quality of Abstracts

The user of an abstract journal naturally wants to know what kind of abstracts to expect and something about their quality. For strictly chemical papers, particularly

those from the less accessible publications, *Chemical Abstracts* endeavors to publish informational abstracts, not merely descriptive or indicative abstracts. Completeness enters into the picture again in the kind of abstracts published. *Chemical Abstracts* places special emphasis on having abstracts complete from the indexing point of view. Abstractors are reminded repeatedly that they should report every measurement, observation, method, apparatus, suggestion, and theory that is presented in papers as new and of value in itself. Also we insist that abstracts include all new compounds and all elements, compounds, and other substances for which new data are given.

The quality of abstracts is determined in part by the kind of abstractors used. *Chemical Abstracts* endeavors in so far as possible to have each abstract made by an individual who has reason to be well informed as far as the subject matter is concerned.

Abstracts in *Chemical Abstracts* are not critical. It is believed that users of *Chemical Abstracts*, both present and future, will want to be their own judges as to what is of value and of interest to them and would prefer not to have the editor select their diet. Accordingly, once a paper has passed the editorial board of a reputable journal *Chemical Abstracts* tries to report its chemical content faithfully, no matter what the editor's estimate of its value may be.

Accuracy in an abstract journal is naturally of interest to users. Too many mistakes get into *Chemical Abstracts*. Nevertheless a good deal of care is exercised to keep abstracts accurate (much checking is done). Because an abstract journal is secondary information, not source material, *Chemical Abstracts* does not publish an erratum section, but the more serious mistakes and omissions discovered are corrected by the use of supplementary abstracts or by suitably worded index entries.

The users of an abstract journal have a right to expect good nomenclature in the make-up of abstracts and indexes. It is the policy of *Chemical Abstracts* to accept and use the nomenclature as recommended by the Nomenclature, Spelling, and Pronunciation Committee of the AMERICAN CHEMICAL SOCIETY and as approved by the International Union of Pure and Applied Chemistry. A special effort is made to use good, consistent, systematic nomenclature in the subject indexing of *Chemical Abstracts*, with an adequate supply of cross references. These subject indexes are sometimes used as a source of nomenclature information in addition to their use as a key.

Promptness in Publication

Promptness in the publication of abstracts is of much interest to users of an abstract journal. As abstract journals go, *Chemical Abstracts* has a reputation for reasonable promptness. For example, a study by Dwight E. Gray has shown that, during the 6-month period of 1948 from January to June, 1731 abstracts were published in *Physics Abstracts* (it is a part of *Science Abstracts*) and that of the papers covered by these 1731 abstracts 811, or 47%, were abstracted by *Chemical Abstracts*. Of these 811 papers 55% were reported sooner in *Chemical Abstracts* than in *Physics Abstracts* while 15% were reported simultaneously by the two abstract journals. Our showing is better in the covering of chemical than in the covering of physical journals. However, prompter abstracts are desirable and much effort is made in that direction. It takes a month for abstracts to go through the printing mill. On an average it takes perhaps a little more than a month to get papers assigned and abstracted, with a week or two of additional time for recording, checking, and editing. There is always a scattering of abstracts of relatively old papers in *Chemical Abstracts* because a journal has been missed, an abstractor has been ill or on a trip or has had other reason to delay, a question has come up concerning a paper or an abstract which has required correspondence, etc. Some overseas journals appear long after the date carried on their covers, or at least reach this country late.

With world-wide coverage, the effort for completeness means the continuous picking up of papers from remote places or obscure publications. Discovery of these is possible only after a period of time. Wars play havoc with promptness and regularity in the obtaining of papers and abstracts. The users of *Chemical Abstracts* can count on this journal continuously striving to make amends for things missed. Most of the periodicals

published during World War II were covered currently (*2*), and most of the papers missed have now been obtained and abstracted in one way or another.

Economy is a factor in promptness. Work done as a service, as by the abstractors, cannot be pushed so much as can work done on a full-time, full-pay basis, and tasks must take their turn when an office staff continuously has its hands full to overflowing.

Form and Arrangement

The form and arrangement of *Chemical Abstracts* must be largely a matter of observation by users.

While the development of chemistry has required some changes in the classification of abstracts in *Chemical Abstracts* through the 43 years of its existence, these changes have purposely been kept to a minimum. Users of *Chemical Abstracts* get accustomed to looking in certain places for certain kinds of information. We do things to disrupt such habits only when there is urgent need for reclassification.

With the exception of the section on biological chemistry (this section annually contains about three times as many abstracts as does its nearest competitor in this respect) the sections of *Chemical Abstracts* are not subdivided, but an effort is made to group like abstracts and to follow a more or less regular outline of subjects in the grouping.

When an abstract bears a more or less direct relation to the subject matter of more than one section of *Chemical Abstracts*, it is placed in the section considered most suitable, with a cross reference entered in the one or more related sections. Users of *Chemical Abstracts* are warned that there are several limitations affecting this use of cross references. Aside from the human factor, which results in suitable cross references being overlooked at times, there is the necessity, for the sake of economy, of avoiding cross references between certain sections. For example, a large percentage of the abstracts in the section on nutrition are of interest to the food chemist as well as to the nutrition chemist, so that many cross references might properly be placed in the section on foods and vice versa. Instead of using such a wholesale lot of cross references it is considered reasonable to expect that those who use *Chemical Abstracts* will remember to look in sections other than the one in which they are principally interested when there are distinctly related sections. Many who use *Chemical Abstracts* regularly examine groups of sections rather than single sections. Of course, after the annual indexes appear these take the place of classification and cross references as a means of locating information.

Greatly to our surprise we have discovered that some readers of *Chemical Abstracts* do not take advantage of the fractional column designation in *C.A.* references. both in abstracts and in the indexes. *Chemical Abstracts* pioneered in the numbering of columns instead of pages and in the designation of fractions of a column. The large amount of time to be saved by the use of these devices is obvious.

With more space available in 1950, authors' addresses as a part of abstracts have been restored. Users of our abstracts no doubt wonder sometimes why some abstracts do not give the authors' addresses. With rare exceptions the omissions are due (1) to absence of an address in the paper being abstracted, or (2) to inadequacy in the address as given. Not infrequently overseas publications merely give the name of an institution without saying where it is.

Indexes

Chemical Abstracts is thoroughly, carefully, and we believe, properly indexed. This is an important factor in its use. The journal is regarded as more valuable as a permanent record of the progress of chemistry than as a source of current information obtained by scanning. About half of the effort expended in the production of *Chemical Abstracts* is devoted to the building of the indexes. Five kinds of indexes are produced, devoted to (1) authors, (2) subjects, (3) formulas, (4) patent numbers, and (5) organic rings. A discussion of the indexing program of *Chemical Abstracts* was recently published (*3*).

No discussion of the use of author and numerical patent indexes seems necessary.

The Subject Index is the most frequently used of the indexes published by *Chemical Abstracts*. Statistics show that this is true by a wide margin.

Here is a table showing in percentages the order in which 500 representative chemists have reported finding our indexes useful to them.

	Subject	Author	Formula	Numerical Patent	Organic Ring
First	76.0	20.1	2.9	0.8	0.2
Second	18.7	62.0	12.7	5.5	1.1
Third	2.1	17.2	45.5	26.9	8.3
Fourth	0.7	4.5	28.6	32.5	33.7
Fifth	0.0	2.4	3.2	33.4	61.0

This same inquiry brought forth the information that 71.9% of our abstractors use the *Chemical Abstracts* Formula Indexes, though they find the Subject Indexes primarily more useful by the wide margin shown in the table. Another more extensive inquiry has shown that 48.6% of our readers use the Subject Index regularly while 33% use it occasionally. The corresponding figures for the Author Indexes are 19.9 and 40.0%, respectively.

Incidentally, inquiry has brought forth the information that 81.7% of the subscribers to *Chemical Abstracts* use the Author Indexes to the individual numbers of this journal and 73.4% expressed themselves in favor of 5-year instead of 10-year collective indexes in the future, with 17.3% on record as in favor of continuing the 10-year span for such collective indexes; the remaining 9.6% expressed no preference.

Information in an extensive abstract journal becomes buried, so that part of the purpose of such a journal is defeated if the indexing, particularly the subject indexing, is not thorough and thoroughly well done. The indexes to *Chemical Abstracts* are built with this conviction constantly kept in mind and with the hope that they serve as a workable key to all of the recorded information. In subject indexing, titles of papers are usually wholly inadequate for complete indexing. As a matter of fact, the subject and formula indexes to *Chemical Abstracts* are based not only on whole abstracts, but often on the original papers. Much of this indexing is done with original papers open before the indexers. This means that while the abstracts are normally built to be adequate from the indexing point of view, experienced indexers do sometimes discover omissions and remedy them. In the use of these indexes this fact should be borne in mind. The words used in indexing information omitted from abstracts, or only referred to there in general terms, are chosen in such a way as to help identify such a situation.

Subjects, not words, are indexed by *Chemical Abstracts*. There is a wide difference. Word indexing leads to omissions, scattering, and unnecessary entries. True subject indexing avoids these defects. Subject indexing means, of course, that the words used in the index may differ from those used in the abstract. For the best results index users must be subject-minded rather than word-minded, so to speak.

Cross references, abundantly used in the subject indexes to *Chemical Abstracts*, serve not only to guide the index user from place to place as a help in making his search a thorough one, but also to overcome some of the limitations of words as an exact and definitive medium of expression. The cross references in the indexes to *Chemical Abstracts* are put there for use, for more use than they sometimes get by inexperienced index users.

It is the custom of *Chemical Abstracts* to publish an introduction to its Subject Indexes. The indexes are built to stand on their own feet. The introduction is not essential to the ready and effective use of a *Chemical Abstracts* Subject Index. Nevertheless, for the best results in the use of any index, the user must meet the index maker part way in an understanding of the indexing problem and in particular of nomenclature. The information in the Subject Index introductions is put there to help, and its use is recommended to the searcher who is doing more than incidental searching.

Words

Nomenclature has just been mentioned, as has also the fact that words have limitations. In spite of these limitations, particularly as they apply to the naming of chemical compounds, it is well to bear in mind that words play a tremendously important part in the work of scientists as well as of all others. The cooperation necessary for scientific progress depends principally on the use of words. For some purposes chemical formulas, mathematical expressions, and the like take the place of words usefully in

scientific communication, but by a wide margin words come first in general usefulness and this is considered true for indexing as well as for the everyday types of communication.

Formula Index

Because chemical names are subject to a certain amount of developmental change and because complex compounds are difficult to name, and lend themselves to correct naming in more than one way, *Chemical Abstracts* as long ago as 1920 adopted the practice of indexing compounds by systematically arranged empirical formulas (these do not vary), but it did not abandon the use of words also in the indexing of compounds. Readers are given their choice, with both the index by names and the index by formulas made complete. Entry in the Formula Index of the simpler and commoner compounds in the form of cross references to the Subject Index is regarded as wholly adequate formula indexing. Reference to the Subject Index from the Formula Index is possible for all entries because the names following formulas in the Formula Index are given just as they are to be found in the Subject Indexes. We have reason to feel convinced that this indexing of compounds in two ways effectively serves the purposes of the many kinds of users of *Chemical Abstracts;* some prefer the indexing by names, others prefer the indexing by formulas, and many others use both kinds of indexes, with one kind of index more helpful in some circumstances and the other kind more helpful in others. The Formula Index is particularly useful in the location of information concerning individual compounds.

Simplicity of form and structure and suitability to serve the needs of all kinds of chemists have been important considerations in the indexing of chemical compounds. The use of both name and formula indexes helps in this connection. It is considered that it would not be wise to limit the indexing of compounds to the Formula Index or to adopt a formula-indexing plan which is not applicable to all kinds of known compounds. Many kinds of chemists would not find exclusive formula indexing convenient or satisfactory. How many analytical chemists would like to be required to look up specific indicators by formulas, how many biochemists would want to look up folic acid, riboflavin, cholesterol, etc., by formulas, how many agricultural chemists would be happy if they were required always to look up insecticides by chemical formulas if definite compounds are involved, how many industrial chemists and how many physical chemists would want to figure empirical formulas before hunting up the more or less common compounds in which they are often interested? As a matter of fact, how many organic chemists would want to go to that trouble for the commoner, well-known compounds?

The calculation of formulas is not a simple and easy matter in many instances and experience has shown that Formula Index users sometimes get into difficulty because mistakes are made in formula calculation.

Use of the Hill instead of the Richter or Beilstein system of arranging formulas and of arranging the symbols of elements in these formulas has the advantage, on the side of simplicity, of the use of an alphabetic order of symbols beyond C and H and it also has the advantage of being suitable for inorganic as well as organic compounds.

The Richter system effects a certain degree of classification of compounds, but the purpose of an index is not classification. Classification is, to a degree, a tool of the indexer, but it is not his objective. If the classification brought about by the Richter system is good, and it has a certain value, so is the still more extensive classification brought about by our plan of using systematic nomenclature with inverted names in the Subject Indexes to *Chemical Abstracts*. Both classifications have limitations. Britton, Coleman, and Perkins (*1*) have spoken of the grouping of compounds possible in our Subject Index as outweighing "the disadvantages of having in some cases to look under several headings for isomeric compounds" and have verified what has been said about working with molecular formulas, the lack of difficulty in using the Hill arrangement, the existence of fields of chemistry in which searching by formulas would be a stumbling block, and the planning of a Formula Index to serve primarily as a means of locating individual compounds. With reference to this they have spoken of the *Chemical Abstracts* Formula

Index as satisfactory "because the policy is to include all described compounds and because of its conciseness of form."

The inclusion of inorganic compounds in a Formula Index of chemistry is considered highly desirable. Although many of the simpler inorganic compounds can be readily named and are accordingly entered in our Formula Index by the use of cross references only, there are many complex inorganic compounds, and the nomenclature of inorganic chemistry presents difficult problems. It is not so well worked out as is the nomenclature of organic chemistry.

The most important consideration in this connection is the fact that while *Chemical Abstracts* does not make its Formula Index the exclusive index of organic compounds or even the primary index of compounds, it does enter all compounds by formulas and thus gives the inorganic chemist the same consideration as that given the organic chemist without any neglect either of the organic chemist or of the chemist who is not prepared readily to calculate empirical formulas for complex yet familiarly named compounds.

There are certain other interrelations of indexes helpful in searching. The ring index aids in the use of the Subject Index, for example. Another example is the use of the author index to learn of possible other related work of an author when his work on some subject of interest has been discovered by use of the subject or formula index.

In the use of *Chemical Abstracts* there is no need to refer to the annual indexes if one of the collective indexes is available. There is nothing of value in the annual indexes which is not also in the collective indexes. There are more entries in the collective subject indexes than in the annual indexes for the periods covered and these collective indexes reflect the growth of chemistry and of the language of chemistry which has taken place during these periods. Mistakes discovered in the annual indexes are corrected in the collective indexes.

A factor in the usefulness of any publication is confidence in it to serve its purposes. This can be gained only by use. Confidence is not produced by editorial comment. It is hoped, however, that there may be some gain in that direction from our admission of mistakes made, of the need of more and constant growth, and of readiness always to listen to users of *Chemical Abstracts* who have criticism and suggestions to offer. It is hoped that our record of "firsts" in abstract-journal development proves the validity of this claim as to attitude. The abstract-journal staff has long believed in reasonable conservatism for the sake of stability in its service, but has never been afraid of change when real progress could be made within the journal's economic limitations.

This paper begins with the statement that "an editor needs ears more than he needs a pen when the use of his journal is discussed." So long a paper would seem to contradict this. The editor promises to subside now and become a listener again, with assurance to all users that criticisms or suggestions will be welcome always and will receive careful consideration. One criticism has been that the editor does not speak up often enough. This time it has been done.

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Influence of Nomenclatural Evolution upon Comprehensive Literature Searches

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Orismology, the science of definitions and defining, especially with reference to scientific and technical terms, is of special concern to all branches of chemistry. A concise survey of the more outstanding attempts of the past two centuries to reduce nomenclatural principles to law and embody them in system reveals that in this area progress lags far behind experimental discoveries and developments. Truly sound and permanent nomenclature in the rapidly growing and expanding field of chemistry can no longer be achieved merely through its part-time nurture by devoted individuals or the occasional hurried attention of committees composed of geographically scattered and professionally preoccupied persons. Modern conditions demand from the professional chemical society its generous, sympathetic, and protracted support of a small but full-time staff specifically and solely charged with this responsibility.

Not long ago among the intriguing tidbits which make up so much of the daily press, a brief item appeared which purported to have determined the dozen words most pleasing to the layman's ear. The specific content of this list has no concern for us, but one word which was not included does have interest and bearing. This word is "orismology," the science of definitions and defining, especially with respect to scientific and technical terms.

Once we have recognized orismology as the science of definitions, let us next be sure to extract the real juice of both of these words. Science comprises exact knowledge of facts, together with their correlation by means of recognized principles, methodically formulated into some rational and systematic arrangement. Factual knowledge by itself is mere information; its correlation through perception of regular principles advances the art, but not until this correlated factual knowledge is expressed in a regular and systematic formulation do we arrive at a science. Science is knowledge reduced to law and embodied in system.

If we accept orismology as the generalized, systematic formulation of definitions, let us be sure of the significance of the latter. A definition implies a formal and exact expression of a concept. A definition defines, limits, and specifies; it must include all that properly belongs while excluding all which does not. Definition differs from exposition and from interpretation, though these processes may felicitously amplify and enrich its significance. A definition is specific and compact; it may be described or illustrated, but neither description nor example in itself defines.

The field of nomenclature is one whose orismological characteristics both deserve and require the best efforts of all persons concerned with chemistry. Here indeed we must

truly develop a science of definition, or soon we shall become the victims of a confusion of tongues beside which the Tower of Babel will seem a room of silence.

Although the current difficulties of chemical nomenclature are both formidable and pressing, it may be encouraging to recognize that the existence of difficulties in this field is not new. The problems faced by contemporary chemists, perplexing and refractory though they may be, are merely variants and extrapolations of those that have faced the science from its beginning.

In this brief contemplation of the evolution of chemical nomenclature, no attempt can be made to probe into the multiplicity of small changes in usage of prefixes, suffixes, etc., which have occurred during the past two centuries. The number of such variations is legion, and to attempt to recapitulate even selective examples would quickly become tedious and soporific. This paper, therefore, proposes first to re-examine our nomenclatural foundations, next to review their extension to the organic field, and finally to direct attention to a few contemporary problems which are beginning to assume substantial magnitude.

The Foundation of Nomenclature

At the time of the Declaration of Independence (1776) there were known a total of twenty-three elements: carbon, sulfur, phosphorus, sixteen metals (gold, silver, platinum; copper, iron, lead, mercury, tin, zinc; arsenic, antimony; bismuth; cobalt, nickel, tungsten, manganese), and four gases (hydrogen, oxygen, nitrogen, and chlorine). Although numerous substances containing these materials were recognized, the composition of not a single compound of the group which we now call organic had been established. No one had ever heard of either atoms or molecules, much less of radicals, ions, electrons, protons, neutrons, magnetons, photons, mesons, and the rest. Nevertheless even then men of science were disturbed over the chaotic state of their scientific language and soon there appeared a quartet who were truly the pioneers of chemical nomenclature.

In fact, it was 163 years ago on April 18, 1787, that Antoine Laurent Lavoisier, then aged 44, personally appeared before a public assembly of the Royal Academy of Sciences in Paris and presented a paper entitled "The Necessity of Reforming and Bringing to Perfection the Nomenclature of Chemistry." Lavoisier was acting in this respect as the spokesman for three compatriots, de Morveau, Berthollet, and Fourcroy. In the following year this group published a volume entitled "Méthodes de Nomenclature Chimique," subsequently translated into English and still appropriately venerated (*14*) as the foundation stone of modern chemical nomenclature.

Even before the delivery of his speech there had been numerous other expressions of consonant ideas requiring only the prestige of Lavoisier to make them generally acceptable. Of these perhaps the most significant is a paper by de Morveau (*13*), who laid down even in those early days certain desiderata and principles well worth our review at this time. These were concentrated into a platform, each of whose six principal planks we may profitably note and discuss.

A chemical name should not be a phrase. In the early days of chemistry prior to the general acceptance of atomic and subsequent theories, many substances were characterized by clumsy and inconvenient expressions derived from various associations. Examples of these would include "oil of vitriol," "butter of antimony," "cream of tartar," "flowers of zinc," "liver of sulfur," "milk of lime," "sugar of lead," "spirits of nitre," etc. Very possibly de Morveau anticipated the probability that the substances designated by such names would occasionally, by careless classification, become indexed under "oil," "butter," "cream," "flowers," "liver," "milk," and "sugar," and thus be withdrawn from the chemist to the kitchen. Despite his warning, however, chemical names were frequently rendered as phrases for the next one hundred years and such forms as "acetate of sodium," "peroxide of hydrogen," and "permanganate of potash" have only recently disappeared from texts and books of reference.

The name should be neither arbitrary nor trivial nor involve the name of the discoverer. Presumably de Morveau sensed that in time there would be found a limited number of components whose combination in various ways and proportions would

yield the numerous substances with which he was familiar. Perhaps he sensed the confusion which would arise if a substance designated by a name derived from one chemist should subsequently be found to have, still earlier, been recognized by another or numerous others. Perhaps he recognized that such terminology would eventually place upon the minds of chemists an entirely unnecessary and laborious task. Names such as Glauber's salt ($Na_2SO_4.10H_2O$), Fremy's salt (KHF_2), Mohr's salt [$FeSO_4(NH_4)_2SO_4.6H_2O$], Rochelle's salt ($KHC_4H_4O_6$), etc., give no inkling of the nature of their composition.

It is, of course, in the field of organic chemistry that this second postulate is most extensively and frequently violated or disregarded. The number of trivial names—i.e., special or nicknames—which are in common use is colossal, and so many of these are so firmly embedded in the literature that their perpetuation by successive generations of chemists is possibly unavoidable. One type is represented by such common examples as aniline, glycerol, oxalic acid, succinic acid, and the numerous homologs and analogs which these individuals suggest. Another type is recalled by such designations as Michler's ketone, Laurent's acid, Martin's yellow, methyl orange, and thousands of others.

The name should recall or suggest the constituents of a compound. In this prescription de Morveau placed in a positive and constructive admonition the principle which its predecessor had expressed negatively. The name sodium sulfate decahydrate is precise, concise, complete, and unambiguous and requires no mental effort to interpret, whereas the term Glauber's salt gives no suggestion that a sodium salt, a sulfate, or a hydrate is involved. Potassium hydrogen difluoride cannot be misunderstood, whereas the designation Fremy's salt carries no suggestion of its nature. Many would with difficulty recall the structure of Michler's ketone but would instantly appreciate the nature and reactions of 4,4′-bis-(dimethylamino)benzophenone.

As we contemplate the application of this postulate to the vast field of organic chemistry which has developed since de Morveau's time, we might even be permitted to recognize in its spirit somewhat more than the literal wording states. If a name should suggest the components of a compound, this may be interpreted to cover not merely the qualitative but also the quantitative aspects. After all, precise nomenclature consists of stating in an orderly and unambiguous manner what is present and where it is. If reference is made to the neutral ester of phthalic acid with ethyl alcohol, why not express it as diethyl phthalate; if the half ester is meant, why not call it ethyl hydrogen phthalate?

Perhaps this plea for precision seems to scientists pedantic, affected, and obvious. Chemists engaged in the execution and/or consideration of research are well aware of the necessity for precision. This viewpoint, however, is obviously not yet shared by chemical industry, as perusal of its advertising matter and price lists will soon disclose. By their loose practices the advertising divisions of even some highly reputable chemical companies weaken the position of teachers of organic chemistry and confuse their students. How are instructors to persuade their pupils to refer to diethyl phthalate when they see it advertised by well-known companies as "ethyl phthalate"? How can they be persuaded that phthalic anhydride and phthalic acid differ in composition when they see the words used interchangeably in advertisements? How are they to be induced to write 3,5,5-trimethylhexanoic acid when it is offered for sale as nonanoic acid, or 3,5,5-trimethylhexylamine when advertised merely as nonylamine? How are they to be taught that ethylamine is one word when the great chemical companies advertise it as "ethyl amine" in two words?

In the absence of knowledge concerning the constitution of a substance the name assigned to it should be noncommittal. With this cautious admonition it would appear that little fault could be found. It amounts to an encouragement of trivial naming, yet does so only as recognizing this procedure as the lesser evil. With modern rate of advance in research, adherence to this prudent principle is even more desirable than in de Morveau's era. Especially in the biochemical field new physiological materials are being isolated in great numbers and in most cases their structures are established with commendable dispatch.

An example of laudable discrimination and caution is afforded by the case of folic acid. In 1941 (*12*) there was isolated from spinach a nutrilite found to possess extraor-

dinary activity in stimulating the growth of certain strains of bacteria. Because their product appeared to be a definite chemical entity, especially abundant in numerous leaves, they suggested for it the name "folic acid" from the Latin *folium* = leaf and defined it "as the material responsible for growth stimulation of *Streptococcus lactis* R on a given medium." Soon afterward a material with similar properties was isolated (*15*) from liver and designated as liver *L. casei* factor. Presently the synthesis of this material was announced (*1*). Meantime the name folic acid had become popular as a term to represent any material with such activity without regard for differences in chemical nature, and this usage made it subsequently unsuitable to represent a particular chemical entity. The complexity of the compound precludes general usage of their dull precise chemical names and renders desirable a short designation for the fundamental parent from which the names of relatives may be derived. For the case of the liver *L. casei* factor, this has since been established (*16*) as pteroylglutamic acid—i.e., *N*-[*p*-{[(2-amino-4-hydroxy-6-pteridyl)-methyl]amino}benzoyl]glutamic acid.

Thus the noncommittal name, "folic acid," served its purpose in permitting simple designation of the material during the period between its discovery and the definite establishment of its structure, in this instance a matter of only 7 years. It must be admitted that in what is presumably the ultimate name there remain two roots of admittedly trivial character—viz., pteroyl and glutamic. The latter may be presumed to be so important and of such frequent occurrence that chemists should regard it as making no more excessive demands on the memory than scores of other radicals. The same cannot currently be said for "pteroyl," but presumably it will ultimately become valid. In any case "pteroylglutamic acid" is evidently far to be preferred for indexing purposes to its polysyllabic synonym.

New names are to be coined preferably from Latin or Greek to make their significance more easily and widely understood. This exhortation is no doubt now the least valid of the principles set forth by de Morveau. In his day and for 150 years thereafter, the widespread study of the classical languages gave point and substance to his purpose. Subsequently the extent and intensity of the study of ancient languages have narrowed and diminished, until it is now the exception rather than the rule to find a chemist who has been exposed to systematic instruction in these tongues. There is, however, a substantial body of nomenclature which has become established in the period when this precept was faithfully followed and its very existence tends to protract an analogous practice.

The form of the names should be adapted to the genius of the languages in which they are to be used. Here again we find expressed an idea which was probably more important in de Morveau's day than it is now. At that time the scientific world was entirely European and the dominant languages were French, German, and English. These were at the time of approximately equal importance and the entire foundation of chemical discovery of fact, principle, and theory remains recorded primarily in these three forms. While this scientific reservoir was being built up, however, vast political, social, and economic changes took place, whose net result has been to make English the currently dominant scientific language. The rapid and prolific development of chemistry in America, taken together with serious economic declines in Europe, has completely changed the balance of nomenclatural power. Just as today the nations of the world look to America for economic assistance, so their science is profoundly responsive to American opinion and leadership.

Another new factor has an important bearing on the great part now played by American science in influencing world opinion: the great speed of modern communication. In its utilization for the dissemination of scientific information we are not ordinarily so much concerned with advances in radio, telephony, or even facsimile reproduction, as with air mail and microfilm reproduction. These facilities become instruments for the dissemination of scientific and technical information throughout the world in less time than formerly was required for communication between many European countries. Inevitably what scientists and professional societies do and say in America has, in 1950, a far greater and more immediate effect around the world than the corresponding Euro-

pean activities could have had in 1750. "Some men are born great, some achieve greatness, and some have greatness thrust upon them." It is even so with nations and with professional societies.

These several principles of nomenclature were promptly applied by de Morveau, Lavoisier, Berthollet, and Fourcroy to the naming of 474 substances belonging to the earths, alkalies, acids, and metals. Their procedure was based on a dualistic hypothesis and forms the basis of our present system. The elements retained their accustomed roots, and the terms "oxygen," "hydrogen," and "azote" were introduced. The term "oxide" was employed for the first time and the class was regarded as intermediate between the element and its acid. The suffixes "ic" and "ous" for acids, together with the corresponding "ate" and "ite" for their salts, were first employed. These views found acceptance throughout Europe. They were, of course, gradually amplified, notably by Berzelius, to whom we owe the establishment of many other present practices such as the expression of simple compounds in the forms exemplified by ferrous sulfide, ferric oxide, etc.

The second milestone in the evolution of chemical nomenclature came almost exactly a century later, and this time from a British source. Although the foundation had been securely laid by the French group, chemical progress during the next century was relatively rapid and the nomenclatural superstructure finally again began to develop some insecurity. Eventually, the British Association for the Advancement of Science appointed a committee "for the purpose of drawing up a statement of the varieties of chemical names which have come into use, for indicating the causes which have led to their adoption, and for considering what can be done to bring about some convergence of the views on chemical nomenclature obtaining among English and foreign chemists."

This committee of thirteen distinguished British chemists comprised H. E. Armstrong (1848–1937), A. Crum Brown (1838–1922), James Dewar (1842–1923), H. B. Dixon (1852–1930), E. F. Frankland (1825–1899), F. R. Japp (1848–1925), A. G. Vernon Harcourt (1834–1919), W. Odling (1829–1921), H. F. Morley (1855–1943), H. E. Roscoe (1833–1915), J. Millar Thomson (1849–1933), V. H. Veley (1856–1933), and A. W. Williamson (1824–1904). This committee made two extensive reports (*2*). The committee adhered strictly to inorganic chemistry, effected a certain clarification and systematization of current usage in this area, and achieved a codification of uniform practice, but brought forth no particularly startling or revolutionary changes in nomenclature.

Development of Nomenclature of Organic Chemistry

Although obviously progress was constantly being made from earliest times in the area subsequently designated as organic chemistry, virtually all systematic development of its nomenclature necessarily awaited the rise of a comprehensive and coordinating theory. The early part of the nineteenth century saw the evolution of the concept of radicals, and the notion of types, together with numerous subordinate and transitional modifications. Indeed, the situation had by 1860 reached a point where such confusion prevailed that chemists were hardly able to make themselves intelligible to each other.

At this critical moment there was organized at the suggestion of Kekulé the first international congress of chemistry (*3*, *4*, *8*, *11*), which was held September 3 to 5, 1860, at Karlsruhe, capital of the Grand Duchy of Baden, Germany, and has therefore become designated as the Karlsruhe Conference. It was attended by 140 chemists who recognized the importance of "(1) a more exact definition of the concepts expressed by the words atom, molecule, equivalent, valency, and basicity, (2) the investigation of the actual equivalents of substances and their formulas, and (3) the beginning of a more rational nomenclature." Although this great group of distinguished scientists effected much clarification of the first two items of their agenda, its consideration of the third was diverted into a discussion of symbolism and it made small contribution to nomenclature as the term is now used.

Very shortly after the Karlsruhe Conference the epochal structural theory of Kekulé began to be widely recognized. This promptly led to a rapid increase in the synthesis and study of organic compounds and thus to increased pressure for a systematic nomenclature.

Nevertheless, three decades passed before this need found specific response. In connection with the Paris Exhibition of 1889 (which left as a relic the Eiffel Tower) there was held an international congress of chemistry on whose agenda was placed the reform of organic nomenclature. The topic proved so refractory, however, that it was remanded to an international standing committee. A Parisian subcommittee, after considering during 45 meetings various suggestions from abroad, made a report which served as the basis for an international meeting held at Geneva, Switzerland, on April 19 to 22, 1892—i.e., 58 years ago and 105 years after Lavoisier's speech to the French assembly.

Membership in the Geneva Conference was by invitation only and not by delegation from national societies. Its eight sessions were attended by 35 chemists drawn from nine different countries, were presided over by Friedel, and resulted in the formulation of what is still known as the Geneva nomenclature. Although the principles thus formulated applied only to aliphatic compounds, this conference represented almost the only real progress on systematic organic nomenclature achieved during the entire century and as such comprises an important milestone. The 35 participants were: Amand, Armstrong, Baeyer, Barbier, Behal, Bouveault, Cannizzaro, Cazeneuve, Combes, Cossa, Filati, Emil Fischer, Franchimont, Friedel, Gladstone, Graebe, Guye, Haller, Hanriot, Hantzsch, Istrati, Le Bel, Lieben, Maquenne, Victor Meyer, Monnier, Nietzki, Noelting, Olivier, Paterno, Pictet, Ramsay, Reverdin, Skraup, and Tiemann. A group photograph of the conference with facsimile signatures was published in the *Journal of the Chemical Society* in 1938, facing page 1117. The only American invited to the congress was Ira Remsen, and he was unable to attend.

Subsequent to the Karlsruhe and Geneva conferences, the supreme court of nomenclatural problems in chemistry has been vested in what is currently known as the International Union of Chemistry. A history of the evolution of this organization has recently been published (*4*). Its next meeting is scheduled (*7*) to be held in Washington, D. C., in September 1951.

So far as organic chemistry is concerned, the most important fruit of its labors is the Definitive Report of the Commission on the Reform of the Nomenclature of Organic Chemistry, unanimously adopted at Liége in September 1930, and eventually published in the journals of most national chemical societies, including our own (*9*). For inorganic chemistry a corresponding report was adopted in 1940 (*10*). Although the activities of the International Union were seriously impaired by World War II, it held its fourteenth meeting in London in July 1947, and its fifteenth in Amsterdam in September 1949. This last meeting made very great progress in advancing systematic organic nomenclature (*5*).

Current Aspects of Nomenclatural Difficulties

One of the current problems is the increasing extent to which letters, numbers, and combinations of these symbols are being employed to designate chemical compounds. Fundamentally, these cryptogramic conglomerations derive from the natural desire for utmost brevity and convenience. They stem from the same motives which led our scientific predecessors to represent the names of the elements first by pictures, and later by a letter or at most two letters. With the development of chemical knowledge and the consequent necessity for compact expression of their composition, these elemental symbols were combined and provided with numerical subscripts denoting the number of particular atoms involved. The organic chemist faced with the additional problem of representing the structure of numerous compounds having the same composition and molecular weight responded first by drawing pictures (structural formulas). In time he came to realize that composition and structure were not enough; he must further represent configuration. As soon as the technical hieroglyphics which thus resulted were sufficiently numerous to require some form of orderly classification for indexing purposes, the necessity arose for precise, definite, and unambiguous literal names. With increasing magnitude and complexity of organic compounds, the resultant designations have become really impressive. In many instances, the mere magnitude of the chemical framework common to a large group of related compounds has necessitated its designation by a concise form and thus

we have the evolution of the trivial name. Despite certain obvious advantages of trivial names, there is currently considerable effort to restrict their employment.

There is, however, a relatively recent type of chemical cryptogram whose rapid development and wide popular usage lead to new problems. The genesis of this type appears to have occurred about the time of the second world war. It may be reasonably supposed that the practice developed as a result of the exposure of chemists to the use of initial letters to designate the infinite number of government agencies. Citizens became familiar with the sound of TVA, WPA, ERA, FEPC, and UNESCO quite naturally as chemists began to adopt analogous procedures for unwieldy chemical names. As a result we have now accumulated an impressive number of cryptogramic expressions.

Table I. Examples of Literal Cryptograms Selected from Current Literature

AATP	Diethyl *p*-nitrophenyl thiophosphate (parathion)
ACTH	Adrenocorticotropic hormone
ANTU	1-Naphthylthiourea
ATP	Adenosine triphosphate
BHC	Benzene hexachloride
BMU	β-Methylumbelliferone
BON	β-Oxynaphthoic acid
COT	Cyclo-octatetraene
CTAB	Cetyltrimethylammonium bromide
DBS	3′,5′-Dibromosulfanilanilide
DDD	1,1-Dichloro-2,2-bis-(*p*-chlorophenyl)ethane
DDT	1,1,1-Trichloro-2,2-bis-(*p*-chlorophenyl)ethane
DMBC	Dimethylbenzyl chloride
EBC	Ethylbenzyl chloride
EDB	Ethylene dibromide
EDNA	*N,N′*-Dinitroethylenediamine
HET	Hexaethyl tetraphosphate
MBA	Methylbenzyl alcohol
MBDSA	*m*-Benzenedisulfonic acid
MBC	Methylbenzyl chloride
NBS	*N*-Bromosuccinimide
OMPA	Octamethyl pyrophosphoramide
PAS	*p*-Aminosalicylic acid
PETN	Pentaerythritol tetranitrate
TBA	Tris-(β-chloroethyl)amine
TEAB	Tetraethylammonium bromide
TEP	Tetraethyl pyrophosphate
TMC	2,2,6,6-Tetramethylolcyclohexanol
TNB	1,3,5-Trinitrobenzene
TNT	2,4,6-Trinitrotoluene

Examples culled from the recent scientific and technical literature include, first, the purely literal species, most frequently found in combinations of three letters, but occasionally running to four or even five as illustrated in Table I. Then there is the mixed species comprising combinations of numbers and letters, samples of which are shown in Table II. The examples cited are not imaginary, but have been collected from the scientific and technical literature.

Table II. Examples of Mixed Cryptograms Selected from Current Literature

G^4	2,2′-Methylene-bis-(4-chlorophenol)
T_4	Hexahydro-1,3,5-trinitro-*S*-triazine (hexogen)
2,4-D	2,4-Dichlorophenoxyacetic acid
2,4,5-T	2,4,5-Trichlorophenoxyacetic acid
C-3259	2-Benzylimidazoline
G-11	2,2′-Methylene bis-(3,4,6-trichlorophenol)
G-410	Pentachlorophenol
P-4000	1-*n*-Propoxy-2-amino-4-nitrobenzene
V-147	*p*-Guanylbenzenesulfonamide
IB-946	2,4-Dinitrophenol
KP-504	Bis-(dimethylbenzyl)carbonate
SR-406	*N*-(Trichloromethylthio)tetrahydrophthalimide

There is another troublesome factor in the extensive modern use of trade names and the like. Every practical organic chemist will readily think of numerous examples of trade-marked names which, because they represented true chemical individuals and were thoroughly publicized, have become so firmly established in the literature that many contemporary students do not even realize that they are trade names. This type may be exemplified by the following:

Cellosolve	2-Ethoxyethanol
Methyl Cellosolve	2-Methoxyethanol
Butyl Cellosolve	2-Butoxyethanol
Carbitol	2-(2-Ethoxyethoxy)ethanol
Methyl Carbitol	2-(2-Methoxyethoxy)ethanol
Butyl Carbitol	2-(2-Butoxyethoxy)ethanol

Other examples of the same nature will occur to every chemist.

Regular readers of the technical literature will be well aware, however, of the modern flood of trade names which now attempt to force themselves upon the consciousness of their readers. No longer need the product comprise a chemical individual; it may be a mixture, the components of which are not known even by the producer in the true chemical sense. The name devised and flung before the hapless reader may not convey the slightest suggestion of the nature of the components, nor the character of the use for which the product is intended. Such names are nothing more than fantasies dreamed up by advertising departments and deserve no recognition by professional societies or reputable scientific journals. They represent, however, a professional hazard to elementary students as yet unprepared to distinguish their lack of merit from other superficially similar but better justified cognomens.

Between these two extremes there is a type of arbitrary designation which strongly resembles a trade name but is actually a coined name more or less officially recognized as representing a particular chemical individual. A group of examples of this type is found in the action (*6*) of the American Phytopathological Society with respect to five fungicidal salts:

Ferbam. Ferric *N,N*-dimethyldithiocarbamate
Ziram. Zinc *N,N*-dimethyldithiocarbamate
Nabam. Disodium ethylene-bis(dithiocarbamate)
Zineb. Zinc ethylene-bis(dithiocarbamate)
Thiram. Tetramethylthiuram disulfide or bis-(dimethylthiocarbamyl)disulfide

Information concerning these names and the approval and acceptability of their use as coined common names for these specific chemicals has been filed by the society with the Trade-Mark Division of the U. S. Patent Office to pre-empt the use of the names as trademarks.

Outlook for Future

We find ourselves at the midpoint of the twentieth century with a nomenclatural heritage of 163 years. Our meager progress appears in retrospect to have been due largely to lack of anticipation of predictable difficulties. Except for the initial occasion when de Morveau and his compatriots exhibited their genius with an organized plan adequate for their times, the subsequent history of the evolution of chemical nomenclature is largely a story of attempts to reform defective and inadequate practices already thoroughly established by unguided usage.

Despite some definite though sporadic efforts to effect systematization and simplification, by and large our nomenclatural definitions are often vague and we are not yet entitled to regard them as knowledge reduced to law and embodied in system. The science of definitions will achieve neither the degree nor rate of progress required by this modern age until we recognize that orismological research and development cannot be left to part-time nurture by devoted individuals or the occasional attention of committees composed of geographically scattered and professionally preoccupied persons. As an aspect of chemistry profoundly affecting the daily activities of every member, the generous, sympathetic, and protracted support of a full-time official effort to keep pace with and to anticipate our nomenclatural evolution seems not only a properly appropriate but an indispensable function of a professional chemical society.

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Indexes, Happy and Unhappy Hunting Grounds

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Indexers devote thought and toil to the effort to place subject matter where searchers are most likely to look for it. They must avoid the pitfalls of omitting significant information, burying information under obscure listings, and making poor choice of nomenclature. The searcher must bear in mind connections between English and Latin derivations, reason out probable preferred locations for entries not as precise as chemical names, check specific as well as general terms, and take into consideration peculiarities that creep into the English language from foreign language sources. Successful searching demands a balanced blend of training, experience, and common sense.

Indexers devote much thought and toil to the task of placing subject matter where searchers are most likely to seek it. In a sense, each indexer projects his mind into the future, hoping that searchers will project their minds back to meet his. Often, but not always, they do.

The whole operation is essentially a guessing game of indexers and searchers, playing on the same team against the invisible gremlins of error, mischance, mishap, and false trails. The minds win when the searcher arrives at the wanted information.

Suppose the indexer is directing the searcher to a new, precise determination of "Stannous chloride solutions, density." He makes that entry and moves on to the next item. The gremlins win if the searcher gives up when he finds nothing under "Tin chloride solutions, density."

There are many ways in which indexers and searchers can make success easier and surer than it would be without their skill and care. Assuming that the indexer has avoided the pitfalls of omitting significant information, of burying it under his own obscure fantasies, and of errors or poor choices in nomenclature, what must the searcher do to make sure that his mind meets the indexer's?

First, he can bear in mind such little matters as the connection between "tin" and "stann-," "iron" and "ferr-," "lead" and "plumb-."

Secondly, he can reason out probable preferred locations for entries not as precise as chemical names. He can remember that "Glazes" and "Enamels, vitreous" are sufficiently similar to justify searching both when interested in either, whereas organic baking finishes such as "Enamels, tung oil" may hide under some such congener as "Paints, tung oil," but not under "Glazes."

Thirdly, he can cultivate mental agility when his first thought misses the indexer's in such matters as designating properties or products. He can search "Bactericides" as well as "Germicides," and he can switch from specific to general terms, or vice versa. If "Luminescence" does not serve, he can proceed to its special cases such as "Chemiluminescence," "Fluorescence," "Iridescence," or "Phosphorescence."

Finally, he can allow for peculiarities which creep into English language indexes from foreign language sources. Biochemists should know that the German trick of calling enzymes "ferments" persists in our literature and indexes. Still worse is *Verseifung*, applied in German to all hydrolysis, so that "Saponification" for "Hydrolysis" seems impossible to eradicate from our literature and indexes.

These are merely examples to illustrate how the searcher can do his share toward the meeting of the minds. Engineers tunneling from opposite sides of a mountain or stream are expected to meet without deviating so much as an inch; but their success does not come by haphazard drilling. So the searcher, starting from his end, cannot expect to meet the indexer's mind without skilled attention to orientation.

Chemical Indexing as It Was

Early chemical indexes were sorry specimens as compared with today's best. The preface to the cumulative index of Volumes 1 to 100 (1832–56) of Liebig's *Annalen der Chemie* complained that the first two cumulative indexes (for Volumes 1 to 40, 1842, and Volumes 41 to 70, 1851) were appallingly bad. A few simple rules for better chemical indexing were prescribed and followed.

The *Annalen's* first indexers should not be blamed too much; they were amateurs, without experience or precedent, and the small bulk of literature to be covered did not need an elaborate index. Chemists of 1832 could probably read that year's whole output of chemical literature in less time than we would need now to read one annual index of *Chemical Abstracts*. The *Annalen* for 1832 (Volumes 1 to 4) was indexed in less than 800 subject headings.

The leisurely pioneers used long phrases instead of one or a few words as main entries. Early searchers accepted "Nitro-bromo-phenesic and ampelic acids, on chlorophenyle, and chloralbine and on the relations which exist between the composition of some organic substances and their crystalline forms" [*Chemist (London)*, Vol. 1 (1841)] whereas modern searchers would resent anything longer than "Nitrobromophenesic acid, crystalline form," and would demand separate entries for the other compounds. Even after more and shorter entries won favor, subject indexes remained scanty as judged by modern standards. Cross references were rare and sometimes loosely used, as in *Chemist (London)*, Vol. 1 (1841), "Metallic salts," *see* "Remarks."

Indexers seemed to assume that searchers had minds grooved exactly like their own.

Early chemical indexing did not approach the 67 words of index per 100 words of text which is approximately the present level for *Chemical Abstracts*. But gradually indexers sensed more of the searcher's needs; as chemical literature grew in bulk and complexity, subject indexes made halting but persistent efforts to keep pace. One of the early concessions, dating back at least to 1801 (*3*) was the publication of cumulative indexes (*8*), covering 5 to 100 volumes or years of a periodical. This time-saving practice spread widely later in the 19th century.

The growth of chemical literature also drove indexers beyond the word base to formula and number bases for indexing. When empirical formulas were recognized as inherent characteristics of chemical compounds, inevitably some restless spirit would think of indexing compounds by formulas.

The restless spirit was that of Max Moritz Richter; he brought out his first formula index of all known organic compounds in 1884. Isomers complicate the situation; but Richter devised a way of coping with them which still serves in today's formula indexes.

Patent grants were burgeoning late in the 19th century, with an added impetus from the German chemical industry's complex marvels of coal tar chemistry. Pressure on patent indexing finally led abstract periodicals to publish numerical indexes of patents. *Wagners Jahresbericht der chemischen Technologie* started the custom in 1889, followed by *Zeitschrift für angewandte Chemie* in 1890 and *Journal of the Society of Chemical Industry* in 1901.

Thus, at the turn of the century, chemical indexing was established on its four main bases:

Names (of authors, firms, agencies, laboratories, patentees, assignees, etc.)
Words (subjects)
Formulas (empirical and ring formulas of compounds, organic and inorganic)
Numbers (chiefly of patents)

Chemical Indexing as It Is

As the number of known chemical compounds neared the million mark, literature about them and less definite substances or products became increasingly difficult to index. *Chemical Abstracts* and *Chemisches Zentralblatt* responded with improvements in entry selection and arrangement, and explained their improvements to searchers (*5*, *6*). The German science press of the early 1930's warmly praised the *Zentralblatt's* new "encyclopedic" system, which departs further from the strict alphabetic base than does *Chemical Abstracts*.

Book indexing is still in a very spotty state, but has improved somewhat under pressure. A compendium such as Beilstein (*4*) is well indexed in relatively small space because its arrangement has self-indexing features. Unfortunately, the arrangement is covered by such elaborate rules that an official guide (*11*) is needed. There are also shorter guides (*9*, *12*). Friedländer (*7*) was for many years a monumental example of inadequate indexing, falling far short of the needed detail. The numerous handbooks for chemists and engineers illustrate the spotty character of modern book indexing. In general, the chemical handbooks fare better than those in engineering. In some respects chemical subject matter is more amenable to precise indexing than are engineering topics; but there is a hard core of fact in the fable that engineers cannot read, and it influences indexing.

Searchers who are sensitive to the idiosyncracies of indexers can quickly sense goodness or badness in an index. The needed sensitivity can be acquired if not inherited. Either way, the searcher can train himself to step up his ingenuity voltage when confronted with a bad index.

To illustrate, a certain index (anonymous here) has many entries under "Acoustics" and "Physics, sound" along with a few under "Supersonics," but not even a cross reference under "Sound" or "Sonic(s)." Searchers detoured at "Sound" pass to "Acoustics" without much resistance, but the jump from "Sound" to "Physics, sound" is more difficult.

Skilled searchers start with a list of the significant words relating to any topic complex enough to have a vocabulary. Probably on the old Indian's theory, "No settum trap, no catchum mink," they are called catch words. Because usage varies with place and time, catch words differ in different indexes and in different periods of any serial index. This adds a challenging risk of oversight. Suppose the topic is soils, and the obvious words such as "alluvium," "clay," "humus," "mulch," "peat," "silt," "turf," etc., are all listed. But in recent literature the word "permafrost" demands attention. So a new catch word must be entered. Success in searching depends much on a sensitive alertness to the words used by indexers.

Numerous published current indexes serve the dual purpose of informing subscribers concerning current developments, and aiding searchers in tracking down past records. Generally these indexes offer cumulations at suitable intervals ranging up to five years. They use ingenious tricks of typography and arrangement to aid searchers. Some of the notable examples serve the interests of medicine (*2*), industry (*10*), and agriculture (*1*).

Formula indexes remain basically the same, except that the increasing number of known compounds gives them greater utility. Their drawbacks, notably the inability to distinguish between isomers, have caused discontent and drastic action. Codes which can be written on one line, without any structural ambiguity, are now serving recorders and searchers of chemical information, with promise of broadening utility in the future. Such codes, notably that of Dyson, have received attention in previous programs of the Division of Chemical Literature.

Subject Heading Lists

Chemical formula codes, like empirical formula indexes, depart from the alphabetic base. Another type of special indexing aid which remains on the alphabetic base is found

in subject heading lists. A few enthusiasts see a master subject heading list as the panacea for every ill our documentation flesh is heir to. Their opposites, also few in number, see all woe and no weal.

Proponents see the advantages of accepted standard designations, and of agreeing on one correct term for a given item to the exclusion of other terms even if equally correct. Claiming ample flexibility through skilled use of cross references, they are prone to overlook the irresistible force by which subject heading lists attract the formalists and ritualists. In fact, many of the proponents are the formalists and ritualists of documentation.

The deadening chill of formalism is as fatal to good indexing of facts as it is to worship. The letter kills; the spirit gives life. Dynamic subject heading lists are compiled, maintained, and administered with informed skill and care as potent instruments for better indexing and potent aids to skilled searchers. Static subject heading lists, compiled and administered under slavish adherence to a frozen set of rules, are road blocks.

An apple of discord among the formalists is the inverted heading. One camp will fight for "Acids, fatty," "Esters, keto-," and "Gas, natural." The opposite camp will do battle to the last man for "Fatty acids," "Keto esters," and "Natural gas." Ridicule is a favorite weapon, for it is not hard to trap either form in a *reductio ad absurdum* such as "Halogenated unsaturated fatty acid amides," or "Unsaturated fatty acid amides halogenated," or "Fatty acid amides halogenated unsaturated," or "Acid amides halogenated unsaturated fatty," or "Amides halogenated unsaturated fatty acid." While battle rages, the emancipated makers and users of dynamic subject heading lists concentrate on grappling with problems instead of with each other. When inversion is indicated, they invert; then, if it becomes contraindicated, they restore the pristine order.

Searchers tend to prefer accepting (and perhaps criticizing) the indexing tools prepared for them, not joining the battle. But frequently they preserve neutrality at the expense of insight into the mental processes of indexers. This insight is important to a high percentage of successes in the meeting of the minds.

Subject Classifications

Coded classifications of chemical subjects are indexes on a number or number-and-letter or punch-position base, designed for detailed subject searching. Within their limits of scope and coverage they can be used for that purpose, unlike book-shelving classifications such as those of Melvil Dewey and the Library of Congress.

The Universal Decimal Classification (UDC) is an effort to ride both horses at once. It succeeds within a fixed path directed from Brussels, but not in the struggle to serve academic, industrial, and military needs for bibliographic control. Though the decimal classification has shifted from positioning books to positioning index cards, it is still a position-designating system with only limited applicability to the infinitely variable demands of subject searching.

Advice to Searchers

Searchers need not become expert indexers of chemical literature, but the better they understand indexers' problems and answers, the shorter the path to information needed from an index.

Through all the maze of word, formula, number, and punch-position lanes for placing and retrieving information, the searcher must choose his starting point and his path. If he chooses wisely in a well-indexed area, his search turns up all pertinent information entered in the system. If he knows how well the system covers the field, he has a fair estimate of how near his search comes to totality.

The searcher must have a mind of his own, and use it. Every system has some advocates who can see merit in other systems, and shortcomings in their own. But others, if he lets down his guard, will persuade him that:

Alphabetic sequence is his sole need.
The alphabet is a worse-than-useless mess.
A decimal (or other) classification answers all his prayers.

Punched cards will exorcise every problem.
Selectors needing no cards will solve his problems for him.

Successful searching demands a balanced blend of training, experience, and the faculty known as horse sense.

Training drills the candidate in theory and practice. Knowing that coverage is never perfect, he learns to estimate its thoroughness for each source. He is taught tricks of the trade for tracing the indexer's line of thought, and acquires extensive knowledge of index bases and source materials. He learns how to adapt them to requirements, and to interpret findings according to the interests prompting the search.

Experience teaches him more tricks of the trade, broadens his knowledge of sources, sharpens his detective faculties, and increases his skill in applying the theories and principles learned in training.

Finally, any searcher tempted by easy searching paths, against the promptings of common sense, should ponder the consequences. Wasted effort, delays, missing of existing information, and high costs for small results are among the penalties for violating these rules:

Start with exact definitions of coverage in time, subject matter, and sources.
Find out where prior searchers stopped (on all three counts), and start there.
Slant the whole job to the basic purpose (background, critical review, reading list, anticipation, interference, infringement, state of the art, etc.).
Reserve bulldog tenacity for "must" assignments; on all ordinary jobs abandon any line of inquiry when yield value drops below operating cost, and close the project when the results are reasonably adequate.

Searchers who team training and experience with applied sense will produce effective results efficiently; no reasonable employer will ask more.

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United States and British Index Entries

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The differences in United States and British index entries may arbitrarily be divided into three categories: (1) differences in spelling; (2) the case where different words are used in the two countries to designate the same thing or process; and (3) the case where the same word has different meanings in the two countries. Examples of each category are given.

Crane and Patterson (*1*), Soule (*4*), and Mellon (*2*) have considered in detail the differences in the construction and use of indexes of many countries and in many languages, and a very recent book by Mitchell (*3*) is devoted entirely to British chemical nomenclature practice.

The present paper is an attempt to bring out differences in the English language as it is used in this country and in England, with reference to entries in indexes of American and British scientific and technical publications. The terms chosen to illustrate these differences are, in many cases, semitechnical, if not popular, in nature, but all have been selected from technical indexes, and from *British Chemical Abstracts*, now *British Abstracts*. For the sake of convenience, the differences in usage may be arbitrarilyd ivided into three categories, although some terms belong in more than one category.

1. Differences in spelling of a term or word used in the same sense in the United States and in England.
2. The use of different words in the two countries to designate the same object or process.
3. The case where a word has a different meaning as used in the United States and in England.

Variations in Spelling

As is well known to users of indexes, variations in spelling cause great or little difficulty according to whether the difference in the spelling occurs near the beginning or the end of the word.

Thus while aluminum becomes aluminium in English usage, the additional "i" near the end of the word causes no difficulty when using a British index, if, in fact, it is noticed at all. The word odor, in England, has a "u" in it, odour, tumor is tumour, color becomes colour, also with a "u"; but with a lack of consistency, coloration of glass, for instance, and colorimetric analysis do not have the "u." Polarisation is spelled with an "s" instead of a "z" or "zed," as it is called in England. Other words where the difference in spelling is toward the end of the word are found in fibre, where the terminal "er" is reversed as "re," and olefine, Permutite, and adrenaline, each of which in British usage has a terminal "e." To these examples may be added the whole group of words based on the element sulfur. In England the "ph" spelling is still retained, and we have sulphur, sulphate, sulphide, sulphite, sulphuric acid, sulphurous acid, and so on. This usage extends to verbs, such as sulphonate, for example, and to compound words such as hyposulphite, thiosulphate, and persulphate.

Examples of words where the difference in spelling is nearer the beginning of the word are caesium, where there is an "a" before the "e," tyres, the kind used on automobiles, and cacao, which is spelled c-a-c-a-o as well as c-o-c-o-a.

The nearer the beginning of a word a spelling difference occurs, the more trouble it can cause in using an index. In the following examples the first letter in British usage differs from the practice of *Chemical Abstracts:* oedema, oestrin, and oestrous, all of which are to be found in *British Abstracts* under "o" instead of "e."

Use of Different Words

For the second classification it will suffice to mention some British terms, and to give their American equivalents. An American who drives an automobile in England very soon learns that he does not obtain "gas" or gasoline at a gas station, but instead, petrol at a petrol pump. But it is less easy when the terms are: accumulators for storage batteries; Lucerne for alfalfa; or caster sugar, named for the device used for dispensing it, instead of granulated sugar which is descriptive of the appearance of the form of the sugar. The entry Silk, artificial, for Rayon, causes no difficulty, nor do kinematograph films for moving picture films, and the term Kinematography. The terms Oils, mineral, Petroleum, and Petroleum oils, all appear in *British Abstracts,* and only a careful examination of the abstracts, and possibly of the original articles, would determine how British and American usage compare.

While not precisely a different word, it is worth noting that in *British Abstracts* there are the two entries Moulds, biological, and Moulds, foundry, the word being written m-o-u-l-d in both cases. In some British indexes of the early nineteen thirties the term used for what is known in the United States as deuterium is diplogen. Later indexes of the same periodicals conform to the American usage.

Different Meaning

The third type can cause the most difficulty when using an index. In this country no one would think of trying to get a gallon of paraffin. But one would in England, if one desired to obtain kerosene. What is known in the United States as paraffin is called paraffin wax in England. Another typical example is corn. In the United States corn, apart from certain colloquial uses, refers to a definite grain. In England, corn is a generic term, descriptive of all kinds of grain. The British equivalent of American corn is maize and it will be so found in British indexes, with subheadings for maize oil, etc.

As a final example in this third category, the word "chemist" may be mentioned. There would seem to be no possible doubt as to the meaning of the word chemist, and it is in fact used in England in the same sense. But it also has a very different meaning, and that is its additional use as pharmacist. Thus in England someone desiring aspirin, for instance, does not go to a drugstore, but to a chemist. But in addition to this meaning of the word, which may appear only colloquial, it also appears in technical usage, and in the titles of journals. Thus while the British journal, *Industrial Chemist,* is a publication very similar to American journals such as *Chemical Engineering* or *Chemical Industries, The Manufacturing Chemist* is devoted to pharmaceutical preparations.

The question naturally arises as to how these differences in American and British usage of words and terms may be readily recognized. There is no simple answer to the problem, for Anglo-American dictionaries, as such, do not appear to exist. Perhaps the constant use of indexes from both countries is the best solution.

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Relation of an Abstract to Its Original

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A chain of inquiry, made up of the links of original communication, abstract, index, and searcher, must exist between the searcher and the original source of information, and all links must be in order. Abstracting may be subdivided into the considerations of title, numerical data, critical consideration, authors and references, creation of the abstract, and indexing.

There is a chain of inquiry which must exist intact between the searcher and the original source of information. This chain comprises the links of original communication (journal, thesis, patent, etc.), abstract, index, and searcher.

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. While it is the main object of this contribution to say a little about the link between abstract and original, it is not always possible to avoid encroaching on the subjects of indexing and searching; the main object is, nevertheless, to examine the relation between the original communication and those abbreviated forms which are indispensable to the chemist.

Very few editors of scientific journals today allow any tendency toward verbosity on the part of their contributors, and it is unlikely that any contribution to a scientific journal can be cut down appreciably without losing something of what the author has to say. The days are gone when W. H. Perkin (Senior) could say of a compound "it crystallizes from alcohol in magnificent pale-yellow columnar prisms, which, on slow cooling of the solution, often attain a length of several inches"; today this would be "yellow prisms (EtOH)." This being so, it is clear that the abstractor has to arrive at a decision of what to retain and what to reject. This decision must be consistent—and in this respect consistency is one of the highest of virtues since it will not prove of benefit to users of an abstract system if abstracts prepared by different abstractors, or by the same abstractor on different occasions, are based on varying conventions.

The subdivision of the considerations of abstracting into the following sections is purely arbitrary, and is for convenience of the author.

Title

The statement that the title should be descriptive of the matter of a communication seems to be a truism, but insufficient attention appears to be paid to the titles of papers submitted to learned journals. This is particularly true when papers are part of a series—for example, one of a series of papers may be entitled "Studies in the Chemistry of X and Y, Part 47. Attempted Synthesis of Y." Suppose X and Y are complex alkaloids; often such a paper deals only with the preparation of some complex ring structures—oxaazulenes, perhaps—from which the investigators hope ultimately to synthesize the

subject of their main interest. Hence the paper is really about oxaazulenes and not alkaloids X and Y. The repercussions of this on indexing are serious.

Numerical Data

In abstracting it is desirable that many of the numerical data of the original communication be transferred, always providing that they are relative to properties and not to arbitrary readings taken during experiments. Thus, the determined melting point, boiling point, refractive index, density, and even such lesser known properties as specific inductive capacity and dipole moment are always to be placed in an abstract. Their presence will often avert a search through the original, which is one of the objects of abstracting. It is still frequently observed that "consultation of abstracts cannot replace the reading of original literature." Like all such trite sayings it is true only in part, and some academic colleagues who have researched in a limited field for a lifetime can, no doubt, keep abreast by reading only original papers; for most chemists, however, abstracts are "of the essence."

It is important that where the lesser known constants have been determined, they should be indexed not only under the compound but under the property—e.g., the dielectric constant of camphor should be indexed as Dielectric constant of camphor as well as Camphor, dielectric constant. Such a feature (used in *Chemical Abstracts* consistently) adds vastly to the value of the abstract service.

Critical Consideration

When an abstract is being made, the process of selecting and rejecting may be considered a process of criticism, and in the last analysis it may become so; the single word "polemical" is a case in point. In general, however, anything in the way of technical criticism in abstracting is rightly to be avoided, although it is perhaps a pity not to indicate physical constants that have been determined with more than the usual precautions. This is sometimes taken care of in the title, but often there is no means of telling whether a particular constant has been determined with great accuracy or just casually, as the melting point of an organic compound is determined.

Authors and References

The names of authors are best preserved in abstracts exactly as printed in the original communications; the Chemical Society of London has (1933) dropped its old custom of printing each author's names in full, and contents itself with the use of Christian names only where confusion is likely to arise—as in Sibelius Smith or Samuel Smith. The innovation practiced by *Chemical Abstracts* of including the addresses of authors has much to commend it.

Creation of the Abstract

A consideration of the indexing problems associated with the completed abstract throws considerable light on the philosophy of abstracting itself.

Thus, if we consider a reaction in which ethyl acetate dissolved in diethyl carbonate is allowed to react with methyl propyl ketone (2-pentanone) to give a ketonic ester, in the presence of sodium hydride, we have a set of affairs which can be expressed algebraically as

$$a + b + c \ldots\ldots\ldots n \longrightarrow o + p + q \ldots\ldots\ldots z \qquad (1)$$

Thus a, b, and c represent all the materials prior to reaction and o, p, and q all those after reaction. Some of the cited substances can fall into special categories, such as solvents or catalysts (better described for the purposes of this paper as promoters), and may be present both before and after reaction. Thus, the original Equation 1 may be rewritten:

$$\left.\begin{matrix}[a_1 + b_1 + c_1 \ldots\ldots] \\ [a_2 + b_2 + c_2 \ldots\ldots] \\ [a_3 + b_3 + c_3 \ldots\ldots] \\ [\ldots\ \text{etc.}]\end{matrix}\right\} \rightleftarrows \left\{\begin{matrix}[a_4 + b_4 + c_4 \ldots\ldots] \\ [a_2 + b_2 + c_2 \ldots\ldots] \\ [a_3 + b_3 + c_3 \ldots\ldots]\end{matrix}\right.$$

where $a_1 + b_1 + c_1 \ldots\ =$ reactive substances
$a_2 + b_2 + c_2 \ldots\ =$ nonreactive substances
$a_3 + b_3 + c_3 \ldots\ =$ promoters

Hence the material balance of the specific reaction cited may be written:

$$a_1 + b_1\ [+\ a_2 + a_3] = a_4 + b_4 + \ldots\ldots\ [a_2 + a_3] \tag{2}$$

where a_1 = ethyl acetate
b_1 = methyl propyl ketone
a_2 = diethyl carbonate
a_3 = sodium hydride
a_4 = ethyl alcohol
b_4 = the keto ester
c_4, d_4 = any by-products

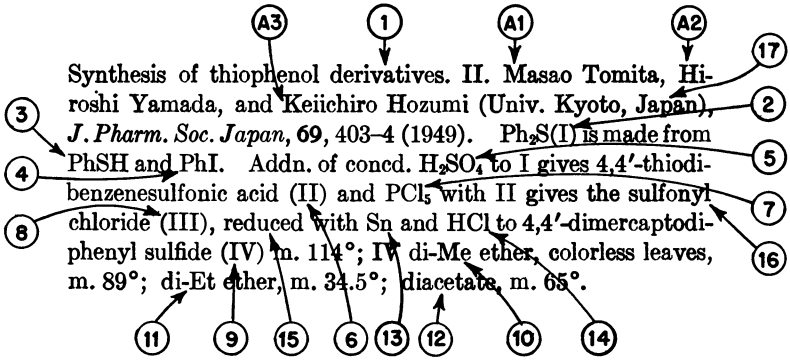
Each symbol constitutes a potential indexing point, and in addition is a "data center" by which term the author refers to its physical and chemical nature. Before, however, we can consider the implications of the data center, it is necessary to complete the algebraic picture by modifying the "arrow" to denote the physical conditions under which the reaction takes place, temperature, pressure, exothermicity, endothermicity, turbulence, etc., being simple examples of the α_1 series. In some cases indexing importance attaches to such matters; it is, for example, convenient and useful to index reactions conducted under high pressure. Thus the nature of any change of matter can be diagrammatically defined by Equation 3. This is the spine or basis of many purely chemical abstracting problems.

$$\begin{matrix}[a_1 + b_1 + c_1 \ldots\ldots] \\ [a_2 + b_2 + c_2 \ldots\ldots] \\ [a_3 + b_3 + c_3 \ldots\ldots]\end{matrix} \quad [\alpha_1 + \beta_1 + \gamma_1 \ldots\ldots \omega_1] \quad \begin{matrix}[\alpha_1 + \beta_1 + \gamma_1 \ldots\ldots] \\ [a_2 + b_2 + c_2 \ldots\ldots] \\ [a_3 + b_3 + c_3 \ldots\ldots]\end{matrix} \tag{3}$$

The concept of each symbol in Equation 3 as a data center is important; if p_1 is the keto ester obtained as the main product in the hypothetical example there are many data which can be accumulated concerning it; normally, we refer to this by saying that the new product has physical properties, chemical properties, biological activity, analytical data, applications, etc. Physical properties are fairly easily defined and are intrinsic—i.e., unaccompanied by permanent chemical alteration of the compound—but chemical properties merely engender a fresh series of equations, similar to Equation 3. The biological activities are not in all cases either measurable or capable of being objectively described, and must therefore be dealt with by a series of arbitrary symbols. Analytical procedures, technical and industrial applications, and patent data are all different, but correlated, data centers that may arise in connection with any of the symbols of Equation 3; these features must all be constantly in mind as an abstract is built up, for it must be arranged with a fair degree of infallibility that each symbol and each center must in some way appear in the abstract; if physiological investigations have been made on a new organic compound, not only must the preparation and physical properties of the new compound appear in the abstract, but reference to the nature of the physiological data is essential. It may, perhaps, be well to reiterate the value of including negative results in the abstract. If the new compound was examined and found to be entirely devoid of local anesthetic activity, then this should be stated, in the hope that it will avert a useless repetition of the work.

Indexing

Consider the abstract:



Synthesis of thiophenol derivatives. II. Masao Tomita, Hiroshi Yamada, and Keiichiro Hozumi (Univ. Kyoto, Japan), *J. Pharm. Soc. Japan*, **69**, 403–4 (1949). Ph_2S(I) is made from PhSH and PhI. Addn. of concd. H_2SO_4 to I gives 4,4′-thiodibenzenesulfonic acid (II) and PCl_5 with II gives the sulfonyl chloride (III), reduced with Sn and HCl to 4,4′-dimercaptodiphenyl sulfide (IV) m. 114°; IV di-Me ether, colorless leaves, m. 89°; di-Et ether, m. 34.5°; diacetate, m. 65°.

All the possible indexing points are marked and are summarized in Table I. All these points may not be used in practical indexing, items 5, 7, and 13 to 17 being considered too trivial to index. This line must be drawn with some care; for, in the case of, say, phosgene ($COCl_2$), the use of this substance even in a reagent capacity may be an indexing point of importance. On the other hand, punched card techniques permit the use of all these associations simultaneously.

Table I. Indexing Points

A1	Tomita, Masao	Author entries
A2	Yamada, Hiroshi	Author entries
A3	Hozumi, Keiichiro	Author entries
1	Thiophenol, derivatives of (synthesis)	
2	Biphenyl sulfide	B6.θ_2S
3	Thiophenol	B6.S
4	Iodobenzene	B6.I
5	Sulfuric acid, condensing agent	
6	Thiodibenzenesulfonic acid	B6.θ_2S.S3,4,10
7	Phosphorus pentachloride	
8	Thiodibenzene sulfonyl chloride	B6.θ_2S.S2:Cl,4,10
9	4,4′-Dimercaptodiphenyl sulfide	B6.θ_2S.S,4,10
10	4,4′-Dimercaptodiphenyl sulfide diMe ether	B6.θ_2S.SC,4,10
11	4,4′-Dimercaptodiphenyl sulfide diEt ether	B6.θ_2S.S[C_2],4,10
12	4,4′-Dimercaptodiphenyl sulfide acetate	B6.θ_2S.S[EQ.C_2],4,10
13	Tin	
14	Hydrochloric acid	
15	Reduction ($SO_2Cl \rightarrow SH$)	
16	Chlorination ($SO_3H \rightarrow SO_2Cl$)	
17	Japan	

In searching, it is necessary for the searcher to weigh up whether or not the path available to him is capable of leading him to the bulk of the information on a topic. He cannot do the abstractor's work for him; he can only assess on the basis of experience, the probability of the work's having been well done.

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Searching the German Chemical Literature

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Since the appearance of the *Chemisches Journal* in 1778, the German chemical literature has represented a sizable segment of the literature of chemistry as a whole. *Chemisches Zentralblatt,* the earliest of the abstract journals, was widened in scope in 1949 to cover the chemical literature of the world. Aside from language difficulties, a search of German chemical literature involves no essential change in methods employed for search of any other area of chemical literature.

The German chemical literature represents a sizable segment of the literature of chemistry as a whole. It has had a history of its own, marked by early beginnings and characterized by an initially slow growth, a period of blossoming and expansion, freedom and restriction, a tapering-off and decline, and a degree of recovery and renewed expansion.

The beginning of scientific periodical literature is usually given as 1665, the year which marked the start of the publication of the *Philosophical Transactions of the Royal Society,* and the corresponding date for patent literature is noted as 1617 with the publication of British Patent No. 1.

German chemical literature entered the picture almost a century later. In 1778 appeared a new publication devoted solely to chemistry; this was the *Chemisches Journal* which in 1784 changed its title to *Crell's Chemische Annalen.* The nineteenth century saw the rise of the journals published by the chemical societies, with the trend from journals devoted to science in general to periodicals dealing with chemistry in general, then to publications covering specific branches of chemistry, and eventually to journals devoted to specific industries and their various aspects.

Today's chemist, if he wishes to gain an over-all and general view of the literature of chemistry, to learn about a specific class of chemical literature, such as abstract journals, monograph series, formula lexicons, or compilations, or to inquire into the history, scope, or quality of a specific source of chemical information, is fortunate in having at his call a number of basic books in this special field (*5, 14, 19, 21, 24*).

A comprehensive survey and review of the German chemical literature cannot be given a balanced treatment within the frame of a single paper. Moreover, the descriptive aspects of German information sources in the field of chemistry have been well covered in a number of books and articles. Therefore in what follows the actual description of such sources is limited and their use in literature research is stressed. Thus, there is a shift of emphasis from "What is German chemical literature?" to "How may German chemical literature be employed and used to the best advantage of the research worker in the library or the laboratory?"

Literature Research

Library research in the chemical literature, the stepchild of earlier days, has recently come into its own. The hit-or-miss operator, lacking a balanced background of chemistry,

information sources, foreign languages, and experience in the field and possibly lacking sufficient time or inclination for this type of work as well, is being replaced by the specialist in chemical literature, be he called a literature scientist, library technologist, or by any other name.

During the past ten years, especially, a number of papers on literature research have been published. They are of two kinds. On one hand, there are the articles on what might be termed "the philosophy of chemical library research," stressing the value and significance of library research as a precursor of laboratory research, especially the papers of Connolly (*3*), Soule (*23*), Cole (*2*), and Lewton (*17*). The other group belongs to the "how to" class, discussing information sources and describing methods and procedures for carrying out literature research; papers by Egloff (*8*), Hoffman (*12*), Hennion (*11*), Berolzheimer (*1*), and Singer (*22*) might be mentioned here.

Any intensive research in the German chemical literature calls for a thorough knowledge of the German language. The amount of German required to pass a qualifying examination, often quickly acquired and as rapidly forgotten, may be sufficient for skip-reading, limited reference work, and the use of compilations like Landolt-Börnstein, Beilstein, or Gmelin (although even Beilstein hardly rates as light reading). But for any serious search where the results may involve securing or not securing a patent, or the initiation and guidance of a research program, only two courses of action should be considered: either to study and practice scientific and chemical German thoroughly, or to turn the search assignment over to someone specializing in this type of work and whose competence can be depended upon, a person experienced in the use of chemical German and one who can express himself properly in English as well. The kind of German required is not necessarily perfection in the spoken language, but rather possession of a broad working vocabulary and particularly a sense of German sentence structure and a feeling for some of the pitfalls of the language involving obscurity and ambiguity of expression which are sometimes hard to discover.

The prominent position of German chemical literature in the late nineteenth and the early twentieth century does not necessarily ensure lucid and unequivocal writing. It is just as easy to be obscure and ambiguous in German as in English. Goethe, the great master of German literature, expressed this idea in the frequently quoted lines from "Faust," where he lets Mephistopheles say: "Denn eben, wo Begriffe fehlen, da stellt ein Wort zu rechter Zeit sich ein" [For just when a concept (idea) is lacking, a proper word comes to the rescue].

Obscurity in German chemical writing is found mostly in two periods: the early to late nineteenth century when new concepts were evolving, new terms were created, and theses proposed and rejected, and also during and to some extent beyond the Nazi period when a program of so-called language purification was initiated. At that time many words of non-German origin were replaced by new expressions which added neither to the intelligibility nor the phonetic beauty of the language.

Changes in Spelling

A problem frequently arising in connection with searching of German chemical literature has to do with changes in spelling instituted in the first decade of the twentieth century. The main changes in this reform of the written German language as recorded in the Duden spelling texts are:

		Old	New
th	becomes t	Thon	Ton
ph	becomes f	Telephon	Telefon
c (with sound of k)	becomes k	Calcium	Kalzium
c (with sound of ts)	becomes z	Calcium	Kalzium

Unfortunately, these spelling rules do not hold one hundred per cent, especially for words of non-German origin, and a number still remain in the transition stage where two spelling variants may be encountered.

In the field of German chemical literature a considerable number of authors and

editors have adopted the Duden spelling—e.g., *Kolloid Zeitschrift.* A notable exception, the publications of the Deutsche Chemische Gesellschaft, came about in connection with a second spelling reform introduced by Jansen in 1907 (*15*). The Jansen spelling method applies to scientific and technical words and terms of non-German origin. It is based on the etymological origin of the word in the original language—e.g., Latin or Greek—in contrast to the Duden spelling which is phonetic and which may change an original "c" sometimes into "k" and another time into "z."

Here are some examples of both the Duden (phonetic, for general use) and Jansen (etymological, for use in scientific writing) spelling:

Duden	Jansen
Azetylen	Acetylen
Kalzium	Calcium
Zäsium	Cäsium
Zer	Cer
Zellulose	Cellulose
Zyan	Cyan

The Jansen spelling brings these German terms a good deal closer to their English equivalents. Jansen suggested that many technical terms belonged in a borderline zone between scientific and popular usage: All these "neutral zone" words were incorporated into his word list with both old and new forms of spelling.

The Jansen spelling caused some controversy and was not adopted by all the German scientific press. However, it was accepted by the Deutsche Chemische Gesellschaft in all its publications from 1907 on: *Berichte der Deutschen Chemischen Gesellschaft, Chemisches Zentralblatt,* Beilstein's "Handbuch der Organischen Chemie," and Gmelin's "Handbuch der Anorganischen Chemie."

Patterson (*20*), discussing this problem of spelling variants, also mentions the compounding of chemical names especially in inorganic chemistry—e.g., Jodkalium versus Kaliumjodid—and the different forms for the lower and higher oxides, chlorides, and other salts.

Whenever the problem of alternative spelling or of alternative word compounding arises in searching, the standard rule is: Consider all possibilities and look in all possible places.

Military German is a language by itself and abounds in innumerable coined and compounded terms and abbreviations which are not part of the ordinary technical language and are unfamiliar to the average German-speaking person. Any search work involving military German calls for the use of special dictionaries.

Dictionaries

We do not have too many recent German-English dictionaries covering chemistry and its borderline fields on a sufficiently broad basis. The more common ones are those of De Vries (*6*) and Patterson (*20*). For less recent background, there are general chemical dictionaries (*13*, *18*, *31*), as well as a number of German-English dictionaries in more specific fields (*7*, *16*).

Military dictionaries have been issued by the U. S. War Department and the British War Office (*27–30*).

A new German-English dictionary of aeronautics, physics, and related terms based on data compiled by the U. S. Air Force has recently been announced (*26*). A dictionary of this type would certainly fill a definite need in view of the large number of newly created German technical terms in new fields like atomic physics, rockets, jet propulsion, electronics, radar, and the like.

Finally, no matter to how many dictionaries a searcher has access, almost every one engaged in search work sooner or later accumulates a collection of specialized word lists and terms used in his own specific field; these are words met in the literature before they have found their way into the dictionaries.

In the German chemical literature, as elsewhere, the abstract journal and its indexes are, of course, the main source of information for the searcher.

Subject Indexes

The problem of producing a really good subject index has evidently caused much soul-searching among the editors of abstract journals and chemical compendia. One of them, (*10*), says (quoted somewhat freely): "The subject index is always a major headache for the editor. It is not merely that the complicated chemical terms are not suitable for alphabetical indexes, but even if they are indexed, most chemists cannot find them anyway." This same editor also felt that most patents were not worth reporting in the first place and merely wasted ink, space, and the editor's time. The one patent which finally sent his blood pressure skyrocketing was "a preparation composed of sugar, flour, sulfur and fat, combined with iron filings, which was to be used either as a skin cream, a hair tonic, a coating, or a rust-preventive agent."

Chemisches Zentralblatt

Any general type of search in the German chemical literature will inevitably lead to the *Chemisches Zentralblatt*, the earliest of the abstract journals. It was started in 1830, and ran through a number of name changes as well as some variations on the number of volumes per year. Since 1945, there has been a good deal of confusion because of the parallel publication of two editions, in the eastern and western zones of Germany. However, recently it was announced that an agreement had been reached and that a single *Zentralblatt* would henceforth be published which would cover all the chemical literature of the world. Beginning with July 1949, the *Zentralblatt* has been widened in scope and divided into six general sections which can be obtained separately. There will be separate indexes for each of the six parts, as well as a complete index for the entire annual unit.

Once before, the scope of the *Zentralblatt* had been extended; that was back in 1919, a key year, for at that date it began the coverage of information on applied chemistry. Such information prior to 1919 is found in the abstract section of the *Zeitschrift für Angewandte Chemie* or the *Chemisch-Technische Ubersicht* which appeared as part of the *Chemiker Zeitung*. From 1919 to 1924 when there were four volumes per year, Volumes 1 and 3 were "scientific" and Volumes 2 and 4 were "technical."

The over-all length and great detail of many *Zentralblatt* abstracts have more often than not been the subject of favorable comment, as has the frequent use of structural formulas. Many abbreviations are used in the text of the abstracts; however, a key in front of the index volumes resolves any problems in this connection.

Although there have been all sorts of indexes from 1830 on, the earlier ones do not offer much help from a subject point of view, for they are essentially word indexes which scatter entries. But the semiannual indexes for authors and subjects, from 1897 and 1889 on, the annual subject index from 1925 on, and the cumulative indexes of 1870 to 1881, then from 1897 on, with one exception, at 5-year intervals, got better all the time with less word indexing and more subject indexing, so that the 1925–29 cumulative index was reviewed by Crane (*4*) with many favorable comments. A new cumulative index for the years 1925 to 1938, a comprehensive author, subject, patent, and formula index, has been announced, but will not be available until a sufficient number of orders have been received by the publisher.

As a rule, the use of *Zentralblatt* author indexes offers no special difficulties, except for methods of spelling Russian names in German, which differ from U. S. usage. The German prefix "von" is sometimes left out, and it is necessary to look in two places in the author index.

The year 1925 brought important changes and improvements in the subject index and the Richter type formula index. There were an increased concentration and a classification into main subject groups and subgroups. Key terms were printed in heavy black type; an especially desirable feature was the addition in parentheses of all synonyms and alternate names of chemical compounds next to their main entry, in both the subject and formula indexes.

Prefixes like cyclo, iso, neo, etc., were disregarded in alphabetizing, but this provision was canceled later and from 1927 on one could again look for cyclohexanone under cyclo rather than under hexanone.

The very strong emphasis on classification which is such a feature of the *Zentralblatt* subject indexes, especially after 1925, has both desirable and undesirable aspects. It is fine for a broad and generalized approach and will save time when one is looking for something the original indexer arranged to have found. The undesirable feature of these convenient classified indexes is their tendency unconsciously to direct the attention of the searcher toward the indexer's intention rather than to what the searcher is looking for. The indexer leads to what he thinks should be looked for, not to what the searcher has in mind when he starts searching. And if one is looking for a specific piece of information he will have to cover a great deal of ground to be sure of not having missed anything, whereas in an ordinary alphabetized subject index he can pin-point his specific piece of information in a few moments if it is at all indexed. Another drawback of the *Zentralblatt* subject index is its "block" or "running" type of printing, which slows down the reader used to a line-an-entry arrangement.

Beginning with 1925, each index volume contains a Richter-type formula index. There also is a formula index in the collective index volume for 1922–24, but not in the individual index volumes for these years. After adding up the structural formula of the compound under consideration, the formula index provides either the *Zentralblatt* reference or a cross reference to the subject index. Most common organic compounds will be found in the subject index itself. For people who have trouble adding up formulas, there is a "Trivialnamenregister der organischen Verbindungen" (index of trivial names of organic compounds), which lists trivial names of compounds described up to that date, together with their summation formulas. Sometimes the subject entry gives a reference to the formula index.

Then there are the well-known German compendia: Beilstein, Gmelin, Abegg, Friedländer, Landolt-Börnstein, Houben-Weyl, Richter, Stelzner, Abderhalden, Hoffmann, etc. Some of them are becoming obsolete and newer ones will no doubt take their places. The Ullmann encyclopedia (*25*) provides good background material in searching in industrial chemistry and chemical technology. A third edition just announced will consist of thirteen volumes and one index volume and publication is to start at the end of 1950.

The wartime gap in the German chemical literature has been taken up by the FIAT review of German science (*9*), a comprehensive review of German fundamental research during 1939 to 1946.

Aside from the language qualification, and the specific peculiarities of individual information sources, a search through the German chemical literature should not call for any essential changes in the methods employed for a search through any other area of the chemical literature. The objective of the searcher should be to secure a maximum of desired information with a minimum of effort and in a minimum of time.

Basic Rules for Literature Search

Thus, the basic rules for conducting a search in the chemical literature might be summarized as follows:

Do the main work before starting the search and thus save time during its course. Confer with the originator of the project; establish subject, subtopics, and scope of search, amount of time to be spent, and limits of coverage. Insist on a written outline of the problem; this will be sometimes even more helpful to the one requesting the search than to the searcher.

Prior to starting, prepare the usual list of subject headings and key words to be checked, consulted, modified, and extended in the course of the search as indicated.

Usually work back from the present to the earlier literature.

Look for bibliographies; it is highly satisfying to find a complete bibliography already prepared. Make all possible uses of personal contacts; it may save much time in developing the desired information.

Know and always look for specific information sources. Never go to a general source when a specific one is available, be it a journal, a book, or a company publication.

Always consult the original references; every time a paper is abstracted or condensed, some information is lost along the line, or some misinterpretation may creep in.

There is a danger of commission as well as of omission. Especially, in a "viewpoint search," the data which are so important at this specific time may not have been of the same degree of importance to the abstractor or indexer of the original paper.

Hold regular intermediate conferences and discussions between search originator and searcher. At that time, it will be decided whether the objective has been reached, the search should be abandoned, or the information disclosed thus far calls for a shift of objective and attack in a different direction.

Know when to stop. Some searchers cannot let go and just keep on searching. There is no such thing as a "complete search." There is, however, a point of diminishing returns when additional time spent on rounding up obscure references no longer yields worth-while results. When that point has been reached, by mutual agreement between search originator and searcher, the search should be terminated and the results written up in a search report.

The actual form of such a search report is likely to vary and to reflect the requirements and standards of the organization in whose interest it has been prepared. No matter what form of final write-up is selected, it should embody:

A complete statement of the original literature research problem.
A complete listing of all information sources covered, with years and volumes checked and the subject headings and subheadings searched.
A listing of all the pertinent information found, preferably in the form of literature or patent abstracts with complete bibliographical description. The extent and amount of detailed data given in these abstracts may vary with their importance or with the type of search.
A discussion of the results of the search, if requested. Sometimes the final search report may be of a noncritical type.

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Searching Less Familiar Periodicals

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Most searches of current periodicals of chemical interest can be readily made with the means now available. The problem is much more difficult for publications prior to 1900 because of their smaller circulation, and less effective, or no, organizing agencies for them. Consideration is given herein to what can be done now with the less familiar periodicals, and what might improve the situation.

New information in chemistry and chemical technology appears almost entirely in periodicals, institutional publications, patents, manufacturers' technical pamphlets, and dissertations. The authors' assignment for this symposium is the discussion of the problem of searching the less familiar periodicals. The presentation is concerned, then, with the nature of the problem, with the present facilities and methods available for meeting it, and with the need for other ways and means in order to work more effectively.

In considering the subject it has been assumed that one is trying to locate all available information relevant to a given topic. Searching every periodical to find every item printed may appear as the wasted efforts of a perfectionist. Often something less than complete coverage does suffice. Also, there is no question of the general applicability of the principle of diminishing returns with increase in time spent searching. However, in at least three kinds of searches knowledge of everything recorded on a topic is important: (1) searches to determine merely all that is known; (2) searches to establish priority of publication; and (3) searches to settle the question of novelty or completeness of disclosure for patents. We are very likely to be concerned with the less familiar periodicals in cases of such searches.

Periodicals differ in many ways. In circulation we have those printed in thousands per issue, and those of perhaps only a few hundred. If one is susceptible to the too common Uesanian (a word coined by Armstrong in England some 20 years ago—U.S.A. plus nian, to refer to us and our work) weakness of mistaking quantity for quality, the best material may be thought to appear only in the most widely circulated, and hence the best known, periodicals. The most striking example to serve as a warning against such a conclusion is the great work of J. W. Gibbs on heterogeneous equilibrium. His papers, published in the then obscure *Memoirs of the Connecticut Academy of Arts and Sciences*, were uncovered only many years later by Europeans, with the result that today Gibbs stands as one of the most famous American scientists. It is especially this kind of thing which we hope to avoid in searching.

Under the heading of periodicals which might be considered less familiar to the chemist and chemical engineer there may today be none devoted exclusively to chemical subjects. If there are such, they must be ones of very limited circulation and/or printed in an obscure language. *Chemical Abstracts* is currently abstracting more than 5300 periodicals appearing in 31 languages, and the editor makes every effort to cover all periodicals having any new chemical interest. The periodicals discussed in this paper are most likely to be of a more general nature, especially (1) those dealing with science in general, one subdivision of which is chemistry; (2) those dealing primarily with a

science other than chemistry, but having incidental articles involving chemistry; and (3) trade journals, or house organs, which an abstractor or editor finds it difficult to justify abstracting.

Recognition of what the problem is ranks high in importance; but equally important is the question of what can be done about it.

Sources for Searching

Attention may be directed to four kinds of publications in order to determine what help they may provide for our problem. These publications include three secondary sources, treatises, bibliographies, and abstracting journals, and one primary source, periodicals. They are considered in the order of the decreasing state of organization of their material.

Treatises. By definition, a treatise is a comprehensive survey of a large general field of knowledge, such as organic chemistry. Ideally the publication should be so comprehensive as to be complete. If so, every relevant reference from every periodical would be cited. One's searching problem would then be simple, at least if the indexing were adequately done. If the treatise itself did not provide the necessary details, one need only turn to the appropriate reference, get the periodical, and read it.

Practically, this ideal has probably never been achieved, and present prospects give one little basis for thinking that it will be in the foreseeable future. Two defects of treatises must be kept in mind: They are never really up to date, the time lag being at times close to a quarter of a century; and they cover only part of the periodicals, those omitted being most likely the ones which concern this paper. The number of periodicals covered by some of the great treatises is shown in Table I.

Table I. Number of Periodicals Covered in Treatises

Publication	No. of Periodicals Covered	No. then Abstracted by *Chemical Abstracts*
Beilstein (*1*)	100, Vol. 6 (1931)	1996 (1931)
Berl-Lunge (*2*)	185, Vol. 1 (1931)	1996 (1931)
Friend (*6*)	175, Vol. 6 (1938)	2808 (1936)
Gmelin (*7*)	169, Vol. 1 (1907)	475 (1908)
	245, Vol. 1 (1926)	1246 (1926)
Grignard (*8*)	135, Vol. 4 (1936)	2808 (1936)
Hoffmann (*11*)	163, Vol. 1 (1919)	959 (1920)
Houben-Weyl (*12*)	187, Vol. 1 (1925)	1246 (1926)
I.C.T. (*24*)	586, Vol. 5 (1927)	1246 (1926)
Kirk and Othmer (*14*)	52, Vol. 1 (1947)	4318 (1946)
Landolt-Börnstein (*15*)	142, Vol. 1 (1923)	1246 (1926)
Pascal (*18*)	104, Vol. 1 (1931)	1996 (1931)
Tables annuelles (*16*)	569, Vol. 7 (1925)	1246 (1926)
Thorpe (*22*)	120, Vol. 6 (1926)	1246 (1926)
Ullmann (*23*)	213, Vol. 1 (1928)	1246 (1926)

The periodicals listed in the Landolt-Börnstein set (*15*) may serve as an example of warning in two directions. The first possibility concerns balance in an editor's selection of sources. Of the 142 journals listed, 74 are German. One cannot discount the great contributions of German chemists to chemical literature, but it seems improbable that their work warrants any such proportion of the journals chosen. The second possibility concerns coverage. At the time of searching the 142 journals for data for the set, *Chemical Abstracts* was covering 1246 journals. Because physical constants concern much of chemistry, it seems improbable that 1100 journals contained nothing sufficiently significant to warrant listing at least some of them.

What value, then, do such works have for our problem? Primarily, they give a perspective of the field nearly to the date of publication of the treatise. If nothing can be found on our specific problem, then the search by the compilers of the treatise in the periodicals listed yielded nothing. One does not know whether something was missed in one or more of the omitted periodicals—that is, the less familiar publications.

Treatises serve first to show which journals were covered and to give what was found. In case there was anything, the original reference is given. Thus the treatise is likely to serve further, for many such papers will themselves contain references to the less famil-

iar periodicals, many of which may not have been covered directly by the compilers of the treatise.

Bibliographies. A bibliography, being by definition a list of references, may be of occasional help. However, this is a likely additional possibility only in case all such references have not been evaluated and incorporated in a treatise dealing with the kind of chemistry involved. Such bibliographies as may be available serve as a cross check on the work of the treatise compiler.

From the viewpoint of the present problem, bibliographies fall roughly into three groups: (1) those compiled from abstracting journals and/or treatises; (2) those resulting from reading and evaluating all the references found in abstracting journals, to which have been added any others found as this evaluation progressed; and (3) those which are, if possible, still more inclusive as a result of browsing around in all possible sources. The first group is of little value, because the references are already covered by the organizing agencies. The second will aid to the extent that any references are included which did not appear in abstracting journals or treatises. The third, of course, is what we hope to find.

What the authors have particularly in mind here as being desirable is the kind of bibliography exemplified by Howe's "Bibliography of the Metals of the Platinum Group," a work covering some 150 years (*13*), beginning around 1750. Unfortunately, there are few compilations so meticulously done.

Two general collections of bibliographies may be mentioned. West and Berolzheimer's bibliography of bibliographies (*25*) is an alphabetical list of bibliographies found by searching about 100 periodicals and treatises for the years 1900 to 1931. Bolton's "Select Bibliography of Chemistry" (*3*), covering the period 1492 to 1902, is very general in nature but it does list several hundred bibliographies for this early period.

Since 1937 *The Bibliographic Index* has functioned as a means of cumulating a bibliography of bibliographies. The arrangement is by subjects, only part of which concerns chemistry. By 1948 over 1500 periodicals were being covered. Lists of these sources are included.

Abstracting Journals. In most respects abstracting journals are our most important agencies concerned with gathering together and organizing the vast annual accretion of new information. Consequently, they are practically indispensable for any kind of extensive journal search.

Ideally, such a publication should at least provide abstracts which will lead any searcher to the original details he seeks, give complete material coverage at any given time for all periodicals then of value in chemistry, and give complete time coverage for all these periodicals.

As with treatises, there is no perfect publication in this class. To the extent that abstracting journals meet these requirements, they are among the most useful means to which the searcher can turn. Any deficiency relating especially to our problem arises from incomplete coverage. Therefore, whatever is involved deserves attention.

These publications roughly fall into selective and general classes. The former group is likely to have limited coverage in terms of time, number of periodicals, or subject matter (*5*, *17*). There should be careful checking of all such sources if the authors' proposed list of periodicals were to be made.

For certain purposes or topics one or more of these selective abstracting services, such as *Engineering Index*, may be most practical, but in the great majority of cases three general journals are believed to be most useful: *Chemisches Zentralblatt* (1830–), *British Abstracts* (1871–, as *J. Chem. Soc.*; 1882–, as *J. Soc. Chem. Ind.*), and *Chemical Abstracts* (1907–). For the past four decades, therefore, one can cross check through all three of these journals. Two of them extend back another four decades, but only the German journal serves for the third period of four decades. The dates given show the time coverage of these three abstracting periodicals.

Prior to 1830, the start of *Chemisches Zentralblatt*, an occasional general journal included some abstracts. Examples are *Annales de chimie et de physique* (1789 to 1870), *Dingler's polytechnisches Journal* (1820 to 1931), *Taschenbuch für die gesammte Mineralogie* (1807–), and *Journal de pharmacie et de chimie* (1809–). However, certain journals

Table II. List of

(Number following title refers

No.	Date	Title
1	1665–	*Philosophical Transactions of the Royal Society of London*
2	1665–1792	*Journal des scavans* (+ No. 43)
3	1666–1790	*Histoire de l'académie royale des sciences* (+ No. 47)
4	1679–1682	*Philosophical Collections of the Royal Society of London*
5	1710–1743	*Miscellanea Berolinensia ad Incrementum Scientarium ex Scriptis Societatis Regiae Scientarium* (+ No. 10)
6	1720–1760	*Recueil des mémoires les plus interessants de chimie et d'histoire naturelle, contenus dans les actes de l'académie d'Upsala, et dans les mémoires de l'académie royale des sciences de Stockholm*
7	1726–1746	*Commentarii Academie Scientarium Imperialis Petropolitanae* (+ No. 11)
8	1728–1757	*Raccolta d'opuscoli scientifici e filologici* (+ No. 13)
9	1739–	*Handlingar Kongliga Svenska Vetenskaps-Academiens*
10	1745–1769	*Histoire de l'académie royale des sciences et des belles-lettres de Berlin* (+ No. 17)
11	1747–1775	*Novi Commentarii Academiae Scientarium Imperialis Petropolitanae* (+ No. 20)
12	1752–1755	*Observations sur l'histoire naturelle, sur la physique, et sur la peinture* (+ No. 14)
13	1755–1787	*Nuova raccolta d'opuscoli scientifici e filologici*
14	1756–1757	*Observations périodiques sur la physique l'histoire naturelle et les arts* (+ No. 18)
15	1769–	*Mémoires de l'académie des sciences, arts, et belles-lettres de Di on*
16	1769–	*Transactions of the American Philosophical Society*
17	1770–1786	*Nouveaux mémoires de l'académie royale des sciences et belles-lettres* (+ No. 31)
18	1771–1772	*Introduction aux observations sur la physique, sur l'histoire naturelle, et sur les arts* (+ No. 19)
19	1773–1823	*Journal de physique, de chimie, d'histoire naturelle, et des arts*
20	1777–1782	*Acta Academiae Scientarium Imperialis Petropolitanae* (+ No. 26)
21	1778–1781	*Chemisches Journal für die Freunde der Naturlehre* (+ No. 24)
22	1780–1829	*Almanach für Scheidekünstler und Apotheker*
23	1780–	*Memoirs of the American Academy of Arts and Sciences*
24	1781–1786	*Neuesten Endeckungen in der Chemie*
25	1783–1791	*Chemisches Archiv* (+ No. 48)
26	1783–1802	*Nova Acta Academiae Scientarium Imperialis Petropolitanae* (+ No. 54)
27	1783–	*Transactions of the Royal Society of Edinburgh*
28	1784–1803	*Chemische Annalen für die Freunde der Naturlehre Arzneygelahrtheit, Haushaltungskunst, und Manufacturen*
29	1785–1795	*Beiträge zu den chemischen Annalen von Lorenz Crell*
30	1785–1787	*Magazin für Apotheker, Chemisten, und Materialisten* (+ No. 33)
31	1786–1804	*Mémoires de l'académie royale des sciences et belles-lettres* (+ No. 55)
32	1787–1802	*Bibliothek der neuesten physisch-chemischen, metallurgischen, technologischen, und pharmaceutischen Literatur*
33	1788–1790	*Repertorium für Chemie, Pharmacie, und Arzneimittelkunde*
34	1788–1803	*Sammlung der deutschen Anhandlungen der königlischen Akademie der Wissenschaften zu Berlin*
35	1790–1802	*Annali di chimica e storia naturale, ovvero raccolta di memorie sulle scienza, arti, e manufatture ad esse relative*
36	1790–1794	*Journal der Physik* (+ No. 41)
37	1793–1817	*Journal der Pharmacie für Aerzte und Apotheker* (+ No. 70)
38	1794–1815	*Journal des mines* (+ No. 67)
39	1795–1840	*Berlinisches Jahrbuch für die Pharmacie*
40	1795–	*Journal de l'école polytechnique*

were being published prior to part, at least, of such abstracting services. Table II lists examples of such publications. Some titles vary with time.

As far as the authors know, no study has been published on the degree of completeness of the coverage of the big three abstracting journals, let alone all journals which have carried abstracts at some time. Table III lists the number of periodicals covered by each of the big three at various dates. Those not covered at any given time by a particular journal might be determined by checking its list against a list of all known periodicals of that date. The authors have not presumed to attempt this check.

An important aspect of this coverage problem concerns borderline fields, with the periodicals devoted to them. Biochemistry, in all its involvements with physiology, clinical medicine, and other related subjects, may well be the outstanding example of difficulties in this direction. Two less involved cases illustrate the point.

METALLURGY. Some 15 years ago *Metals and Alloys* was abstracting from nearly 400 publications, although *Chemical Abstracts* was listing less than 100 for the metallurgical field. Presumably the other 300 were considered by abstractors of *Chemical Abstracts* as either unimportant or of no chemical interest.

ANALYTICAL CHEMISTRY. For over two decades spectrophotometers have found increasing use as a means of making certain kinds of analytical measurements. Twenty years ago chemical abstractors apparently did not consider this instrument of much analytical importance and consequently one could not depend upon finding articles abstracted for equipment of this kind. The obvious answer in this case is that the subject was considered to be physics and the searcher should have turned to that subject. One might reply that all measuring instruments, such as the analytical balance, belong in the strict sense just as much to physics.

These two examples emphasize the importance of maintaining a broad viewpoint in

Selected Early Periodicals

to entry number of superseding periodical)

No.	Date	Title
41	1795–1797	*Neues Journal der Physik* (+ No. 50)
42	1796–1815	*Bibliothèque Brittannique. Sciences et arts* (+ No. 66)
43	1797–	*Journal des savants*
44	1797–1813	*Journal of Natural Philosophy, Chemistry, and the Arts*
45	1797–1806	*Magazin für den neuesten Zustand der Naturkunde*
46	1798–1803	*Allgemeines Journal der Chemie* (+ No. 52)
47	1798–1815	*Mémoires de l'institut national des sciences et arts* (+ No. 68)
48	1798–	*Neuestes chemisches Archiv*
49	1798–	*Philosophical Magazine*
50	1799–	*Annalen der Physik*
51	1802–1813	*Annales de muséum d'histoire naturelle* (+ No. 64)
52	1803–1806	*Neues allgemeines Journal der Chemie* (+ No. 56)
53	1803–1818	*Archiv der Agriculturchemie für denkende Landwirthe*
54	1803–1822	*Mémoires de l'académie imperiale des sciences de St. Petersbourg*
55	1804–	*Abhandlungen der königlichen Akademie der Wissenschaften in Berlin*
56	1806–1809	*Journal für die Chemie, Physik, und Mineralogie* (+ No. 62)
57	1806–1818	*Afhandlingar i Fysik, Kemi, oc Mineralogi*
58	1807–1817	*Mémoires de physique et de chimie de la société d'Arcueil*
59	1808–1827	*Giornale di fisica, chimica, et storia naturale*
60	1810–1814	*American Mineralogical Journal*
61	1810–	*Memoirs of the Connecticut Academy of Arts and Sciences*
62	1811–1833	*Journal für Chemie und Physik*
63	1813–1826	*Annals of Philosophy*
64	1815–1832	*Mémoires de muséum nationale d'histoire naturelle*
65	1816–1830	*Quarterly Journal of Science, Literature, and Art*
66	1816–1835	*Bibliothèque universelle des sciences, belles-lettres,.et arts*
67	1816–	*Annales des mines*
68	1816–	*Mémoires de l'académie royale des sciences de l'institut de France*
69	1817–1822	*Allgemeine Nordische Annalen der Chemie für die Freunde der Naturkunde und Arzneiwissenschaft* (+ No. 77)
70	1817–1834	*Neues Journal der Pharmacie*
71	1818–	*American Journal of Science*
72	1819–1826	*Edinburgh Philosophical Journal* (+ No. 82)
73	1820–1928	*Transactions of the Cambridge Philosophical Society*
74	1821–1849	*Jahresbericht über die Fortschritte der Chemie und Mineralogie*
75	1821–1851	*Arsberättelse om Framstegen i Fysik och Kemi till Kongligsche Vetenskaps-Akademien*
76	1822–	*Archiv der Pharmacie und Berichte der deutschen pharmazeutischen Gesellschaft*
77	1823–1831	*Magazin für Pharmacie*
78	1824–1832	*Edinburgh Journal of Science*
79	1824–1835	*Archiv für die gesammte Naturlehre*
80	1825–1876	*Journal de chimie médicale, de pharmacie, et de toxicologie*
81	1826–1864	*Edinburgh New Philosophical Journal*
82	1826–	*Journal of the Franklin Institute*
83	1826–	*Bulletin de la société industrielle de Mulhouse*
84	1828–1833	*Journal für technische und ökonomische Chemie*
85	1829–	*American Journal of Pharmacy*

searching in order to avoid missing possibly important borderline periodicals. Many subjects are not exclusively the province of sharply defined fields.

Periodicals. We come finally to the most difficult part of the problem, and, unfortunately, the part for which least advice can be given for searching. Each treatise has its index, accompanied usually with a list of the periodicals covered. The current abstracting journals are probably unsurpassed in the quality of their indexes, and each occasionally publishes lists of the periodicals covered. In brief, the problem remaining is to discover any lack of coverage of the periodicals by these organizing agencies and then to determine what indexes are available for such periodicals.

First of all one needs a complete list of all present and discontinued periodicals having any possible chemical interest. This would include those devoted entirely to

Table III. Number of Periodicals Abstracted by Different Abstracting Periodicals at Different Dates

Chemisches Zentralblatt		*British Abstracts*[a]		*Chemical Abstracts*	
Date	No.	Date	No.	Date	No.
1890	115	..	..	..	..
1900	145	...	...	...	...
1910	162	1910	222	1910	435
1915	153	1916	264	1915	671
1920	306	1920	464	1920	959
1926	480	1926	406	1926	1246
1930	839	1931	474	1931	1996
		1936	715	1936	2808
		...	...	1942	3740
		1946	1317	1946	4318

[a] Prior to 1926 divided between *J. Chem. Soc.* and *J. Soc. Chem. Ind.*

Table IV. Periodicals

1633–1876. Catalogue of Scientific Serials, by S. H. Scudder.
The 4390 entries include transactions of learned societies in the natural, physical, and mathematical sciences. The titles are listed by countries and sublisted by place. Separate indexes cover places (towns), titles, and certain subjects, such as chemistry.

1665–1895. A Catalogue of Scientific and Technical Periodicals, by H. C. Bolton.
This great compilation was "intended to contain the principal independent periodicals of every branch of pure and applied science, published in all countries from the rise of this literature to the present time" (1895). The 8600 titles are arranged alphabetically. Included also are chronological tables, a classified subject index, and American library holdings.

1665–1800. Repertorium Commentationum a Societatibus Litterariis Editarium Secundum Disciplinarum Ordinem Digessit, by J. D. Reuss.
Of the 16 volumes of this work the third, Scientia Naturalis, deals with chemistry and metallurgy. It functions as a precursor to the Catalog of Scientific Papers, listed next.

1800–1900. Catalog of Scientific Papers, by Royal Society of London.
The 19 volumes of this indexing serial contain entries from 1555 periodicals. Our interest is the list of many periodicals covered. The number varies, there being 1400 in Vol. 1 and 1865 in Vol. 13.

1901–1914. International Catalogue of Scientific Literature, by Royal Society of London.
This publication, a continuation of Catalog of Scientific Papers, is divided into 17 sections, chemistry being D. The first volume for chemistry lists 116 periodicals, which increased to 417 in the fourteenth volume. The total list of journals for 1903–04 contains 5546 entries.

1802–1907. Index to Periodical Literature, by W. F. Poole.
The 470 periodicals indexed are in the English language and are of a general nature. The entries concerning chemical subjects are relatively small in number.

1823–1908. Repertorium der technischen Journal-Literature, by E. L. Schubarth *et al.*
This serial began as Repertorium der technischen Literature and in 1909 became Fortschritte der Technik. During the 105 years shown more than 400 periodicals were covered at some time.

*–1866. Catalogue of Publications of Societies and of Periodical Works Belonging to the Smithsonian Institution.
The alphabetical list, by country and city, includes publications of more than 25 countries.

*–1888. Bibliographie des travaux scientifiques publiés par les sociétés savantes de la France, by J. Deniker and R. Descharmes.
This set, completed thus far only to the heading "Sarthe," lists the publications of French scientific societies. The arrangement is by departments, then by towns, and finally by societies.

1879–1934. Bibliographie der deutschen Zeitschriftenliteratur.
This work is especially useful as an indexing serial for German periodicals. The number of journals covered ranges from 275 in the first volume to over 4500 at the peak of the 55-year period.

1884– . Engineering Index.
The periodicals covered in this indexing serial, now in the neighborhood of 2000, concern primarily engineering and allied technical fields.

1889– . Experiment Station Record.
This digest of current agricultural literature serves practically as an index in this field prior to the start of Agricultural Index in 1916.

*–1898. Publications of Societies, by R. R. Bowker.
Over 1000 American societies issuing publications of general or technical interest are listed.

1900– . Readers' Guide to Periodical Literature.
This index is of possible use for general or popular articles in a limited number of periodicals.

*–1914. Die wissenschaftlichen Vereine und Gesellschaften Deutschlands im neunzehnten Jahrhundert.
A list is given of German societies and periodicals.

*–1938. Hand-List of Titles of Current Periodicals in the Science Library. His Majesty's Stationery Office.
This list contains titles of the publications, together with details of the holdings.

*–1900. British Museum Catalogue of Printed Books.
Volume 1, Academies, lists academy publications in the library of the British Museum prior to 1885. Volume 41, Periodical Publications, includes periodicals prior to 1900. Listing is by place of issue, with sublisting by societies.

1879–1926. Index Medicus (Quarterly Cumulative Index Medicus after 1926).
This is an indexing serial covering medical publications in all the principal languages.

1880– . Index Catalogue of the Library of the Surgeon-General's Office.
This is an index of our great medical library, with various lists of the serials covered in the several series. Thus, Volume 10, 4th Series, lists 6776 serial publications.

1900–1933. World List of Scientific Periodicals.
Over 36,000 periodicals are listed for the publication period shown. All details are included for checking, such as changes of name, and library holdings.

1907– . International Index to Periodicals.
This list covers several hundred periodicals not included in sources such as Engineering Index, Industrial Arts Index, and Agricultural Index.

Table IV. Periodicals (*Continued*)

1911– . Bibliographie der remdsprachigen Zeitschriftenliteratur.
Here are indexed some 2000 non-German periodicals. It is said to be valuable for French and Italian publications.

1913– . Industrial Arts Index.
Because of its nonscientific emphasis, this work is probably of less value for our purpose than various other lists.

* –1943. Union List of Serials in Libraries of the United States and Canada, by W. Gregory.
Since this vast collection lists more than 115,000 titles, it includes many relatively unimportant entries. However, it does undoubtedly cover some of our less familiar works.

* These publications are supposed to be complete to the dates shown.

chemical information; those devoted either to general science or to a nonchemical field but containing incidental chemical items; and those devoted to borderline fields, some of the information of which has some bearing on some chemical problems.

Such a list should give the inclusive dates covered by each periodical. Along with the date should appear notations to show which treatises and which abstracting journals have covered the periodical, with inclusive dates if the whole period of the periodical was not covered. We shall assume for the present purpose that coverage by a treatise and/or an abstracting journal is adequate.

When there is not such coverage, the following cases might arise: The periodical was completely overlooked or disregarded by editor and/or abstractor; there was no organizing agency during the period of the periodical, or some part of it; and the abstracting journal began later than the periodical to be abstracted.

To the best of the authors' knowledge, there is no annotated list of uncovered periodicals, such as that suggested. Until its possible compilation, we seem to be dependent largely upon a collection of other lists arranged for various purposes. Table IV shows some publications which are believed to be of use for our purpose. Special attention was given to including works listing the early publications. Journals published prior to 1900 are most difficult to locate and least likely to be available except in very large libraries.

Having in hand the possible residue of uncovered or partially covered periodicals, one can then turn to whatever means are available for searching the publications concerned. Lacking organizing agencies, about the only alternatives remaining are the indexes for the individual periodicals. Most likely they are annual indexes, with some cumulative indexes covering either specified intervals of time or the entire run of the periodical. As a final entry, then, for each periodical in our projected list there should be notations on the availability of such indexes.

The authors know of no general list of the available cumulative indexes for all periodicals of interest. However, some help may be had, as in Haskell's check list (*10*). Also during the past two decades Columbia University has issued a number of such lists covering its own acquisitions. An example is the list of Roys (*20*) for the period 1934–38.

Perhaps mention should be made here of the occasional help of comprehensive historical articles, especially if their aim was to present a complete survey of a subject. An American example is the paper by Silliman (*21*) on "American Contributions to Chemistry" which covers over 60 pages. In this review of the work of the century 1774 to 1874 one finds not only the names of now familiar periodicals, such as the *Journal of the Franklin Institute* and *American Journal of Science*, but also less familiar ones, such as *New York Medical Repository, Boston Journal of Chemistry, New York Medical and Philosophical Journal, Thomson's Annals of Philosophy, Mémorie des savants étrangers*, and *Memoiri degli spectroscopisti italiani.*

House organs and trade journals constitute part of our periodical problem. Mention was made of the difference in number of publications abstracted by *Metals and Alloys*, a metallurgical journal, and by the metallurgical section of *Chemical Abstracts*, a general abstracting journal. As the editor of the latter periodical endeavors to abstract from every original source which contains new chemical information, one may assume that any unmentioned house organs and trade journals contain little that is new. In fact, many items therein are intended to be of only passing interest or for advertising purposes.

In this connection, a work of possible value is the "Directory of House Organs" (*19*), a work listing more than 5300 titles in 1947. The arrangement is by title (alphabetical) and by sponsor (both alphabetical and geographical). A symbol indicates the user as internal, external, or both. Titles of special chemical interest must be inferred from the name or the sponsor. An earlier work by Groves (*9*) dealt with British house organs.

In conclusion, if one has at hand the periodicals, house organs, and any other like periodicals, together with their indexes, it remains only to use the works. This involves chiefly subject indexes and there is nothing peculiar about those concerned here. Perhaps the chief point to remember is that many of them are in no way comparable in usefulness to the present expertly constructed subject indexes of *Chemical Abstracts*. If one can live through the experience, page-by-page examination of the periodical is the last resort for searching an inadequately indexed publication. In a recent book (*4*) the authors report use of such means in order to locate every reference to boron trifluoride and its derivatives.

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Identification of Less Common Forms of Abbreviations of Chemical Journal Titles

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Journal citations are unwelcomed by the literature searcher only when they tend to obscure rather than to disclose the actual journal title. Confusion in such a citation may arise from a change in the normal word order, as inversion; addition of extra words, such as the society name, place of imprint, or founder; unusual contractions or abbreviations of individual words; and the complete omission of certain words appearing in the full title. Standard abbreviations have been established from time to time, but as yet no one system of constructing abbreviations may be considered to be truly international.

To the chemical worker, references to periodicals, books, and patents are the means by which the wealth of published scientific knowledge is made accessible. Without the elaborate network of abstract journals, bibliographies, reviews, and indexes which exist today, the research worker is little better off than the first man who discovered the use of fire. An important phase of locating any article is the identification of the periodical in which it appeared, or, as is more often the case, the abbreviations of its title.

General Forms of Abbreviation

Few literature searches can remain within the *Chemical Abstracts*' system of abbreviations for any length of time. Even within the confines of *Chemical Abstracts*, Beilstein, *British Abstracts*, and *Chemisches Zentralblatt*, the abbreviation of Justus Liebig's *Annalen der Chemie* will vary from *Ann.* to *A* to *Annalen* to *Liebig's Ann. Chem.* Other examples could easily be appended.

One question arises immediately: Is there not at least one standard list of abbreviations of journal titles? In 1922, the abbreviations used in the "List of Periodicals Abstracted by *Chemical Abstracts*" (*8*) were adopted as a standard by the International Union of Pure and Applied Chemistry. Crane and Patterson (*12*) commented in 1927 that these abbreviations "have not been accepted universally, but their use is increasing," and Soule (*42*) added in 1938 that the adoption of the "List of Periodicals Abstracted by *Chemical Abstracts*" by the International Union of Chemistry "gives the list a definite status and increases the probability of its wider adoption in the near future."

One can readily observe that the acceptance by the International Union of Pure and Applied Chemistry of *Chemical Abstracts*' abbreviations has not led to many drastic changes in practice. It is encouraging that, among the standard reference works published since 1922, at least one (*18*) follows this list.

Another list of abbreviations is offered by the "World List of Scientific Periodicals"

[1] Present adddress, Sinclair Refining Co., New York 20, N. Y.

(*44*, *45*). The second edition of this work, published in 1934, contains abbreviations which follow the system recommended at an international conference of the International Institute of Intellectual Cooperation. The original World List abbreviations, published in 1927, required only slight modifications to comply with this system.

The whole problem of abbreviated titles is aptly reviewed by Mitchell in his preface to the second edition of the World List, where he states that "the use of abbreviated titles is a necessity in scientific literature, but unless the abbreviations have been devised so that each one indicates only one periodical and also unless they are in general use, they fail of their purpose." The Royal Society Scientific Information Conference, held in London from June 21 to July 2, 1948, recommended that the World List abbreviations be adopted by abstracting agencies.

Pflücke in 1933 (*31*) mentions that the *Chemisches Zentralblatt* abbreviations are based on the World List and the rules of the International Institute of Intellectual Cooperation, as set forth in German Standard No. 1502.

Thus there are two sets of abbreviations which have attained, at the very minimum, the nominal status of international standards.

A comparison of the two lists—i.e., "List of Periodicals Abstracted by *Chemical Abstracts*," most recently revised in 1946, and the "World List of Scientific Periodicals"—discloses the following data:

Chemical Abstracts 1946	7842 entries, including 4318 titles in current usage and 3524 earlier titles, with references to succeeding ones
World List 1934	36,000 titles listed

In general, the citations in the World List are slightly longer than those in *Chemical Abstracts*.

Chemical Abstracts	World List	Title
Ber.	*Ber. dtsch. chem. Ges.*	*Berichte der deutschen chemischen Gesellschaft*
Chem. Ind.	*Chem. Industr., Berl.*	*Die Chemische Industrie*
Compt. rend.	*C. R. Acad. Sci., Paris*	*Comptes rendus hebdomadaires des séances de l'académie des sciences*
Monatsh.	*Mh. Chem.*	*Monatshefte für Chemie und verwandte Teile anderer Wissenschaften*
Rec. trav. chim.	*Rec. Trav. chim. Pays-Bas*	*Recueil des travaux chimiques des Pays-Bas*

This difference in length of citation would be expected, because the World List must distinguish among nearly five times as many journals as *Chemical Abstracts*.

Another system of abbreviations, which also has a world-wide perspective, is utilized in the "International Catalogue of Scientific Literature" (*21*). This work, a continuation of the "Catalogue of Scientific Papers" which will cover the literature of the nineteenth century, is issued annually in seventeen volumes, the fourth of which deals with chemistry. The rules for periodical abbreviations which are given in the "Instructions for Use of Regional Bureaus" (1903) are most brief. The first two rules state general principles to which no one would object.

1. Abbreviated titles must be intelligible without a key.
2. Words in abbreviated titles must follow each other in the same order as the original title.

The remaining two rules presuppose a little more than what is common knowledge of the histories of various journals.

3. Titles of proceedings, reports, or scientific periodicals in general, which are

edited or published by learned societies, academies, etc., must begin with the name of the place where the society resides.

4. When the society does not reside in a fixed place, the publication must be dealt with as stated in Rule 2, the place of present publication being added at the end of the abbreviation.

Chemical Abstracts has no written rules for abbreviation of periodical titles (*5*). In general, the normal word order of the title is preserved. The abbreviations should suggest the title without use of the List of Periodicals.

In each of the prefaces to the two editions of the World List, a special description of the rules employed in constructing the abbreviations is given. The rules of the "International Code of Abbreviations for Titles of Periodicals" (1930) and its supplement (1932) were utilized in revising the directions given in the first edition (*22*). A brief summary of these rules, as they now exist, is as follows:

1. Contractions are differentiated from abbreviations by omission of full stop. Thus if *Engineering* is contracted to *Engng*, no period follows the abbreviation, whereas if *Engineering* is shortened to *Eng.*, a period is used.
2. Nouns have capital initial letters, adjectives small.
3. Prepositions, articles, and connectives are generally omitted.
4. Singular and plural words are not distinguished.
5. Places of imprint are omitted, except where a question of the language used, or the need to distinguish two periodicals with the same title, arises.
6. In Germanic and Scandinavian languages, different parts of complex words are abbreviated as if distinct. For example, *Kunstseide* might be abbreviated *Kt.-sd.*, but never *Kunst.*

Similar problems arise when one attempts to define the most general forms used in citing journals in other sciences. The question of standard abbreviations for titles of periodicals in botany was discussed recently by Little (*25*). The confusion within this science exists in part because each of the four main botanical indexes—i.e., *Bulletin of the Torrey Botanical Club*, *Agricultural Index*, *Biological Index*, and *Bibliography of Agriculture*—stoutly adheres to its own system of abbreviating periodical titles. The suggestion is made by Little that an attempt to eliminate these differences be made at the forthcoming Seventh International Botanical Congress at Stockholm.

Thus, various schemes for standardization of abbreviations have met with only partial success. It is not surprising that additional proposals for eliminating abbreviation problems have been made. One suggestion that has been presented from time to time is to assign a number to every periodical and use these numbers in place of word abbreviations. Whereas such a scheme would eliminate the confusion which now exists between the same or similarly titled periodicals, it would create problems when periodicals change titles or cease publication, or when new periodicals are initiated. Also the numbers would give little indication of the subject matter or type of journal cited.

A more feasible plan was proposed by the International Institute of Intellectual Cooperation and, more recently, by the Royal Society. Let it be the responsibility of the periodical publisher to obtain an abbreviation which has the approval of either *Chemical Abstracts* or the World List (preferably both). This abbreviation would then appear printed on the covers and at the bottom of each page of the journal. Such a plan would make abbreviation problems a thing of the past.

Less Common Forms of Abbreviation

There seem to be logically only four types of word order which can be used in abbreviating the name of a journal.

1. Exact title order, as appears in the periodical.
2. Name of issuing society, followed by the title.
3. Place of imprint, followed by the title
4. Founder or successive editors of journal, followed by title.

Thus, for the *Journal of the American Chemical Society*, there would be:

1. *J. Am. Chem. Soc.*
2. *Am. Chem. Soc., J.*
3. *Washington, J. Am. Chem. Soc.*
4. *Lamb, J. Am. Chem. Soc.*

In addition to the problem of which word order is to be used, there is the question of which words or parts of words shall be omitted or retained. For instance, the word *American* might appear as *A*, *Am.*, *Amer.*, or *Amern.*, not to mention what is done to the word *Journal*. In addition, the letter *A* might also stand for *Annalen, annaler, annales, annali, Annalen der Chemie, abstracts, age,* or even *British Abstracts*, Section *A*.

Generally no difficulty arises in the case of a periodical abbreviation given in exact title order, provided that the individual word abbreviations chosen are long and distinct enough. The abbreviation *Z. an.* follows the principle of strict order, but its parsimony leads to a possible confounding of the following:

Z. anal. Chem.
Z. anal. Entwichlungsgeschichte
Z. angew. Chem.
Z. angew. Mikroskop. u. Klin. Chem.
Z. angew. Mineral.
Z. angew. Phot. Wiss. u. Tech.
Z. anorg. Chem.
Z. anorg. u. allgem. Chem.

Similarly, the Russian word *Trudy* as an abbreviation would lead to the possible confusion of 126 citations (86 of which now have other titles).

By beginning an abbreviation with the name of the issuing society, as in the case of *Am. Chem. Soc., J.*, one benefit is procured: Most libraries index and shelve society or institutional periodicals and pamphlets under the name of the society issuing them. Whereas *Deutsche chemische Gesellschaft, Berichte* may be entirely logical to a librarian; however, its utility to the research worker is more questionable.

An ingenious variation for the abbreviation of an important Italian journal can be found by considering *Atti della reale accademia nazionale dei Lincei, Rendiconti Classe di scienze fisiche, matematiche e naturali. Chemical Abstracts* accords one of its lengthiest abbreviations to this journal, maintaining, however, the normal word order—*Atti accad. nazl. Lincei, Classe sci. fis. mat. e nat. Chemisches Zentralblatt* also conforms to the logical word order in using *Atti R. Accad naz. Lincei, Rend.* However, Beilstein and *British Abstracts* invert the order and place the society first so as to produce *R.A.L.*, and *Real. Acc. Lincei*, respectively.

The third arrangement of abbreviations, with the place of imprint first, is exemplified by *Wash., J. Am. Chem. Soc.* Thus *Berichte der deutschen chemischen Gesellschaft* is sometimes cited as *Berliner Ber.*, or even *Ber. Ber.*

The methods in which the society or place of imprint is placed first in citing journals are not too common, and the fact that such systems have been utilized can generally be recognized without too much difficulty.

The last type of word order to be considered consists in placing first the name of the founder or one of the successive editors of the journal. A brief list of the most common of such abbreviations includes the following:

Crell J., Journal für die reine und angewandte Mathematik
Dingl, J., Dingler's Polytechnisches Journal
Drude, Annalen der Physik
Erdemann's J., Journal für praktische Chemie
Fr., Zeitschrift für analytische Chemie (Fresenius)
Gilb. Ann., Annalen der Physik (Gilbert)
H.-S., Zeitschrift für physiologische Chemie (Hoppe-Seyler)
Liebig's, Annalen der Chemie
Pogg. Ann., Annalen der Physik (Poggendorf)
Pflüger Arch., Archiv für die gesamte Physiologie
Sill. J., The American Journal of Science (Silliman)
Wiedermann's Ann., Annalen der Physik

An extensive list of older periodicals, including their editors, is given by Dyson (*14*).

Given an abbreviated citation that is not immediately decipherable, how then to proceed to identify it?

One tendency might well be mentioned here. The shorter and seemingly more obscure abbreviations are generally those given to the most widely used journals within any one field. It is more likely that *A.*, *B.*, and *C.* will refer to *Annalen der Chemie, Berichte der deutschen chemischen Gesellschaft,* and *Comptes rendus hebdomadaires des séances de l'académie des sciences,* than to periodicals such as *Allgemeine Textile-Zeitschrift, Bulletin of Pharmacy,* and *Coal Age.*

A first step in unraveling the obscure citation is to place it in one of the four categories described above. Thus *Lond., P.R.S.* is obviously a case of the place of imprint preceding the title, whereas *S.C.I.J.* is probably an example of the issuing society placed first. By omitting the place or society name, the remaining parts of words may be found by using any of the periodical lists giving abbreviations. The location of some of these sources is given in the bibliography.

If it is suspected that an editor's or founder's name has been utilized—for example, *Lamb, J. Am. Chem. Soc.*—the abbreviations shown above should be considered, as well as descriptions of the history of chemical periodicals such as those of Crane and Patterson (*12*), Mellon (*26*), or Soule (*42*). The various sources of lists of abbreviations may aid in discovering the journal name.

When the citation is seemingly given in normal title order, clues to the subject matter considered may help to identify the journal. The subject matter might be deduced from such key words as *Bot.* (Botany) or *Anal.* (Analytical) or from the content of the reference itself. The data of the reference and the language in which the reference is published may also be valuable; these would aid in placing the journal within definite time-space limits. Again, such guides to the chemical literature as Crane and Patterson (*12*) or Mellon (*26*) should be utilized. Perhaps even the synchronistic tables as found in Lange (*24*) may be of value.

This discussion is by no means complete. No attempt has been made to consider the problems which arise when it is necessary to transliterate other alphabets into the Roman. This problem arises especially with the Slavic languages, Chinese, Japanese, and Hebrew. Generally, such citations tend to be lengthy, and hence more easily deciphered.

No complete scheme can or should be proposed for identifying obscure journal citations. An outline is suggested which may be valuable at times, and at other times totally useless. In this problem, as in all others considered in this symposium, the searcher needs a good general knowledge of chemical literature, plus intuition and the proverbial grain of skepticism to produce the desired results.

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Theses and Dissertations

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This paper covers the relative importance of dissertations as a part of the chemical literature, methods used in searching for dissertations, comment on information and documentation centers, some recommendations for increasing the accessibility of dissertations, and an annotated bibliography of useful sources of information.

Dissertations and theses are an important part of the chemical literature because they record original work. Most of them are doctoral dissertations, for many foreign universities do not grant a master's degree. Although there is great variation in the quality of the work reported, the results throw light on a problem and prevent expensive duplication. Research for the M.A. or Ph.D. is sometimes the first fruit of a brilliant scientific career and at other times a flash in the pan—the only work of the author; in either case, it is worth consideration.

Dissertations and theses are often neglected in literature searches or covered superficially because it is assumed that anything of value in them will find its way into the more important scientific journals and reference works. Unfortunately, this is often not true. Dissertations are rarely printed in full in scientific journals; some appear in obscure journals or academy of science publications that are not covered by the chemical abstracting journals; and many are never published. Consequently, a large body of information is buried in the records and libraries of the universities.

The relative importance of dissertations in chemical literature searches is increasing rapidly because the publication costs of scientific journals are skyrocketing and the volume of research is expanding rapidly, which makes it necessary to publish many more papers in abbreviated form. This also increases the proportion of academic work that appears in obscure publications or remains unpublished.

Methods Used in Searching for Dissertations

In many cases there is no expeditious method, and there are always three problems to be solved: ascertaining the existence of a dissertation, finding an abstract or summary to see if it is worth while to look for the original paper, and locating a copy for examination.

Literature aids for ascertaining the existence of dissertations or theses leave much to be desired. The chemical abstracting journals are useful but in both the United States and foreign countries they include only material published in the journals which they abstract. If the paper abstracted originated in a university, it may represent a portion of a dissertation, but the abstracting journals do not give this information.

Other Aids. Other aids include lists of titles of dissertations for countries and for individual universities, bibliographies, volumes of abstracts issued by the universities, other university publications, and library catalogs. Unfortunately no one of these aids or combination of all assures complete coverage of dissertations at the present time.

Union lists of titles would seem to be the answer, but union lists of dissertations have been made only in the United States of America, France, Germany, Switzerland, Sweden,

The Netherlands, South Africa, India, and Canada. The compilation of a union list for Great Britain was proposed recently by Record (*2*). Some union lists have been issued for many years; others appeared recently.

Lists of titles of dissertations that appear in university publications are difficult to find because locating them depends upon general bibliographic sources, none of which covers this material very completely. The lists of dissertation titles which are issued by the universities appear as separate pamphlets, or in yearbooks, serials, and commencement programs.

Bibliographies attached to papers or included in books sometimes mention dissertations and, occasionally, an extensive bibliography of dissertations on a given subject is found in this way. Annual or periodic reviews of a field of chemistry are likely to refer to some dissertations in the country in which the review originated.

Library catalogs of dissertations are printed very rarely. The cataloging of dissertations is very incomplete in many libraries; some have only author entries, and others have title and author cards but no subject classification. In countries where there are no union lists, the lists of dissertations issued by the individual universities may appear regularly for a long period or only intermittently.

Location of Unpublished Dissertations. The location of an abstract or a summary of an unpublished dissertation is another problem, because it is very difficult to judge content by title; and most of this unpublished material is very inaccessible for direct consultation. Some universities, both American and foreign, issued volumes of abstracts annually or at intervals; and others include abstracts of dissertations in their other publications. The publication of abstracts of dissertations is by no means a universal practice and is most common in Great Britain, Canada, and the United States. These volumes of abstracts must be located through general bibliographic sources, except for universities in the United States and some in Great Britain. The larger research libraries in the United States receive these volumes of abstracts from the universities, but it is impossible to determine how complete their collections are.

Accessibility. The accessibility of dissertations for examination is another stumbling block. No library in the United States has a complete file of dissertations from American universities and colleges. Many American universities exchange dissertations and have built up large collections for many different universities, but because printed catalogs are lacking it is necessary to consult the catalogs in person if the libraries lack information and literature searching services. Foreign dissertations are extremely difficult to locate for examination in the United States. There seems to be no reference work in existence which gives both the libraries that have collected foreign dissertations and the coverage of their holdings.

"Special Library Resources" (*3*) is a very complete survey of the collections in all the research libraries in the United States and Canada. It gives specific information on scientific books and periodicals in each library, mentions photographic and information services, gives the number of dissertations in many of the collections, but does not indicate the proportion of foreign dissertations or their origin. The author knows from personal experience that Columbia, Harvard, Princeton, and Yale Universities, the University of Chicago, the University of Minnesota, and the New York Public Library have many foreign dissertations in their collections, and that there are very large numbers of them in the Army Medical Library and the Library of Congress, Washington, D. C.

There is no international depository of dissertations where copies can be obtained, although one has been proposed many times; and few countries have a national center—to the best of the author's knowledge, only France and Germany at the Bibliothèque Nationale and the University of Berlin. What happened to the collection at the University of Berlin during World War II is still undetermined.

The nearest thing to an international collection of dissertations is at the Bibliothèque Nationale, Paris. It is a very large one which is the result of an exchange system operated by the Ministry of Education of France. This collection, and the ones in the government libraries at Washington, D. C., the British Museum, and Oxford University, England, are the most important of the international but incomplete collections of dissertations

at the present time. The location and examination of a copy of a dissertation may involve an interlibrary loan, but more frequently a photoprint or microfilm, and considerable correspondence with libraries and universities.

Documentation Centers and Information Services

Documentation centers and information services operated by the libraries are helpful in locating and obtaining copies of dissertations. Unfortunately, the documentation centers in most countries are not well enough organized to provide extensive services in dissertation searches and there is no international cooperation between them at the present time.

The American Documentation Institute, Washington, D. C., can give some information on the activities of documentation centers in other countries and their services, and it operates a microfilm and photoprint service.

The Association of Special Libraries and Information Bureaux, London, England, can also give some information on documentation centers in Great Britain and in Europe. It is equipped to give various services, and it can give information relating to the dissertations of the universities of Great Britain.

The American Documentation Institute and the UNESCO Library, both in Paris, can give some help in locating dissertations and obtaining copies of those for European countries, but they are not able to offer extensive services in literature searches, even for a fee.

In Austria and Hungary there are apparently no organized centers, but the University of Vienna Library and the Austrian National Library (The author is indebted to discussion from the floor for this information.) are good sources of information for those countries and for the universities in the area of the old Austro-Hungarian Empire.

The information service of the Swiss National Library, Bern (*1*), has been open to foreign countries since 1930. It is part of a well organized documentation organization on a national basis, and it can furnish information on dissertations in the Swiss library collections which were not disrupted by two world wars.

For Scandinavian countries, there are no formally organized documentation centers, but these libraries are good sources of information for their respective countries: the University of Copenhagen, Denmark; Helsinki University, Finland; the Royal Library and the Swedish Institute, Stockholm, Sweden; the Royal Norwegian Society of Sciences and the University of Oslo, Oslo, Norway.

For India, the best source of information on dissertations is the Inter-University Board of India. The amount of scientific research in Mexico and South America is increasing and information on dissertations seems to center around the principal universities of those countries.

Increasing Accessibility of Dissertations

A union list of dissertations should be prepared for each country.

Each country should establish a center where all its dissertations are available in microfilm or some other suitable form. This center should utilize modern methods of cataloging and sorting its catalog cards—for example, punched cards or microfilm cards which can be sorted mechanically to obtain the location of desired information—and it should cooperate with similar centers in other countries.

Perhaps the effort to build up one international collection of dissertations in sciences should be renewed. Certainly such a center should use modern methods of recording dissertations and isolating needed information.

Conclusions

It may seem that unpublished dissertations and theses are not worth the bother and expense of locating them until the tools for the process have been greatly improved, but it must be remembered that approximately 50% of the doctoral dissertations and probably most of the masters' theses are never published. There are no exact figures in existence, but these estimates have been made on the basis of information available.

These estimates are not based on printed dissertations but on the number that appeared in scientific journals or as books. There are still other problems: The published portion of a dissertation may not cover all of the useful information, and the deluge of scientific research necessitates further limitations on the publication of the results of academic work.

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   2. The University of Vienna. Faculty of Philosophy, "Verzeichnis über die seit dem Jahre 1872 and der philosophischen Facultät der Universität in Wien, eingereichten und approbierten Dissertationen," 4 volumes, 1935–37. Vol. 4 contains basic list for Innsbruck and 1934–37 supplement for Vienna.

IV. General Bibliographic Aids. (Useful for locating publications of universities, both U. S. and foreign, which give lists of dissertations or abstracts; bibliographies of dissertations for certain periods and individual universities.)
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Searching Medicinal Chemical Literature

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The technical information department of the research and development division of a manufacturer of fine chemicals has many interesting problems in searching for information in the medicinal chemical literature and that of pertinent and allied fields. Three such representative problems have been selected for presentation.

Knowledge of somewhat obscure sources of botanical drug information is necessary in answering such queries as those concerned with a folk remedy known only by its vernacular name, the determination of the scientific nomenclature of a popular plant name in some dialect or foreign language, the active pharmacological principles of a specific drug, or the occurrence in plant materials of certain active principles of a predetermined chemical or biological character.

Searching the Botanical Drug Literature

Many suggestions of folk remedies known only by vernacular names have been inspired by the recently awakened interest in synthetic organicals with activity in the treatment of rheumatoid arthritis. One such example was the report that a local drug named *bawang* is valued in the Philippines for the treatment of rheumatism. Books have been published on the folk remedies of almost every country and geographical area in the world, and the Philippines are no exception. In 1901, Tavero (*13*) published an interesting but now out-of-date volume on the medicinal plants of the Philippines. Often an old compilation of this kind is far more valuable for such a search than new publications written when the old knowledge is lost in the splendor of the new, and for this reason they should be jealously guarded and treasured. In Tavero's work *bawang*, under a slightly different spelling, is described, and the miracle drug is exposed as ordinary garlic.

Often, however, the information available is so indefinite that the search is hopeless from the beginning. The folklore that rheumatism can be cured by infusion of "rheumatism root" or "rheumatism weed" suggests the identification of this herb with a view to further investigation. Clute (*2*) has listed all such vernacular descriptive plant designations. Rheumatism root may be *Chelone glabra* (Scrophulariaceae), *Chimaphila maculata* (Ericaceae), *Apocynum cannabinum* (Apocynaceae), *Jeffersonia diphylla* (Berberidaceae), or even *Dioscorea villosa* (Dioscoreaceae), whereas the name rheumatism weed has been assigned to another species of *Apocynum*.

Clute's invaluable compilation is restricted to American usage. There are, however, many polyglot compilations of this type. Thus, in Lyons' book (*9*), Latin, English, French, German, and Spanish are represented. Even more comprehensive is the illustrated polyglotic dictionary by Bedevian (*1*).

After definite identification of a supposed drug plant, it is necessary to determine the active principles known to occur in the drug and to consider the known biological activity of these principles with reference to the alleged curative properties. For such a search

Wehmer's three-volume work (*14*) is invaluable. In condensed style, consisting mainly of literature references and cross references, this magnificent compilation lists the content of plants and the source of the information. Thus (Volume 1, page 327), *Jeffersonia diphylla*, one of the above-mentioned rheumatism roots, contains berberine, as was shown by Flexor and Gordin (*4*). Wehmer covers the literature up to 1934 only and a similar up-to-date compilation would be a welcome addition to the library files.

Wehmer also gives preliminary answers to the question of what species might be suitable sources of a definite compound or product—the type of question that arises when substitute raw materials must be found in times of economic stress or dislocation. Thus, he gives 31 references to the occurrence of berberine in different plants. Apart from sources familiar to all chemists such as abstract journals, additional references for information of this type can be found in monographs on alkaloids (*6*, *11*).

Considerably more difficult than the search for a definite compound such as berberine is that for plants yielding a material with given definite biological activity, because the required effect may be provided by various substances of like or unlike chemical nature. Thus, compiling a list of drug plants having digitalislike physiological activity might be required. Much preliminary information can be gleaned from texts dealing with the chemical class of compound under investigation. Its steroid and glycosidal nature suggests a study of the many available texts on steroids, particularly that by Fieser and Fieser (*3*) and of monographs on glycosides (*12*) or the chapter on glycosides by Lebeau and Courtois (*7*). In continuation of the search, reference would then be made to books on medicinal plants with indexes of therapeutic applications. Thus, Madaus (*10*) lists seven species alleged to have digitalislike action on the heart, one such plant being the beautiful mountain laurel, *Kalmia latifolia* L. Finally, purely medical compilations will be consulted. Thus, the "Cumulative Quarterly Index Medicus" lists numerous papers on "heart insufficiency" and some of these deal with vegetable drugs other than those of the digitalis species. Sufficient information, however, may be gleaned to round out this most difficult of all searches into the botanical drug literature.

Interpreting the Foreign Prescription

The postwar scarcity of drugs in Europe, particularly of previously well-established specialties of the prewar drug concerns, the shifting of large populations, and the entry of many displaced persons into the United States have, of recent years, made the tracking down and identification of prescription specialties, and of chemicals indicated in obscurely written foreign prescriptions, a matter of much concern and significance.

As many European countries do not insist on prescription forms with printed letterheads, initial difficulty in deciphering the text prior to its translation may be due to doubt as to the country of origin. Once a clear text has been obtained, the problems that interest the worker in the chemical literature field are mainly those of the identification of a European specialty or drug, the establishment of its correct chemical name, and the identification of its American equivalent. To illustrate these problems, a recent Polish prescription is given:

Asthma! 7—1—49r
Rp.
Coramini liq. 50,0
Jurasthmol, scat. orig. VI
Dehydrit vel Euphyllin, amp XV
Ad manus medici!
Dr. Adelmann

Because this prescription for asthma is Polish in origin (as suggested by the date line), the European specialties prescribed must be sought in the various excellent repertoria and codices of medicinal drugs. According to Ludwig (*8*), Coramin (Ciba) (pyridin-β-karbonsäure-diäthylamid) is made available in Europe as a 25% aqueous solution for oral use. In the index of *Chemical Abstracts* Coramine is listed under *N*,*N*-diethylnicotina-

mide, and from "New and Nonofficial Remedies" we learn that the compound is officially designated as Nikethamide in the United States and is sold by numerous companies under the official designation "Solution Nikethamide 25% w/v."

Although the index of *Chemical Abstracts* is extremely helpful in giving the chemical name of Coramine and thus immediately making the search for an American equivalent of the European drug relatively simple, it would not have been so simple to identify the well known drug, Caronamide (now Carinamide [R]). In the index to *Chemical Abstracts*, Volume 42 (1948), several references are given under the heading Caronamide. The same references are given under the heading Benzoic acid, *p*-(benzylsulfonamido), but the references are not cross-indexed.

According to Bernoulli and Lehmann, Jurasthmol is a powder for the treatment of bronchial asthma and contains antipyrine, iodopyrine, citrated caffeine, and lobeline sulfate, together with minute amounts of digitalin and strophanthin. By reference to Gutman (*5*), the pharmacist can select a corresponding American proprietary remedy and adjust the prescription to fit the number of powders to the requirement of the demand for six original packages (of 15 powders each).

The Polish proprietary medicine Dehydrit is described in Gehe's Codex (3rd supplement, 1950) as the sodium salt of *o*-[(3-hydroxymercuri-2-methoxypropyl)carbamyl] phenoxyacetic acid dissolved in aqueous theophylline solution. This preparation is known in the U. S. Pharmacopoeia as Mersalyl and theophylline injection, and in the U. S. Dispensatory (page 700, 24th edition) the pharmacist is informed of the United States equivalent in the form of Salyrgan-Theophylline Ampuls (Winthrop).

The compendia cited give the composition of drugs and the chemical identity of their ingredients. Unfortunately, no book exists which lists trade names under the chemical name. The Merck Index provides this service to some extent and attempts are being made to further this feature in the forthcoming sixth edition.

A comparatively new monthly publication is *Unlisted Drugs*, edited by the Pharmaceutical Section of the Special Libraries Association. This listing attempts to be truly international in scope and has already become a trustworthy tool of workers in the field of medicinal chemical literature whose labors carry them into the field of prescription translation.

Identifying Merck References

A somewhat difficult problem encountered by librarians of pharmaceutical houses and other institutions concerned with research on medicinal problems is that of tracing and identifying references to Merck literature.

Heinrich Emanuel Merck, intimate friend of Justus von Liebig, and founder of the first factory of the enterprise, E. Merck, Darmstadt (Germany), had as his main objective the preparation of pure alkaloids. His many achievements included the original commercial manufacture of morphine (1827), codeine (1836), and cocaine (1862).

Following the scientific tradition established by the founder, the Chemical Works of E. Merck, Darmstadt, up to the beginning of World War II, serially issued various types of pharmaceutical publications including, among others, the following important reference material:

"E. Merck's Jahresbericht" (1887–1946; Vols. 1 to 60). In German, though some early issues appeared in English. Originally intended as a report on E. Merck's products, it began publication of original communications on natural products with the article "Neue Alkaloide aus Sabadillsamen," Vol. 4 (1890). Contains many valuable communications, particularly on alkaloidal investigations, not elsewhere available.

"E. Merck's Annual Report on the Advancements of Pharmaceutical Chemistry and Therapeutics" (1887–1940). English, French, Spanish, Portuguese, and Italian (1930) editions. Contains original articles of general and scientific interest, a pharmacotherapeutic review, and medical opinions regarding E. Merck products. Originally a translation of E. Merck's Jahresbericht but later a different and more popular publication.

"E. Merck's Wissenschaftliche Abhandlungen aus den Gebieten der Pharmakotherapie, Pharmazie und verwandter Disziplinen" (Nos. 1–42; 1890–1929). No translations or foreign editions known. Published to provide the busy practitioner with information not readily available in the inter-

national literature concerning old and new therapeutic or diagnostic useful preparations. Includes monograph No. 22, "Nicht offizinelle Alkaloide" (480 pages).

"Merck's Index" [1897, 1902, 1910, 1914 (in French), 1927, 1928 (in 1930 in Spanish), 1935 (in French)]. A collective index of preparations, drugs, and minerals listed by E. Merck with descriptions of their chemical composition, physical properties, and medical, technical, and other uses.

"Merck's Reagenzien-Verzeichnis" (1903, 1907, 1913, 1916, 1924, 1928, 1932, 1936), in German. Useful reagents and reactions listed according to author's name. Afterwards appeared serially in translation in American Merck's Report and Merck Report and reproduced in Merck Index (5th edition).

The American house of Merck, established in 1887 in New York and organized in 1891 as Merck & Co. by George Merck, grandson of Heinrich Emanuel Merck, was incorporated in 1908 in New York and in 1919 became an independent American enterprise, consolidated with Powers-Weightman-Rosengarten Co. of Philadelphia, Pa., in 1927 to form Merck & Co., Inc.

During the gradual development from an offshoot of E. Merck, Darmstadt, to the present independent American corporation, the enterprise published works with titles originally identical and later more or less similar to those of the publications of E. Merck, Darmstadt. In the course of time, these publications became entirely different and individually distinct works. A brief résumé is accordingly given of the publications of Merck & Co. and of Merck & Co., Inc., to lighten the difficulties arising from the similarity of their titles to those of the original and often contemporaneous publications of the entirely distinct German organization.

Merck's Bulletin (Merck & Co., 1888–1891). A periodical record of new discoveries, introductions, or applications of medicinal chemicals.

Merck's Archives of the Materia Medica and Its Uses (Merck & Co., 1899–1901; Vols. 1–3).

The Merck Report (1892–, issued quarterly). *Merck's Market Report and Pharmaceutical Journal* (Merck & Co.), (1892–96; Vols. I to V). *Merck's Report* (Merck & Co., 1897–1927; Merck & Co., Inc., 1927–34). A practical journal of pharmacy, materia medica, and chemistry, with a section of each quarterly devoted to current price lists. *The Merck Report* (Merck & Co., Inc., 1934–, Vol. 43–). For many years, Theo. Holm contributed a series of articles on "Medicinal Plants of North America" with figures drawn from nature. This extensive series, covering 99 plants, has never been reproduced elsewhere and is often cited by botanists and pharmacognosists.

"The Merck Index." First American edition (E. Merck, 1889); Merck's 1896 Index (Merck & Co.); Merck's 1907 Index (Merck & Co.); Merck's Index, 4th ed. (Merck & Co., Inc., 1930); The Merck Index, 5th ed. (Merck & Co., Inc., 1940). An encyclopedia for the chemist, pharmacist, physician, dentist, and veterinarian.

"The Merck Manual." "Merck's Manual of Materia Medica" (1st English ed., E. Merck, 1899); "Merck's 1901 Manual" (Merck & Co.); "Merck's Manual" (Merck & Co., 1905, 1911, and 1923); "The Merck Manual" (Merck & Co., Inc., 1934, 1940, 1950; 6th, 7th, and 8th eds.). First five editions were counterparts of the original first English edition prepared for British physicians. No German edition seems to exist and no translation of the original E. Merck publication of 1899 is known. In 1934, "The Merck Manual" appeared as a newly revised sixth edition, and extensive revision and enlargements were continued in seventh and eighth editions.

Conclusions

Although the problems discussed are but a few of those facing workers in the literature of the fine chemical field, they are probably of concern to many others because of the widespread interest due to recent advances in medicinal chemistry. The discussion of the Merck literature seems of peculiar importance at this time because no study has previously been published of this source of so many papers in the fields of alkaloid chemistry, pharmacognosy, and related disciplines.

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Exploring United States Chemical Patent Literature

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"The issue of patents for new discoveries has given a spring to invention beyond my conception."—Thomas Jefferson. "The patent system added the fuel of interest to the fire of genius."—Abraham Lincoln. "The American patent system has promoted countless applications of the arts and sciences to the needs and well-being of our people."—Franklin D. Roosevelt.

The publication of printed patents has been an important factor in the development of science and industry. Published patents have stimulated technological advances directly; and indirectly by revealing information that might otherwise have disappeared. Classified sets of patents are often unique collections of knowledge and may be the only existing good source showing the evolution of important fields of industrial activity.

In the United States, this as well as other features of our patent system can be credited primarily to the wisdom of the founding fathers in laying the basis for the fostering of inventive genius by means of the well-known constitutional provision for patents. We are also the beneficiaries of the far-seeing statesmen and conscientious office holders who implemented this provision by enacting the basic patent laws and by formulating and administering the essential rules. We are no less indebted to their able successors who improved the laws and rules when they considered it necessary in order to "promote the progress of science and useful arts."

Our first Commissioner of Patents under the Act of 1836 deserves special mention because his capable administration gave a good start to the patent system now in force in our country, and also because he has been so grossly misrepresented in recent years.

Henry L. Ellsworth, son of Oliver Ellsworth, a Chief Justice of the U. S. Supreme Court, was born in 1791 at Windsor, Conn. He was in charge of the Patent Office from 1835 to 1845. His annual reports on Patent Office activities are excellent summaries which were not limited to problems of the Patent Office, but included statistics and discussions of our industrial, agricultural, and economic progress.

One paragraph, in his annual report for 1843 (*3*), has been so distorted from the context in which it was presented as to lead to false rumors that he had prophesied the near arrival of an era of no more inventions, and the end of the usefulness of the Patent Office. In truth, it is clear from this report as well as from others he wrote, that his views were quite the opposite. The paragraph,

> The advancement of the arts from year to year taxes our credulity, and seems to presage the arrival of that period when human improvement must end.

appeared as part of his plea to Congress to approve funds for the publication of patent claims and other information about patents and to increase the salaries of Patent Office

personnel. Said he, "If there is any bureau where are needed scientific attainments of a high order, it is in the Patent Office."

His 1843 report also includes (page B33) the following passage from the pen of one of the examiners:

The great mass of inventions are of a character to make us alike proud of the genius of our countrymen, and the Government which fosters and protects it. Man's wants increase with his progress in knowledge; and hence the paradoxical truth, that the growing number of inventions, instead of filling the measure, increases its capacity. The offspring of each distinct and notable invention may be hundreds, or even thousands; and each of these may claim its host of descendants. In an incalculable ratio will inventions increase, till space will hardly be found to preserve their representations. No other conclusion can be reached by the deep thinker upon this subject; no truth to him more forcible than that so happily expressed by Sir Humphrey Davy: "the greater the circle of light, the greater the boundary of darkness which surrounds it."—Charles G. Page.

In his letter of resignation, dated April 1, 1845, Commissioner Ellsworth could well say, "I now leave the bureau in a prosperous condition." This letter also states (*7*):

During my superintendency, a reorganization has taken place and I have been grateful to witness the expediency of the changes I so strongly recommended. In common with many others I have found the discharge of public duties incompatible with a due attention to private concerns. Nor will I omit to acknowledge the existence of an honest jealousy against the monopoly of emoluments. I wish to express a willingness that others may share public favors and have an opportunity to make greater improvements.

It is hoped that these brief quotations will evoke in the reader due feelings of gratitude and respect toward the architects and builders of our patent system.

Any doubts concerning the significance of patents as sources of chemical information will be dispelled on perusal of recent annual reports on *Chemical Abstracts*. According to the most recent of these (*2*), *Chemical Abstracts* during 1949 listed 11,390 patents, which were distributed among 29 of the 32 sections. The bibliography section of recent books and review articles in various chemical fields generally carries a goodly proportion of patent numbers

The proportion of chemical patents in the United States has risen from a figure which

Table I. U. S. Chemical Patents[a] Issued between July 3, 1906, and Sept. 28, 1948

Patent No. Range	Total Chemical Patents	% Chemical Patents
825,000	...	...
(1907)		
900,000	2,240	3.0
(1910)		
1,000,000	4,870	4.9
1,100,000	5,950	6.0
(1915)		
1,200,000	5,320	5.3
1,300,000	4,860	4.9
(1920)		
1,400,000	6,740	6.7
1,500,000	7,000	7.0
(1925)		
1,600,000	8,360	8.4
1,700,000	10,400	10.4
(1930)		
1,800,000	12,980	13.0
1,900,000	14,780	14.8
(1935)		
2,000,000	18,030	18.0
2,100,000	19,970	20.0
(1940)		
2,200,000	20,050	20.1
2,300,000	19,410	19.4
(1945)		
2,400,000	21,770	21.8
2,475,000	9,780	19.6
Worden 1,123,212 to 1,521,589, inclusive	22,882 (*11*)	5.7
C. A. (Jan. 1, 1915–Dec. 31, 1924)	24,140	(6.1%)

[a] Abstracted in *Chemical Abstracts*, not counting reissues.

may have been as low as one chemical patent per thirty patents issued in 1907 to about one in five during the past two decades. The detailed statistics are given in Table I and are shown graphically in Figure 1. The totals are based on the United States patents listed in the "Patent Index to Chemical Abstracts 1907–1936" (*8*) and the "Numerical Patent Index to *Chemical Abstracts*" for 1937–46, 1947, 1948, and 1949. It is possible that the percentages of chemical patents for the early years may be somewhat lower than the true figure, because of incomplete coverage of chemical patents at that time. However, there can be no doubt that a significant increase in this percentage occurred during the period 1907 to 1937.

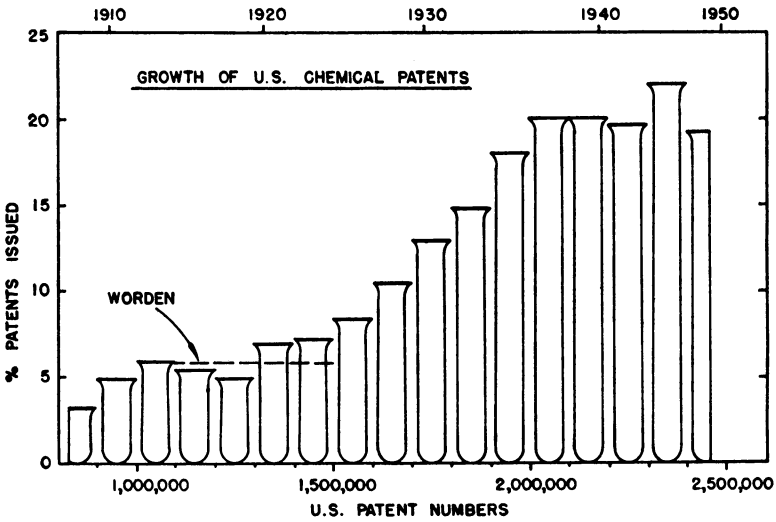

Figure 1. Statistics on United States Patents

A good independent check is available for the middle of this period. Worden (*11*) attempted to index all United States chemical patents issued between January 1, 1915, and December 31, 1924. The number of patents indexed was 22,882, 5.7% of the 398,378 United States patents issued in that period. Close to 24,140 patents of this span, amounting to 6.1%, were abstracted in *Chemical Abstracts*. so that the comparison inspires confidence in the extent of its coverage while verifying the significance of the data in Table I.

Historically, chemical patents have always been important in the United States. As early as 1641, Massachusetts granted a patent, the first issued on this continent, to Samuel Winslow, for a 10-year term, on a method of making salt. The first United States patent law was the Act of April 10, 1790. The first patent under this law was granted July 31, 1790, to Samuel Hopkins of Vermont for a method of "making pot and pearl ashes."

Structure of Patents

An understanding of the general structure of modern patents will lead to greater efficiency in reading and understanding them.

Many modern chemical patents are well-written documents which have much in common with scientific papers on the same subject. An obvious reason for this happy circumstance is that essential portions of the specifications in these cases are written by the chemists who did the work or reported it. During the past two decades, many chemists have become engaged in patent work, so that what might be termed the legalistic part of a considerable proportion of chemical patents has also been written by chemically trained personnel.

The patent specification corresponds to the body portion of a scientific paper. It

generally starts out with a brief statement of the field of the subject matter. Usually, one then finds a listing of the objects of the invention, followed or preceded by a discussion of earlier efforts in the same or related fields, often with special emphasis placed on their deficiencies.

The setting has now been indicated both as to field and the existing difficulties which were to be overcome. The solution to the problem is then revealed by a general statement of the invention.

The patent then proceeds to describe specific examples or embodiments of the invention. This is the section of chemical patents which is frequently taken directly from or largely based upon reports written by chemists.

The specification usually ends with a broad restatement of the invention and its most important advantages and applications.

These patent components are similar to corresponding sections of scientific papers. The section devoted to the description of specific examples or embodiments can very well be identical for the two types of publication.

The greater differences are apt to occur in the discussion of earlier work (prior art), in the listing of objectives (sometimes characterized by what Chaucer would have called "superfluitee abomynable"), and particularly in the general statement of the invention. It sometimes involves more art than science for an inventor to recognize his own brain child, luxuriously bedecked in polysyllabic raiment in the patent application. Fortunately, there seems to be a decreasing tendency toward the use in patents of what a judge once called (*6*) "those erosive and mind-grooving processes of unyielding reiteration of concept and ready prestidigitation of words."

Mark Twain had some words for this sort of thing, when in 1870 he promised "to strip the nutritious facts bare of that effulgence of imagination and sublimity of diction which too often mar the excellence of these great works," in connection with his purpose to write condensations of the annual Patent Office Reports (*5*).

It is noteworthy, however, that Mark Twain, despite serious financial losses in the backing of inventions of others, had Sir Boss say, in his "Connecticut Yankee," that "a country without a patent office and good patent laws is just a crab and can't travel any way but sideways and backways."

The summary, which is generally found at the end of scientific papers, differs from the claim section which concludes patents. A summary should emphasize what is new in the paper. But the applicant for a patent must, according to the patent laws, "particularly point out and distinctly claim the part, improvement, or combination which he claims as his invention or discovery." The claims thus constitute the section of the patent which defines the new technological area in which exclusive rights are granted to the patentee or his assignee during the life of the patent. The drafting of proper claims is the most difficult and essential task in obtaining good patents and is the phase which makes greatest demands on the unusual combination of insight, literary skill, and thorough knowledge of the art as well as of patent law, which characterizes most successful patent solicitors.

It may happen that patent claims constitute good summaries of the new subject matter in the patent specification. But the legalistic form and expressions will often be found a hindrance to the utility of claims as summaries. It is not unusual to find that the disclosure in a patent is much more extensive than indicated by the claims.

Drawings are required in patents "whenever the nature of the case admits of it" (Rule 81, Rules of Practice of the United States Patent Office in patent cases). "The drawing must show every feature of the invention specified in the claims" (Rule 83). Similarly, scientific papers include drawings illustrating new relationships, or novel components or arrangements of apparatus.

Patents and papers both carry titles, which should be informative but all too often are not, especially in patents. Too frequently, one finds modern patents with unjustifiably broad titles such as "Process of extracting metals from ores," "Chemical process," "Chemical composition," or "Controlling chemical reactions." As a patent title, "Chemical testing device" will indicate a new and improved test tube only to the uninitiated.

Scientific papers usually carry a bibliography at the end. There used to be no cor-

responding section in United States patents, except for the occasional mention of earlier publications in the specification. However, United States patents now end with a list of all references which were cited during the prosecution of the application in the Patent Office. This worthy addition was introduced in 1947 during the tenure of Casper W. Ooms, appointed Commissioner of Patents in 1945. Among other advances made by Commissioner Ooms before his retirement from the office in 1947 was the adoption of the single signature form for patent applications, so that one inventor's signature now does the work of three formerly required.

It will be evident from the foregoing analysis of the usual structure and contents of patents that particular emphasis should be concentrated for the purposes of literature surveys or abstracts on the section describing specific examples. Attention should also be given to the general statements of the invention which usually precede and sometimes follow the description of the specific embodiments.

The patent claims are, of course, of primary interest when the patent is being studied for scope or validity in connection with determining a question of infringement. However, it is more the exception than the rule for patent claims to be helpful in a literature survey.

The above generalization may fortunately be going out of style, in that more and more chemical patents carry specific titles and have claims that are informative even to amateur patent attorneys. An excellent recent example is the patent on streptomycin and process of preparation, which has been assigned to the nonprofit Rutgers Research and Endowment Foundation (*10*). The specification scarcely differs from a scientific paper and the process claims constitute easily understandable summaries of essential steps in the manufacturing procedure. Claim 13, a product claim, cannot be surpassed for conciseness: "13. Streptomycin."

An unusual ending appears in a patent issued to L. B. Swan in 1847 (*9*) and entitled "Improvement in Galvanic Batteries for Telegraphs":

> In the foregoing specification and claim I have, as it will be seen, limited my claim to the use of my solution in batteries used for telegraphic purposes, and this I have done that I may not be supposed in any way to interfere with experiments having for their object the advancement of science.

Locating Patents

Over 2,500,000 United States patents have been issued since 1836, over 200,000 of which contain information of chemical interest. Clearly, an efficient classification of patents is essential for the proper functioning of the patent system and for making the information available.

The first classification in 1830 grouped the total 6170 United States patents in 16 classes. At present, there are over 300 main classes, each further divided into subclasses. Nearly every patent has its niche in one of the 45,000 or so subclasses, and may also be cross-referenced in other related subclasses.

The classified list of 1830 was accompanied by a statement by the superintendent of patents, John D. Craig, from which the following is quoted (*1*):

> The difficulty of classifying natural objects is well known, the gradual and imperceptible shades of difference rendering it impossible to determine exactly where one class should end and another begin. In the productions of art this difficulty is not diminished. Hence, in compiling the list of patents a doubt frequently arose concerning the class to which some of the patents did properly belong. For instance, whether the partial rotting of hemp and flax should be classed under agriculture or chemistry, dry docks under navigation or land works, etc. Besides, many of the machines patented are applicable to purposes widely different, and consequently could not be included exclusively in any one class; while the titles of others are so indefinite as to render it impossible to determine either their genera or species. In such cases, no specific disposition being practicable, when the subject or patent sought is not found where it was expected it will be discovered under some other title, to which the nature of the subject will generally refer.

This appraisal and advice, issued in 1830 with respect to some 6000 patents classified in only 16 groups, can well be kept in mind 120 years and some 2,500,000 patents later.

The chemical class was entitled, "Chemical compositions: Tanning, patent medicines cements, dyes, etc."

In 1836, six classes were added, class 4 having the following definition: "Chemical processes, manufactures, and compounds, including medicine, dyeing, color making, distilling, soap and candle making, mortars, cements, etc."

The classification was further expanded in 1868 (36 classes) and again in 1872 (145 classes). Subclasses appeared in the classification in 1880 (164 main classes).

The classification system has continued its growth with the years, a separate Classification Division being established in the Patent Office in 1898 for the administration of the work and problems pertaining to this field. The revisions and amplifications of the system have of course had to be accompanied by the movement of patents to their newly assigned locations.

The "bible" of this system is the "Manual of Classification of Patents," published by the Patent Office. Supplementing the manual are the class and subclass definitions contained in the Classification Bulletins, also obtainable from the Patent Office.

The manual comprises a listing of each class showing its subclass titles, and a lengthy (192 pages) subject index which gives the proper class and subclass for each item listed. A brief description of the use of the manual is included. There is also a list of the classes as assigned to the Patent Office Examining Divisions. A further interesting feature is a grouping of the classes under five main headings:

I Chemical and Related Arts
II Radiant Energy, Signaling, Sound, Electricity
III Manufacturing, Tools, Machine Elements
IV Weapons, Transportation, Materials Handling and Treating, Motors and Pumps
V Miscellaneous

Of the 70 examining divisions of the Patent Office, at least 30 deal with chemical patents. Eleven of these divisions handle chemical patents principally.

The following is a list of the classes listed in the manual under Group I. The classes are arranged in numerical order and the titles have in some cases been abbreviated.

I. Chemical and Related Arts

Class No.	Class Title
8	Bleaching and Dyeing
18	Plastic Shaping
21	Preserving, Disinfecting, Sterilizing
22	Metal Founding
23	Chemistry (Inorganic, Testing, Apparatus)
25	Plastic Block and Earthenware Apparatus
41	Ornamentation
44	Fuel, Igniting Devices
48	Gas, Heating and Illuminating
49	Glass
52	Explosive, Pyrotechnic, Match
71	Fertilizers
75	Metallurgy, Processes and Alloys
91	Apparatus
92	Paper
99	Foods, Beverages
106	Plastic, Coating
107	Bread, Pastry, and Confection Making
117	Coating, Processes and Miscellaneous Products
127	Sugar, Starch, Carbohydrates
130	Threshing
148	Metal Treating Processes
154	Laminated Fabrics
167	Medicines, Poisons, Cosmetics
183	Gas Separation
195	Fermentation

I. Chemical and Related Arts (*Continued*)

Class No.	Class Title
196	Mineral Oils
202	Distillation
204	Electrical and Wave Energy Chemistry
209	Classifying Solids
210	Liquid Separation or Purification
233	Centrifugal Separators
252	Compositions
259	Agitating
260	Chemistry, Carbon Compounds
261	Gas and Liquid Contact
266	Apparatus

A number of classes could well be added:

Class No.	Class Title
47	Plant Husbandry
51	Abrading
95	Photography
134	Cleaning
136	Batteries
250	Radiant Energy

Some features of the United States classification system which it is important to keep in mind are:

The class numbers are arbitrary, serving merely to identify the individual classes. Generally, the basis of classification is essential function or effect. The order of the subclasses in a class is that of proceeding from the complex to the simple. When a patent is classified, it is placed in the most complex subclass suitable for it and it is cross-referenced in any appropriate subsequent (more elemental) subclass.

A patent is classified primarily on the basis of its claimed subject matter.

Various paths can be followed in conducting a patent search, just as in searching the nonpatent literature.

A thorough search of United States chemical patents since 1907 can be made in any good library by the use of *Chemical Abstracts*. The tables and Figure 1 inspire confidence in such a search. But it is a laborious and tedious method, especially since one must order and wait for the pertinent patent copies in order to complete the study.

The spacious, though usually crowded, Search Room at the Patent Office is the only place in this country where a thorough patent search can be made expeditiously. The term "expeditiously" is here used in a comparative sense, because the search in a complex field may require several days or weeks of concentrated effort even at the Patent Office, but would require much more work and time elsewhere.

Patent Office Search Room

The Search Room is located on the first floor of the E Street end of the Commerce Building. Row after row of search desks, provided with racks arranged for convenient "flipping and scanning" of patent subclasses and each having its convenient fluorescent light, extend across the room. During working hours, there is a continuous hum of activity, searchers constantly emerging from the adjoining stack room loaded down with subclasses, or entering for more armsful, assistants collecting the discarded subclasses from the tops of the reading desks, here and there an animated discussion and above all the whirr of the patents as they are expertly flipped and scanned for that 50-year-old anticipation of some fond inventor's "million-dollar-invention."

It is awe-inspiring to enter the stack room, crammed as it is with rows and columns of stacks, with one or more subclasses or a portion of a subclass housed in each rack opening. Here is the Patent Office set of classified patents, starting with the designs classes at the 14th Street side and then progressing numerically from Class 1, Nailing and Stapling, to Class 346, Recorders, toward the 15th Street side.

Along the front inner wall of the stack room, there are provided for the convenience of the searchers hat and coat racks, with patented locks. But no one has yet invented a sure way of finding an unused and unlocked rack there in the middle of a working day.

A complete numerical set of United States patents is housed conveniently along the walls of the Search Room and extends into the 15th Street end of the stack room. Annual indexes, Commissioner's Reports, and Commissioner's Decisions are also available.

A number of sets of the Classification Manual are located at a desk near the 14th Street entrance. There is also a complete set of class definitions in loose-leaf binders, arranged in numerical order at the start and close of each business day. Nearby is an important card file, listing the class and subclass of every United States patent (the entries are in pencil).

At the other end of the room (15th Street end), file histories of issued patents can be obtained for study at the nearby desks, which are conveniently arranged for this purpose.

A thorough search requires the study of all the subclasses pertinent to the subject. It is therefore necessary to compile a list of such subclasses.

This can be done in a number of ways. According to what might be called the fundamental way, the first step is to find subclass numbers by looking up the subject and related terms in the index to the Manual of Classification. But occasionally no relevant term can be located in this index. It is then necessary to scan the class titles under the appropriate one of the five main groups of classes and then the subclass titles under any class that seems promising.

Then, by looking up the detailed explanation of each of the preliminary list of subclass numbers in the book of class definitions, one obtains an expanded list by adding such further subclasses as are cross-referenced there.

Subclass numbers may also be obtained during the course of perusing the patents in a classified set by noting patents that are cross-referenced. Recent patents carry the subclass number on page 1, immediately below the patent heading. The classification of earlier patents can be found in the card file, mentioned above.

The patents relevant to the subject are themselves a source of additional pertinent subclass numbers. One finds the classification of the patents which were cited during the Patent Office prosecution, again by use of the classification card file. The cited patents are listed on recent United States patents and, in the case of earlier patents, can be obtained from the file histories.

A useful list of subclass numbers can likewise be compiled, with the use of the classification card index, by means of a list of pertinent patent numbers found in *Chemical Abstracts*, books, or review articles.

These procedures can lead to an enormous list of subclass numbers, even though one starts with only a single or a few patent numbers. However, many such subclasses can be eliminated from the scope of the particular search on mere inspection of the titles.

Generally, it will save time to locate subclasses through patent numbers obtained from *Chemical Abstracts*, rather than via the index to the manual and the class definitions. This is in part due to the complexity of many of the definitions, which tend to be more confusing than clarifying until one has become thoroughly familiar with the method and style of presentation.

The index, although characterized by some disadvantages, such as type which is difficult to read, is an amazing guide, ranging in subject from Abacus (Class 35, subclass 33; Education—teaching—mathematics—abacus) to Zwieback (Class 99, subclass 86; Foods and Beverages—processes and products—cereals—baked products), or speaking chemically, from Abietic Acid (260/97; Chemistry, Carbon Compounds—natural resins and reaction products) to Zirconium (23/15; Chemistry—compounds—rare element compound recovery). Indeed, items neighboring those sought frequently will catch the eye and distract the reader's attention from the immediate objective. However, in a thorough search, the use of the Manual of Classification and the class definitions is usually advisable, at least as a check.

Having secured the list of subclasses needed, the searcher proceeds to gather them from

the racks in the stack room. Each rackful consists of a flat pile of unbound "hard" copies of patents (each sheet laminated for stiffness) between two thick cover sheets, the upper one being imprinted with the class, subclass, and rack number.

The rack at the search desk conveniently holds such a group, which at the start is placed against the inclined back rest. The reader examines the topmost patents (lowest numbers) first, flipping them in turn against the front rest. With an experienced searcher, this flipping and scanning process is accomplished at a surprising speed, especially when drawings can be relied upon for the location of the information being sought. Chemical patent searching is more difficult and time-consuming, and is generally more accurately characterized as a process of "flip, read, turn the page, read, etc."

The Search Room is smoothly and efficiently run by a group of conscientious employees, whose first concern is to see that operations proceed so that information in the patents becomes readily available to the public. They are courteous and helpful in answering questions, and the answers are reliable and likely to save the searcher much time and effort. But, in view of their duties and responsibilities to the public, they cannot be expected to spend undue time and effort in solving all the problems peculiar to an individual search.

After several days of conscientious looking, reading, and note-taking, the searcher's spirits rise, as he flips feverishly through the last ten patents of his last subclass. The next to the last patent is a cross reference, in a subclass he hasn't yet searched. The manual and the definition indicate it should not be overlooked. "Oh well, just one more subclass," says he, as he strides confidently toward the proper stack. And sure enough, there it is, one of those subclasses that extend from the top to the bottom of the stack and into the next row—which can well be expected to evoke the well-known comment from those skilled in the art, "There must exist some substantially more facile means for deriving adequate sustenance."

It seems appropriate to close this account with an apt quotation from one who helped build our patent system while fully realizing that he was not just earning a living, nor merely erecting masonry, but was participating in the construction of a cathedral. In Commissioner Ellsworth's Annual Report for 1844 (*4*), Charles G. Page, examiner of patents, wrote:

> The increase of man's wants is commensurate with the enlargement of the field of knowledge—not such actual want or privation as is characterized in the aphorism, "Necessity is the mother of invention," but something far happier, and more ennobling—the want or desire of those means which shall gratify his thirst for knowledge, and place him in a higher sphere. It is true we might, in running over the annals of invention, reverse, in many cases, the adage, and pronounce invention to be rather the mother of necessity, and tell of the unmerited fate of many a poor inventor; but, still, with all our sympathy for him, there is yet this encouragement to offer to others—that, in a large number of cases, genius meets with its true reward; and to it mankind will be ever indebted,though they may sometimes forget or withhold remuneration.

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Searching United States Government Documents

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Documents that may be particularly useful to chemists have been produced by the Office of Scientific Research and Development, Office of Technical Services, Department of Agriculture, National Bureau of Standards, Atomic Energy Commission, the military departments, and the National Archives. The best ways of finding and using such publications are discussed here.

The general problem of finding government documents has been discussed at length and in detail in a number of books, pamphlets, and periodical articles. A full treatment of the subject would make a good full-length course in a library school. This paper is limited to relatively brief comments on documents that may be particularly useful to chemists—for example, those produced or supplied by the Office of Scientific Research and Development, the Office of Technical Services, the Department of Agriculture, the Atomic Energy Commission, the military departments and, for inactive records and reports, the National Archives.

Indexes or abstract publications may be used to determine the document desired. A very comprehensive bibliography on "New Guides and Aids to Public Documents Use" has been prepared by Jerome K. Wilcox, librarian of the College of the City of New York, and a well-known authority on this subject (*2*). A list of books and periodical articles relating to the use of government documents, supplementing the material found in the Wilcox bibliography, was prepared recently by Spencer C. Stanford, head of the Research Library at Brookhaven National Laboratory.

For the purpose of this paper the term "searching" is understood to mean the finding and obtaining of documents of interest to the searcher, rather than the process of deliberative thought which is sometimes included in the searching of patents. In the latter case, the searcher may stop and study an individual item while he is making up his mind whether or not it is pertinent to the search he is making. There is at this time no other equivalent collection of documents so arranged that a searcher can go through them one by one and make his selection by such a process of deliberation. Perhaps this is one of the reasons why a discussion of the problem of searching government documents almost invariably brings out the comment, "It is much better to have a good list of telephone numbers." This means, of course, that it is better to rely upon the advice of specialist experts in various fields who work constantly with particular masses of material.

The word "document" itself requires some definition for effective discussion. The most pertinent of many found in the unabridged dictionary reads: "an original or official paper relied upon as the basis, proof, or support of anything else; in its most extended sense including any writing, book, or other instrument conveying information; any material substance, as a coin or stone, having on it a representation of the thoughts of man by means of any species of conventional mark or symbol." The emphasis in this paper is laid

upon such parts of the above definition as seem to be of most interest to members of the AMERICAN CHEMICAL SOCIETY.

Office of Technical Services

The Office of Technical Services was established within the Department of Commerce a few years ago for the purpose of collecting and disseminating unclassified and declassified scientific and technical reports on wartime and postwar research by United States government agencies, reports on research by cooperating foreign governments, and technical documents captured in enemy countries. The office is still receiving reports on current research and now has a total collection of some 150,000 technical reports. Bibliographies of reports on some fifty major fields of technical interest, such as ceramics, foods, plastics, protective coatings, etc., are available upon request, many of them free of charge.

The Office of Technical Services file of unclassified reports of the Office of Scientific Research and Development is one of the best in existence and a special bibliography of these reports has been prepared (*1*). It is arranged in three parts. There is first a bibliography arranged by OSRD number with a correlated PB (Publication Board) number. A volume and page reference is supplied leading to an abstract of the report as issued in the *Bibliography of Technical Reports* (formerly *Bibliography of Scientific and Industrial Reports*). Following this is a cross-reference list arranged in the order of PB numbers and giving the corresponding OSRD numbers. Finally, there is an author and subject index to the reports. The reports themselves are available in photostat or microfilm form at prices indicated in the bibliography. It is always best to order copies by PB number.

If a thorough coverage of Office of Scientific Research and Development medical reports is necessary, it may be advisable to look further into the records of the National Archives or the National Research Council's Division of Medical Sciences, as copies of these reports had been so depleted by the time the records were transmitted to the Office of Technical Services that many important reports may be missing from the Office of Technical Services collection.

The Office of Technical Services Technical Advisory Service is designed to gather information for clients not hiring regular consultants to make studies of the literature. Over 10,000 searches have been made by this group. Reports once identified can be purchased directly from Office of Technical Services if in mimeographed form; from the Library of Congress if photostats or microfilm.

Two regularly issued Office of Technical Services publications serve as guides to the collection of reports: the *Bibliography of Technical Reports*, which is now in its fourth year, lists the reports as they are received and abstracts most of them. Abstracts are grouped by subject matter—for example, under a main division entitled "Chemicals and Allied Products" are subdivisions such as detergents, plastics, and plasticizers, as may be appropriate to the reports appearing in a given issue.

A subject index to each of the earlier volumes is available through the Office of Technical Services. The Special Libraries Association has published a "Numerical Index to the Bibliography of Scientific and Industrial Reports, Volumes 1 to 10," which lists all the reports by PB number and sells for $10. The *Technical Reports Newsletter* enables business men and industrial firms to keep posted on new technical reports available from federal and nonconfidential sources. Each issue includes complete instructions on ordering OTS reports. The *Newsletter* may be purchased as part of the *Bibliography*. The subscription price which covers both services is $5 per year; the *Newsletter* may be obtained separately at a cost of 50 cents a year.

Through a cooperative arrangement, the Office of Technical Services is regularly informed of new British government reports in various technological fields. To acquaint readers with the wide variety of subjects covered, a free "sample" list of reports available from British Information Services will be furnished by the Office of Technical Services on request.

There is in Washington (732 Woodward Building) a privately operated Technical Information Service which may be of interest to chemists. Miss Bradshaw, its director, was employed for several years by a chemical corporation to assist in obtaining government

technical reports. She is now working on her own and conducts searches on a fee basis. In addition, she is preparing a cumulative subject index to the chemical reports listed in the Office of Technical Services *Bibliography of Technical Reports.* This index, which will be in twelve volumes, each devoted to a different field of chemistry, is much more detailed than the Office of Technical Services volume indexes. The first two volumes of the index on agricultural chemistry and analytical chemistry are completed and sell for $5 per volume.

Bibliography of Agriculture

A government publication which is a model of a useful index to technical material prepared both economically and quickly is the Department of Agriculture's *Bibliography of Agriculture.* It is issued monthly and is as comprehensive as its editors know how to make it. The February 1950 issue contains approximately 8000 different entries. An index is compiled annually in December. The printed publications of the Department of Agriculture which are listed in the bibliography are usually available in limited supply for free distribution, and photoprint or microfilm copies of any publication listed may be obtained from the Library of the Department of Agriculture.

National Bureau of Standards

A *Technical News Bulletin,* published monthly by the National Bureau of Standards, contains brief articles on current activity at the bureau. It carries a list of the periodicals and research papers issued by the bureau during that month together with the prices and instructions for ordering. Also listed are articles currently published by members of the bureau staff in other publications.

Department of Defense

The Department of Defense has two large scientific documentation centers which collect reports on current scientific research conducted by or sponsored by military agencies and publish guides to those reports. The Central Air Documents Office at Wright-Patterson Air Force Base, Dayton, Ohio, until recently handled only material of air technical interest—that is, reports of research conducted by the Air Force and the Navy Bureau of Aeronautics, together with reports of aeronautical interest from other sources. This center is now providing the same services on all army scientific and technical reports. CADO, as the center is commonly called, publishes regularly *Air Technical Index* sheets covering classified documents. These are available for distribution only to military contractors. A monthly publication entitled *Technical Data Digest* contains articles describing current research activity. Included are abstracts of published articles and technical papers presented before technical and scientific meetings, arranged according to the categories of the "ATI Distribution Guide." This was formerly known as the "Standard Aeronautical Indexing System," and was prepared for the Central Air Documents Office under contract with the Institute of Aeronautical Sciences. It is planned that new categories to provide for subject matter of army interest not previously covered will be added.

The other center is the Navy Research Section of the Library of Congress, which collects, catalogs, abstracts, and disseminates information concerning all navy reports. Its major publication is an abstract bulletin, the *Technical Information Pilot,* generally referred to as "TIP," which is issued in unclassified and in several levels of classified editions. This bulletin is issued only to contractors and is sent to the principal investigator under a given contract rather than to a library. Approximately 2000 copies of each issue are distributed. The reports are arranged in 21 main classes of material according to categories divided between pure science and applied science. A contractor may, upon request, be provided with as many as six duplicates of individual cards for each abstract issued by the Navy Research Section. He may receive all cards or only those relating to subject matter within a given main class. Indexes to the *Technical Information Pilot* are included with each issue and are cumulated quarterly.

Atomic Energy Commission

As a producer of much technical information, the Atomic Energy Commission is required by its basic act to maintain "a program for the control of scientific and technical information which will permit the dissemination of such information to encourage scientific progress." Classified information is made available on a restricted basis to scientists and engineers who are working with the commission by a system of standard distribution lists, made up by categories and specifying addressees authorized to receive reports in a given category. The classified reports are automatically sent to the addressees listed. A semimonthly *Abstracts of Classified Research and Development Reports* is sent to certain authorized persons to keep them informed of all classified research in progress.

In connection with unclassified research activity, the commission encourages the publication of reports in regularly established, privately supported scientific periodicals. Many scientists prefer this method to a centralized government-controlled system of publishing and distributing their reports. Unfortunately, private journals are unable, at the present time, to cope with the quantity of government research being done. As a result, it is necessary to reproduce and distribute unclassified reports which have not been published in the regular journals. These reports are available on an exchange basis to universities and other institutions and are sold by the Office of Technical Services to individuals or institutions unable to make appropriate exchange arrangements. Many reports concerning classified research become declassified with the passage of time or the occurrence of some event, and are then treated in the same way as reports which were unclassified from the start.

In order to assist in finding appropriate unclassified or declassified reports, the commission has established a major semimonthly abstracting publication in the field of nuclear science known as *Nuclear Science Abstracts*. It covers not only these reports but also some published material in its field of interest. It is believed by the commission that the activities of its program require faster abstracting service than existing private abstracting services provide and that nuclear science cuts across many diverse fields such as medicine, agriculture, geology, ceramics, industrial sanitation, instrumentation, metallurgy, chemistry, and physics. Each issue is indexed, and cumulative indexes are prepared semiannually. The use of mechanical sorting, collating, and printing machines allows preparation of cumulative indexes without setting new type for separate cumulations. The abstracts are available without charge to all scientists officially connected with the atomic energy program, and on an exchange basis to universities, hospitals, medical schools, research institutions, and scientific societies, and by purchase from the Office of Technical Services.

The Atomic Energy Commission is also attempting to develop new techniques and procedures for storing, recording, selecting, and disseminating information. It has joined with the Department of Agriculture in developing a machine, known as the rapid selector, which looks through microfilmed units of information at very great speed. It can scan as many as 120,000 coded subject entries per minute, compared to the 15 or 20 entries which an individual research worker is able to scan in the same time. The machine also reproduces abstracts of the desired documents while the scanning is in process, and could be set up to reproduce the original document, which would save the time now spent in searching the shelves of local libraries or waiting for the information to come from distant places.

National Archives

All government records and documents of continuing value eventually find their permanent home in the National Archives, where they are made available for use by government officials, scholars, and other persons who have a legitimate interest in the information contained in them. Statistics are indicative of the phenomenal growth in recent years of government records. In the last budget statement prepared by the National Archives it was estimated that since 1774 approximately 30,000,000 cubic feet of government records have been created: from 1774 to 1916, 1,500,000; 1917 to 1930, 3,500,000; 1931 to 1940, 10,000,000; 1940 to 1949, 15,000,000.

Herbert Angel, head of the Records Control Division of Archives, has stated that the

only hope of checking this tremendous growth of records is to educate government employees in certain "birth control" practices, so that fewer records will be created in the first place; and to educate officials in government agencies in the maintenance of control over the "life cycle" of records, so that those which are no longer of value may be destroyed rather than stored indefinitely.

Of the 30,000,000 cubic feet of government records which have been created, perhaps 10,000,000 cubic feet of records of temporary value have been destroyed, leaving 20,000,000 in existence at this time. Most persons who might be interested in searching for material among these records tend to assume that it is next to impossible to find certain material of interest in such a vast collection. However, this is not the case if the research man is willing to dig.

Included in the records maintained by National Archives are many documents of importance for retrospective search in various fields of science. Outsiders do not have access to the stacks, but they are permitted to browse through the inventories and check lists prepared by Archives covering all material on hand and to use the guides and searching aids prepared both by Archives and by the agencies which originated the records. The collections are maintained just as they were arranged by the original agency and the indexes and other guides prepared by that agency are available to searchers. It is of first importance to the searcher to know something of government structure and to know which agencies might have records of importance in any particular field. As soon as a searcher has determined what records might contain material of interest to him, those records will be made available to him in blocks as large as he can handle at any one time.

The latest edition of the "Guide to the Material in the National Archives" was published in 1948. It is a book of some 600 pages which provides a general description of the records and is designed to suggest to potential users the kinds of information that can be obtained from them.

The National Archives has facilities for making photostats, microfilm, photographic and Ozalid prints, and copies of motion picture and sound recordings; it is empowered by law to provide authenticated or unauthenticated copies of records in its custody not exempt from public examination nor protected by copyright. It may provide copies of records protected by copyright if authorized by copyright owner.

Nederlands Instituut voor Documentatie en Registratuur

Among the more novel aspects of finding and obtaining government documents should be mentioned an institution in The Netherlands. There the national chapter of the International Federation of Documentation has been set up as a quasigovernmental, nonprofit organization which makes very effective searches of all government documents, including patents, at cost. The organization is equipped with very modern document reproduction equipment and does a thriving business in making such searches and supplying copies of documents, full-sized or on microfilm. It has one practice which might be unacceptable in this country. In many cases, the government employees who work with the particular documents make the appropriate searches; patent e aminers make patent searches for clients of the organization.

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Chemical Trade-Marks

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In searching for the composition, maker, or use of a trade-marked chemical, books, directories, trade papers, and available lists are consulted. Service organizations make searches of trade-marks, and lists of trade-mark applications filed but not acted upon are available. An extensive bibliography of possible sources of information is presented.

Makers' names and trade-marks have been used for hundreds of years on all kinds of products, although the modern system of trade-marks was introduced in the United States about 1865. Trade-marks are of value not only to the seller but also to the buyer, who can more easily remember PEG than polyoxyethylene monostearate, for example. The seller of a trade-marked product finds it to his advantage to furnish a product of uniform and satisfactory quality; the buyer can depend on getting quality on each purchase.

A trade-mark refers to a commercial product usually designated by a coined or fanciful name, which is rarely its true chemical designation. A trade-name (often confused with a trade-mark) refers to the firm or house that makes or sells a product. Thus, Glycopon is a trade-mark covering a chemical product; Glyco Products Co. is a trade-name.

The naming of a new product is not as simple as it may appear at first glance. The name must be an entirely new one in the field concerned. Because of the many thousands of names now registered, it is not too easy to find a name that is suitable and does not bear some resemblance to a name already in use. Generally, a preliminary list of names is drawn up and is weeded out until only a very few names are left, but even these may not be acceptable because conscious or subconscious analogies are drawn from existing names.

There are four general types of trade-marks:

The name of a company, its abbreviation, or modification—Dowicide, Goodrich, Esso
A synthetic or coined word or words indirectly descriptive—Acrawax, Duriron, Fiberglas
Nondescriptive word or words—Acme, Crown, Supreme
Synthetic nondescriptive word—Abopon, Daisite, Gamal

Under chemical trade-marks it is proper to consider not only chemicals but mixtures of chemicals, plastics, detergents, insecticides, tanning agents, textile specialties, and divers other chemical specialties used in industry.

While many trade-marks are registered in the U. S. Patent Office and in the patent offices of foreign countries, many are not registered. Those that are registered are listed in the weekly issues of the *Patent Office Gazette* and similar publications of foreign countries. Trade journals covering the various industries usually list trade-marks granted in their fields. Thus, *Drug and Cosmetic Industry* (a monthly) lists trade-marks granted in the previous month on drugs, cosmetics, perfumes, and soaps by the U. S. Patent Office. Many journals and trade papers—*Chemical and Engineering News, Chemical Industries*, etc.—have notes of new products, some of which are marketed under trade-marks. Some trade papers issue an annual directory or yearbook in which are listed trade-marks

with the name of the manufacturer or seller. In some cases a partial or full disclosure of the chemical composition is given.

The most recent and most comprehensive compilations of trade-mark chemicals and chemical compositions are those of Zimmerman and Lavine (*204*) and Bennett (*35*) and the *Chemical Industries*' "Buyers' Guide" (*51*).

In starting a search for the composition, maker, or use of a trade-mark chemical, use is first made of those books, directories, trade papers, or lists on one's premises. If the above-mentioned books are not available in the library, they may be found in most large industrial, college, or public libraries.

There are a number of service organizations that make searches of trade-marks for lawyers and others—for example, Trade Mark Service Corporation, New York, N. Y., and Thompson & Thompson, Boston, Mass.

Lists of trade-mark applications filed but not acted upon are available from the Toilet Goods Association, New York.

Often one tries to derive from the name a clue as to the chemical composition, properties, or use of a trade-mark chemical. Sometimes it is possible, more often it is not.

Aldo (glyceryl monostearate) gives no true indication of its composition.
Alacet (aluminum acetate) is somewhat descriptive.
Bubene (butylbenzene) is somewhat less easy to figure out.
Cadaloy (cadmium-mercury-zinc alloy) is indicative of a cadmium alloy, but gives no clue to the other two components.
Caranol (sodium lorol sulfate) is not an alcohol as the terminal "ol" would indicate.
Pyridose (pyridyl mercuric acetate) is not a sugar, as the terminal "ose" would indicate.

The uses of trade-mark chemicals are more frequently discernible.

Hydratite indicates waterproofing.
Mersize exemplifies a sizing compound.
Moldol is a mold preventive.
Opax is an opacifier for glass.
Tanak is a tanning agent.

Some trade-mark chemicals offer a clue as to their progenitors.

Gastex is made from natural gas.
Kelgin is made from kelp.
Spermafol is made from sperm oil.
Tallex is made from tall oil.

Part of a company name in a trade-mark often identifies the manufacturer or seller.

Cibanet, a product of Ciba Co.
Dowicide, a product of Dow Chemical Co.
Glycowax, a product of Glyco Products Co.
Hercolyn, a product of Hercules Powder Co.
Nevinol, a product of Neville Chemical Co.
Santomerse, a product of Monsanto Chemical Co.

The method employed by the writer in looking up trade-mark chemicals is the one that best serves his purpose and will not be exactly suited to all others. Recourse is first had to Bennett's book, "Trade-Marks," which is the latest and most complete book in this field (published in 1949). This book gives an extensive list of chemical trade-marks, their compositions, uses, and suppliers, the entire U. S. and British trade-mark laws, methods of forming or coining trade-marks, and trade-marks classified by industries. Since new trade-marks appear daily, auxiliary current sources are used, such as the *Patent Office Gazette, Chemical Industries*' "Buyers' Guide," and the new products notes in technical journals. Some of the publications in the appended bibliography are annual publications and each issue contains new listings. These are next examined. When these sources do not have the desired information, requests are made to the librarians of some of our larger industrial concerns, who keep running files of trade-mark chemicals of interest to them.

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Exploring Foreign Chemical Patent Literature

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"Science knows no country because knowledge belongs to humanity, and is the light that illuminates the world."—Louis Pasteur.
"In so far as we may at all claim that slavery has been abolished today, we owe its abolition to the practical consequences of science."—Albert Einstein.

Many of the patent publications in the Scientific Library of the Patent Office are to be found in no other library in the United States"—so starts the preface to the invaluable "Manual of Foreign Patents" (*232*).

Actually, there is no other library in this country where it is practical to attempt a thorough search of foreign patents. And no publication other than the manual is known to the writer which contains a concise, yet comprehensive, account of the patent publications of foreign countries, together with an indication of those obtainable at the Patent Office.

The manual also includes, as its introduction, a unique article on "Searching Foreign Patents," by Worischek (*14*). This is a survey of the broad subject which presents an interesting combination of the highlights and many unusual, but valuable, details garnered through years of experience.

It was possible in 1921 for a sole author, Frank E. Barrows (*2*), to write a series of articles having practically the scope of the present symposium for that time. The trend toward specialization in chemical fields now evidently extends into the area of the literature.

Patent Office Library

As indicated by the name, the Scientific Library of the Patent Office comprises far more than its vast collection of foreign patents. It is also an excellent library of science, both for the examining divisions of the Patent Office and for the public. The start was made in 1836, when Congress appropriated $1500 for the purchase of a library of scientific works and periodicals. Its predecessor in earlier years is stated to have been Thomas Jefferson's own collection of books. Increased appropriations would enable the filling of gaps and expansion of this valuable collection, and would constitute a wise investment.

A person entering the Department of Commerce Building through the doors on E Street near 15th, walking straight ahead through the short corridor (though invariably pausing at the glass cases exhibiting the intricate models of some nineteenth century inventions), and finally proceeding through the next doorway, finds himself in the reference section of the library. To the right are a number of offices; extensive card files occupy the wall space between doors. This is an assignee file of United States patents which enables the identification of the patents which have been assigned to individuals or firms as well as of the assignee of any given inventor's patents.

To the left, bookcases extend across the room and along the walls, except at the center. The shelves house the reference volumes, mainly customary and unusual abstract and index publications, foreign trade-mark compendia, and sets of patent source volumes for

certain foreign countries. Study desks are available between bookcases. The complete set of *Chemical Abstracts* could well be supplemented by additional chemical reference works.

The Library's extensive card catalog and the librarians' desks are located in the central area to the left. Behind these is the entrance to the two-floor stack room. This adjoins the stack room which houses the classified set of United States patents, and there is a connecting door between the two. Most of the several million foreign patents are housed in the many rows of tall bookcases extending across the ground floor of the stack room and along its left and rear walls. Reading desks or tables are provided at intervals between the bookcases, as are staircases leading to the upper floor. One side of the second floor houses an extensive collection of technical books, sets of journals, and volumes of government publications, practically all the well-known ones and many that are rare. These are arranged according to subject. A "Table of Chemical Periodicals" (*46*) lists 38 chemical journals, their Patent Office Scientific Library call numbers, and the volume numbers for the years 1880 to 1948.

The opposite (E Street) side contains the Patent Office sets of Indian, Japanese, and Russian patents, and provides temporary storage space for unbound patents of other countries. The intermediate space has study tables. A tremendous variety of current technical periodicals is available at the 15th Street end of the upper floor.

The maintenance of this vast collection in proper order is the responsibility of a surprisingly small number of Patent Office employees. They perform their duties well, conscientiously, and swiftly. It is also fitting to acknowledge the courtesy and cooperation with which these fine workers respond to requests for information.

Foreign patents are in general similar to United States patents in form and content. They present the field of the invention, the difficulties overcome thereby, a general statement of the invention, and the specific examples, and conclude with one or more claims, as generally found in United States patents. However, the foreign patents are likely to be more concise, to avoid unnecessary repetition—for example, in the recitation of objects of the invention—and to be limited to one or a few claims. In some countries the inventor's name does not have to appear on the patent, while, in contrast, the United States law requires that the application for patent be made in the inventor's name. Swiss patents are outstanding for the legibility of their printed matter and Austrian patents for the clarity of their drawings.

The Patent Office collection of foreign patents is in the form of numbered bound volumes. Generally, two sets of each country's patents are available, one a numerical set and the other a set classified according to subject. However, the Czechoslovakian, Hungarian, Italian, Japanese, Polish, and Russian patents are available in only the numerically arranged set. When two sets are available, the arrangement of the patents is in accordance with the classification system in use by the issuing country at the time the patents were issued.

Each country has had its own classification system or systems, each of which differs from all other systems, except that some countries—for example, Austria, Denmark, Holland, Norway, and Sweden—adopted systems based on and similar to the German classification. The British collection does not include a set of classified patents, but has instead bound sets of "Abridgements" in classified groups or classes.

Searching aids of various types supplement the collections of foreign patents; these are similar to, and in some cases more extensive than those provided in the search room for facilitating the location of pertinent United States patents. The manuals of classification and alphabetical indexes thereto are available, and usually in the form of English translations. Annual indexes listing the names of patent applicants in alphabetical order or similarly listing the subjects of invention are frequently consulted. Cumulative indexes covering a span of years are great timesavers when they are available. The patent journals or gazettes of some countries present patent number lists of various kinds—for example, in accordance with subject classification, which can be utilized to good advantage in searches. Detailed information on the patent indexes and publications of each country can be found in Severance's "Manual of Foreign Patents" (*232*).

It seems best, within the scope of the present article, to limit the discussion to patents of a few of the countries, to the highlights of their chemical classifications, and to specific features which might be of general interest or importance.

British Patents

The historical development of British patents is of special interest to us, because the foundation of our own patent system depended considerably on traditions which originated in England and were retained in original or modified form by our early colonists. Modern patents got their start in 1623 with the enactment in England of the Statute of Monopolies. This statute forbade the grant of monopolies by the crown, the field of inventions or new manufactures excepted, as follows:

Provided also, and be it enacted that any declaration before mentioned shall not extend to any letters patents, and grants of privilege for the term of 14 years or under hereafter to be made of the sole working or making of any manner of new manufacture within this realm to the true and first inventor and inventors of such manufactures which others at the time of making such letters patents and grants shall not use so as also they be not contrary to the law nor mischievous to the State by raising prices of commodities at home or hurt of trade, or generally inconvenient . . . .

Earlier, monopolies had been granted on the manufacture of commodities—for example, salt, soap, and others—as well as on inventions. It is of interest to note that on July 1, 1617, John Casper Wolfen and John Miller obtained Letters Patent for 21 years for the sole making of "a certain oyle to keep armor and armes from rust and kanker," paying "into his Ma^{ties} Exchequer yearlie XLS."

In connection with Letters Patent No. 5, dated Jan. 11, 1618, to Thomas Murraye for "a newe invention for the sole making of sword blades, faulchions, skeynes, and rapier blades," authority was given to the patentee and his agents, with a constable, to enter and search places where they had cause to suspect the invention was being put in practice.

A similar provision in Letters Patent No. 44, dated July 13, 1628, to Arnold Rotsipen provides "that the offenders therein may receive condigne punishment for the same," mention being made of such punishment, fine, and imprisonment as thought fitting by the Court. The same patentee received Letters Patent No. 71, dated June 24, 1635, for a term of 14 years "if he live soe long."

John Wilkinson was granted Patent No. 1063, dated January 27, 1774 on "a new method of casting and boring iron guns or cannon." A parenthetical note to the abridgement states, "The boring machine of the patentee, an ironmaster of Brosley, was the first machine capable of boring cylinders with sufficient truth to enable Watt to use them for his steam engine." Thus, we have an eighteenth century example of a conversion of "swords to ploughshares."

Changes in the classification of British patents can be illustrated by the disposition of chemical patents. The abridgments covering the earliest patents, issued between 1588 and 1883, are divided into 103 classes. Volume 40 of this series, "Acids, Alkalies, Oxides and Salts," contains abstracts of patents dealing with the manufacture of salt, saltpeter, alum, vitriol, and the separation of silver from lead, among other subjects.

Letters Patent No. 52, dated Oct. 2, 1632, to Copley, Sharpey, and Hobart concerns "a peculiar newe way, mystery, arte, or meanes for making white salt and bay salt with sea water and brine without any such pannes or furnaces or other meanes as are now in use."

For the years 1855 to 1908, inclusive, illustrated abridgments were issued in 146 classes. Chemical patents appear in Class 1, "Acids, alkalies, oxides, and salts, inorganic," and in Class 2, "Acids and salts, organic, and other carbon compounds (including dyes)." Chemical patents will also be found in classes dealing with other subjects; Table I gives the classes under which the listed subject was classified.

These volumes of illustrated abridgments constitute convenient sources of information in searches. They contain abstracts of each patent (not merely a copy of a patent claim or claims), a part of the patent drawings considered most representative, and indexes both of the patent applicants and of subject matter.

Some indication of the importance of British chemical patents at that period is given by the comment of the United States Patent Office examiner in that field, Charles G. Page, when he stated in 1844 ("Report of the Commissioner of Patents for the year 1843," 28th Congress, 1st session, Doc. No. 177, page 314):

The progress of this branch, so far as may be inferred from the records of the Office, has been slower than might have been expected, considering the rapid progress of chemistry within a few years past. The proverbial ingenuity of our countryman, their readiness and tact in availing themselves of scientific discoveries, in turning directly to practical account the investigations of philosophers, have failed to sustain their reputation in chemical science, when viewed in comparison with numerous improvements made abroad, more especially in England.

Page then mentioned, as a single exception, the development here by Draper of marked improvements in photography.

For the period 1909 to 1930, inclusive, the abridgments were divided among the same 146 main classes, but some of these were further subdivided, to bring the total number of classes to 271—For example, Class 1 (Inorganic) was subdivided as follows:

1 (I) Chemical processes and apparatus
1 (II) Inorganic compounds other than metallic oxides, hydrates, oxyacids, and salts (including alkali manufacture and cyanogen compounds)
1 (III) Oxides, hydrates, oxyacids, and salts, metallic (other than alkali manufacture and cyanogen compounds)

Class 2 (Organic) was subdivided as follows:

2 (I) Acetylene
2 (II) Cellulose, nonfibrous, and cellulose derivatives (including artificial filaments, sheets and the like containing same)
2 (III) Dyes and hydrocarbons and heterocyclic compounds and their substitution derivatives

The abridgment classes were next reshuffled into 40 groups, and British patents are now classified into these broader groups commencing with those whose specifications were published in 1931 (patent numbers higher than 340,000). Patents which previously would have appeared in classes 1 (I–III), 32, 90, 91, and 95 are now classified in Group III, "Chemistry, Inorganic. Distillation. Oils. Paints."

Present Group IV, "Acetylene. Cellulose. Chemistry, Organic. Dyes and Dyeing," includes the patents which would formerly have fallen in Classes 2 (I–III) and 15 (I–II). Similarly, the current Group V, "Cements. Indiarubber. Moulding, Nonmetallic. Starch," represents a consolidation of previous Classes 22, 70, 87 (II), and 121.

In some cases, the regrouping has brought together some strange companions. Group XXI, for example, is entitled "Excavating and mining. Fires, fighting. Lifesaving. Subaqueous buildings. Warfare," representing a consolidation of Classes 9 (I and II), 47 (I and II), 68 (I and II), 77, 85, 92 (I and II), and 119. Group XXXVIII is designated "Music. Phonographs. Signals and Alarms." One almost expects to read next *Exeunt omnia* as part of this definition.

The older British patents have been thoroughly indexed in a number of publications

Table I

Class	Subject	Class	Subject
9	Explosives	87	Molding plastic substances
15	Bleaching		
22	Cements	90	Nonmetallic elements
32	Distilling and concentrating	91	Oils, fats, and soaps
		95	Paints, colors, and varnishes
53	Batteries		
56	Glass	96	Paper
70	India rubber and gutta-percha	98	Photography
		121	Starch and adhesives
76	Leather	127	Sugar
82	Metals and alloys	140	Waterproof fabrics

of the British Patent Office. The 50-year subject index (1861 to 1910) is especially valuable, a separate index having been provided for each class; the patents in each subdivision are in chronological order (*168a*).

The British classified abridgments provide a considerable aid to searches, because the abstracts and illustrative drawings can be scanned more rapidly than complete patents. However, there is a possibility that essential portions of patents escape mention in the abstracts published in the abridgments. The chore aspect of searches has been magnified by the broader groups introduced in 1931.

French Patents

The problem of searching French patents has been concisely and accurately summarized by Worischek (*14*): "Research in the French patents is a tedious matter. The classification is excessively broad and the patents are frequently erroneously placed; many errors in class numbers appear on the printed copies. Some of the classes have more than one hundred volumes. The 'addition' patents must also be covered."

The difficulties of searching are greatly increased in some cases because of the absence from the Patent Office files of a numerical set from 1876 to 1902. Many French patents were not printed in the period from 1897 to 1902; manuscript copies of such patents can be obtained from France.

The Patent Office has available at the Scientific Library typewritten copies of a manual of classification of the French Patent Office (*174*). In this manual, Class XIV, "Chemical arts," has the following subclasses:

1. Chemical products
2. Coloring materials, dyes, varnishes, paints, and other coatings and inks
3. Powders and explosives, pyrotechnics
4. Fats, candles, soaps, and perfumery
5. Petroleum distillates, resins, waxes, rubber, and celluloid
6. Distillation, filtration, purification of liquids and gases
7. Hides and skins, glues and gelatin
8. Processes and products not otherwise specified

The itemized content of these subclass headings requires five typewritten pages in the translated manual (*174*, sheets 147 to 151).

The intricacies of classification when compounded with language difficulties are illustrated by the note under subclass 6 (purification of gases and liquids), "Not to be confounded with removal of dust for cleaning purposes: XIX—6 (The French word 'poussière' means both powder and dust)."

Extensive sets of subject and patentee indexes are available at the Patent Office, but the frequent need for consulting the copy of the patent itself prolongs the agony. Most of the time, the choice one has lies between the "devil" of consulting the indexes and finding the patents, and "the deep blue sea" of scanning through page after page of volume after volume of the broad subclass. A shining light in this area is the collective subject index in English, prepared by the United States Patent Office, of French patents which were granted between 1791 and 1876, inclusive (*181a*).

German Patents

In general, a search of a given subject can be conducted most easily and quickly in the German patents. One reason for this is that the Patent Office has provided a very compact and easily legible translation of the "Manual of Classification of the German Patent Office" and its companion volume, the subject index. The class, subclass, and group titles (*173*, *175*) are generally clear-cut, and cross references, if any, appear after the titles, so that there is no need of consulting a separate book of definitions. The classes were set up logically and the subject indexing of the classification was thoroughly done. One rarely has to search more than several subclasses even in a thorough search and often a single subclass will provide the desired information.

There are also inconveniences in research in the German patents. Some of the publications and annual indexes are printed in the terrible Germanic type. One is haunted by

the specter of artfully concealed disclosures or of deliberately misleading information, in accordance with charges that seem to be made more frequently concerning German patents than about others. Incompleteness of the Patent Office classified set, particularly with respect to the earlier patents, is a nuisance, because it is necessary to "pull" the missing patents from the numerical set. Further pulling is made necessary because of the revised classification of 1933.

The classification manual, which was translated by Lovett of the United States Patent Office (*175*), is the second edition (1910) of the "Gruppeneinteilung der Patentklassen" (*172*). The companion subject index (key-word title index), which was translated by Kuhlmann of the United States Patent Office (*173*), is the 1914 edition of the "Stichwörterverzeichnis, alphabetische Zusammenstellung" (*178*). The bulky United States classification manual (*181*) and its index are wallflowers in comparison with these handy attractive guides. The present discussion is based mainly on the 1910 (*175*) edition, because most of the classified set at the Patent Office is bound in accordance with it.

There are 89 main classes which are divided into alphabetically designated subclasses, further subdivided into numerical groups. The total number of groups is about 8000.

Class 12 is entitled "Chemical Processes and Apparatus, so far as not included in special classes." The alphabetical subclasses of this class are listed below; the cross references are omitted and the titles in some cases are abbreviated.

12*a*. Boiling and digesting processes and vessels
b. Calcining and fusing
c. Dissolving, lixiviating, crystallizing, solidifying, fluids
d. Clarifying, separating, filtering, including filters and filter presses
e. Absorption and purification of gases and vapors. Mixing
f. Siphons, containers, and closures for acids and condensed gases. Charging apparatus. Regulators for inflow and outflow
g. Purely chemical processes in general and related apparatus
h. General electrochemical processes and apparatus
i. Metalloids and their compounds
k. Ammonia, cyanogen, and their compounds
l. Compounds of the alkali metals
m. Compounds of the earth metals and alkaline earth metals
n. Compounds of the heavy metals
o. Hydrocarbons. Alcohols. Aldehydes. Ketones. Organic sulfur compounds. Hydrated compounds. Carbon acids. Carbon acid amides, urea, and other compounds
p. Nitrogen rings and nitrogenous compounds of unknown constitution
q. Amines, phenols, naphthols, aminophenols, aminonaphthols
r. Distillation of tar, extraction of wood vinegar, etc.

To illustrate the numerical subdivision of the alphabetical subclasses and the cross references, we may consider the following detailed listing of subclass 12*n* as given in the manual:

12*n*. Compounds of the heavy metals (metallurgical processes, 40a; 40c)
1. Metal oxides and salts in general. Colloidal metals and metal compounds; purely chemical preparation of metals and metal powders
2. Iron compounds in general (cf. 30h, 8)
3. Manganese compounds, including manganese peroxide
4. Nickel and cobalt compounds
5. Copper compounds
6. Zinc compounds
7. Lead compounds, including lead peroxide
8. Mercury, silver, and gold compounds
9. Tin compounds
10. Tungsten compounds

Many other classes and subclasses are of chemical interest (Table II).

In the 1933 revision (fifth edition), (*172*) the number of groups was increased to over 19,000, the general effect being to narrow the subject matter coverage of the individual groups.

While revising the manual, the German Patent Office also reclassified all German patents and published the revised list of patent numbers belonging to each class, group

and subclass. This is the 1934 (fourth) edition of the "Gruppenliste der deutschen Patentschriften mit Angabe der zu jeder Klasse, Unterklasse und Gruppe gehörenden Nummern," (*172a*). A companion volume, "Nummernliste," was also issued in 1934 and contains a numerical list of the patent numbers with the classification of each (*175a*).

In making a thorough search in the Patent Office collection of German patents, one starts by searching the proper volumes of the classified set, checking the patent numbers against the list shown by the "Gruppenliste" (4th ed.) for the given class and group. The unchecked patents must then be pulled from the numerical set.

The German publication corresponding to the United States Patent Gazette is the "Auszüge" section of the weekly *Patentblatt*. The latter contains various lists relating to patent applications and patents. The "Auszüge" presents the patent information in the order of the subject classification.

The thorough annual indexes (Verzeichnis) contain a number of sections enabling the searcher to obtain complete data fairly readily starting from a knowledge of only the patent number, or the patent application number, or the applicant's name, or the classification. "The Manual of Foreign Patents" (*232*) contains an especially clear presentation concerning the German patent publications.

The Austrian, Danish, Dutch, Norwegian, and Swedish classifications are based on the German. Generally, the main classes are identical, but the subdivision of the classes is not so extensive. The Swedish Patent Office in December 1948 published a revised classification manual (*179*). The Patent Office sets of the patents of these countries are also supplemented by useful yearly indexes.

Russian Patents

The Patent Office collection of Russian patents is limited to a numerical set of those available. The collection of patents of Czarist Russia includes numbers 1 to 29,800, issued during the period 1897 to 1917.

Worischek (*14*) has outlined two methods of conducting a search at the Patent Office when only a numerical set is available: (1) assembling a list of patent numbers of the desired classes from the patent publications of the particular country and pulling the patents from the numerical set, and (2) paging through the numerical set and noting the patents of interest. These methods are applicable to searching Russian, Hungarian, Japanese, Italian, Czechoslovakian, and Polish patents. The comment was added, "U. S. patents on oil refining have already been held invalid in view of Russian art, in costly litigation, and the Japanese art is replete with patents on alloys, magnetic testing, and the like which are not readily available to searchers in this country."

The United States Patent Office has a numerical set of Soviet patents numbered 1 to

Table II

Subject	Class	Subject	Class
Alloys	40b, 40c	Medicines	30
Batteries	21b	Mercerizing	8a, 8k
Beer	6	Metal coating	48b
Bleaching	8	Metallurgy	40
Cement	80	Mixers	50f
Disinfecting	30i	Mortar	80
Dyes	22	Oils and fats	23
Electroplating	48a	Paints	22
Explosives	78	Paper making	55
Fertilizers	16	Photography	57
Fiber and fabric treatment	8, 29, 76b	Plastics	39
Filters	12d	Preserving foods	53
Glass	32	Rubber	39
Glue	22i	Soaps	23e, 23f
Inks	22g	Sugar and starch	89
Laundry	8d, 8i	Tanning	28
Leather	28	Textile fibers	29
Linoleum, etc.	8h, 81	Thermometers	42i
Matches	78a	Water purification	85

3500 (1924 to 1927). The first two patents were chemical in nature, the first on a furnace for the continuous preparation of sodium sulfide and the second on water purification [*Chem. Abstracts*, 27, 3787, 3763 (1933)]. The patents issued since 1927 have not been available; information concerning some of the chemical patents has been published in *Chemical Abstracts* based on abstracts given in the Russian Patent Office periodical. The latter is a monthly publication containing abridgments of issued patents, lists of applications, utility models, information on trade-marks, Patent Office notices, and reviews of current technical literature.

Translations of the Soviet patent law enacted March 5, 1941, and of the regulations issued Nov. 27, 1942, were published by Charles Prince, formerly Soviet Russian expert, U. S. Chamber of Commerce (*229*).

Swiss Patents

Swiss patents have become an increasingly rich source of chemical information, and are easy to search and a pleasure to read, thanks to the clear typography. As one leafs through the volumes, one encounters patents written in French, Italian, or German. This is a constant happy reminder that, as stated by the Encyclopaedia Britannica (1945 edition), "The Swiss Confederation is made up of 22 small states, differing from each other in nearly every point—religious, political, social, industrial, physical and linguistic; yet it forms a nation the patriotism of whose members is universally acknowledged." For over 300 years, Swiss of French, Italian, and German customs and language have lived peacefully together, while their cousins across the border periodically took up the sword against one another. There is no denying the success of this "little United Nations Organization."

It was during his period of employment at the Swiss Patent Office that Einstein worked out and first announced his theory of relativity, as well as other pioneering scientific achievements. That also happened to be about the time when the Swiss classification was revised. Swiss patents 1 to 39,400 (1888 to 1907) are classified under the old system, which contained 116 main classes. A translation of the headings of these classes appears in the second edition (1905) of "Key to the Classifications of the Patent Specifications of France, Germany, Austria, Netherlands, Norway, Denmark, Sweden, and Switzerland" (*169*).

The revised Swiss classification was adopted in January 1908 and has been in use since then. The headings of the 129 classes and their subclasses are given in English in the third edition of this bulletin (*169*).

In the old classification, many chemical patents appear under F, Miscellaneous Industries, Class 40 being entitled "40. Salt industry; manufacture of chemicals," and under K, Manufacture of scientific and technical apparatus etc., Class 59 being entitled "59. Physical, chemical, and electrolytic apparatus, etc."

In the new classification, Class G, Chemical Industries, includes the following subclasses:

36. Chemical processes and apparatus in general
37. Dyes, varnishes, lacquers, paints, adhesives
38. Fats and oils
39. Explosives, cartridges for mining purposes, match manufacture
40. Tanning, chemical section; tanning materials, impregnating and preserving leather
41. Chemical preparation of India rubber, gutta-percha, celluloid and plastic bodies in general
42. Manure preparation
43. Water purification for household or industrial purposes, disincrustants for boilers, preparation of mineral or gaseous waters, water distillation, sewage purification
44. Metal working, chemical

The patent periodical, "*Patent-liste—Liste des brevets—Lista dei brevetti*", is issued twice a month. It contains a classified list of patents granted with accompanying data, a list of recently published patents, a classified list of patent assignments, and other patent notices. The indexes are rather complex, a noteworthy feature being that the name index of assignees lists foreign firms under the city of the home address.

One who reads widely in the patents of many countries soon acquires the feeling that patents, as means of exchanging information of progress between countries, stimulate international comity and understanding. This is particularly true of chemical patents which like music and mathematics, are blessed with symbols and formulas that know no boundaries.

Over a century ago, C. M. Keller, examiner at the United States Patent Office, recognized the potentialities for progress in foreign as well as domestic inventions, when he wrote ("Report of the Commissioner of Patents for the Year 1844," by Henry L. Ellsworth, 28th Congress, 2nd Session Senate 75, page 464):

In this report, as in the preceding, I shall not strictly confine myself to the inventions of the United States, but introduce such of the inventions of Europe, which have come to my notice, as I may deem worthy of public attention, either in their immediate applicability to our industry, or as containing the germs of future usefulness; for it often occurs that ideas which, in themselves, possess no practical usefulness, suggest and lead to the most important and useful inventions.

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This bibliography illustrates the extensive aids which are available for explorations of chemical patent literature. For the convenience of the reader, it is presented under the following headings:

I. Patent searching
II. Special compilations of chemical patents
III. Chemical patent abstracts, lists, and encyclopedias
IV. Articles, books, and journals furnishing chemical patent references
V. Classification of patents
VI. Information on United States and foreign patents and patent laws

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Items under this category are too numerous to attempt an extensive listing herein, especially in view of the existence of excellent bibliographies such as the one by von Hohenhoff (*13*) and the "List of Periodicals Abstracted by *Chemical Abstracts*" [40, I-CCIX (Dec. 20, 1946)]. Valuable review articles have appeared in *Chemical Reviews* and the volumes of "Annual Survey of American Chemistry." Outstanding reviews, in some cases an annual feature in the January issue, have been published in the following journals. (Those marked with an asterisk regularly feature a patent abstract or patent list section.)

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(95) *Brennstoff-Chemie*, Essen, Germany
(96) *Canadian Chemistry and Process Industries*, Toronto, Canada
(97) *Chemical Age*, London, England
(98) *Chemical and Engineering News*
(99) *Chemical Industries*
(100) *Chemical and Metallurgical Engineering*
(101) *Chemiker-Zeitung*, Koethen, Germany
(102) *Chemisch Weekblad*, Amsterdam, Holland
(103) *Chimie et Industrie*, Paris, France
(104) *Deutscher Farber-Zeitung*, Wittenburg, Germany
(104a) *Drug and Cosmetic Industry*, New York
(105) *Fettchemische Umschau*, Stuttgart, Germany
(106) *Gazzetta chimica italiana*, Rome, Italy
(107) *Gummi-Zeitung*, Berlin, Germany
(108) *India Rubber Journal*, London, England
(109) *Industrial and Engineering Chemistry*
(110) *Industrie Chimique*, Paris, France
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(112) *Journal of the American Leather Chemists Association*
(113) *Journal of the Society of Chemical Industry*, London, England
(114) *Journal of the Society of Dyers and Colourists*, England
(115) *Kolloid Zeitschrift*, Dresden, Germany
(116) *Korrosion und Metallschutz*, Berlin, Germany
(117) *Materials and Methods*
(118) *Melliand Textilberichte*, Heidelberg, Germany
(119) *Metal Finishing*
(120) *Metal Industry*, London, England
(121) *Metal Industry*, New York
(122) *Modern Plastics*
(123) *Papier-Fabrikant*, Berlin, Germany
(124) *Rayon and Melliand Textile Monthly*, England
(125) *Recueil des travaux chimiques*, Amsterdam, Holland
(126) *Revue Generale des Matieres Plastiques*, Paris, France
(127) *Seifensieder Zeitung*, Leipzig, Germany
(128) *Textile Institute Journal*, Manchester, England
(129) *Transactions of the American Electrochemical Society*
(130) *Transactions of the Faraday Society*, London, England
(131) *Zeitschrift für angewandte Chemie*, Berlin, Germany
(132) *Zeitschrift für anorganische und allgemeine Chemie*, Leipzig, Germany
(133) *Zeitschrift für das gesammte Schiess- und Sprengstoffwesen*, Munich, Germany
(134) *Zellstoff und Papier*, Berlin, Germany

Many chemical patent references are to be found in books, which in turn are usually readily located through bibliographies, publishers' catalogs, or abstracts of book reviews. Many of the AMERICAN CHEMICAL SOCIETY monographs contain abundant patent references. The following list is illustrative of the variety that is available both as to breadth of field and the scope within the field.

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Searching the Older Chemical Literature

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The older chemical literature, published between 1750 and 1875, offers the searcher the pitfalls of multiple publication, anonymity, short life of many journals, unfamiliar abbreviations, and frequent changes of journal names. It is essential actually to handle the sources themselves. A list of obsolete journals of the nineteenth century is appended.

The "older literature" for the purposes of this paper is taken to mean that which was published between the years 1750 and 1875. It is, of course, true that something in the nature of chemical literature existed before 1750, but the consultation of such records more properly belongs to antiquarian research than to library work in the field of chemical literature. If the reader is curious to know what types of sources are used for the very earliest researches in the field he may consult J. R. Partington's erudite monograph on "The Origins and Development of Applied Chemistry," from which he will soon observe that the earliest records of our science involve the inscriptions and papyri of ancient Egypt, and the documents and remains of the early Arabic and Persian civilizations and cultures. Research in this field is the province of the linguistic and archeological specialist.

In the period commencing with 1750, there are several landmarks which the student will come to regard as turning points in the history of the subject.

1.	Publication of Lavoisier's "Traité élémentaire de Chimie"	1789
2.	Commencement of the *Chemisches Centralblatt*	1830
3.	Commencement of the *Chemical Society Abstracts*	1871
4.	Commencement of the *Society of Chemical Industry Abstracts*	1882
5.	Commencement of the American *Chemical Abstracts*	1907

Thus, the literature from 1875 onward may be said to be fairly well covered by the various abstracting systems, which can give the three major lines of attack in a literature search. Before that date, however, it is not so easy to be sure of having thoroughly covered the ground of a search.

Pitfalls of Searching Early Literature

As the art—perhaps we should say science—of abstracting has become progressively more thorough and skillful, we have come to rely more and more on abstracts and their indexes for surveying the field of chemical endeavor, and today, so complex is the fabric of chemical literature, the abstract systems are the only feasible means of identifying and tracing original communications. The early abstracting systems were much less efficient than those of today; and prior to 1875 it is not sufficient to rely on them for a survey.

It may, perhaps, be of assistance to the beginner to mention some of the pitfalls of searching the early literature, before making suggestions for a plan of attack. One phenomenon encountered by the searcher in the 1750–1840 period is that of "multiple publication." The savants of this age were not content with a single publication of any discovery they chanced to make; often the same paper, with or without minor modifica-

tions, appeared in half a dozen journals and in several different languages. Berzelius, for example, often published in Swedish, with subsequent full publication in English, French, and German, and it was something of an indication of the eminence of a scientist of the period to ascertain how many foreign journals had republished his papers. This makes for many wearisome disappointments in searching the older literature; to secure an apparently new reference to an obscure journal, travel to see it or at considerable cost obtain a copy and translation, only to find that it is merely a translation of a paper available in one's own library.

A second difficulty is that of anonymity. Journals of the time frequently published anonymous scientific communications, especially on controversial subjects. An example of such was published in Thomson's *Annals of Philosophy* in 1815, entitled "On the Relations between the Specific Gravity of Bodies in Their Gaseous State and the Weight of Their Atoms." This was later shown to have been written by Prout, and has led, of course, to "Prout's hypothesis" (which does not anywhere occur in his paper, but originates rather in the editorial comments of Thomson). To discover the authors of such contributions is itself a special field of bibliographical endeavor and is outside the scope of the ordinary searcher; it involves an intimate knowledge of historical minutiae and, moreover, an access to letters and documents not usually available in libraries other than those of the Royal Society and one or two similar ancient institutions on the continent of Europe.

Yet another difficulty lies in the short runs of obsolete journals in which important data were frequently published. In the absence of any organized abstracting service it is often impossible to find a path to information thus published. The origin of the many obsolete journals lies in the fact that during the period under consideration publication was a strongly personal matter; a prominent scientist would, on the least provocation, commence a journal of his own to effect prompt publication of his researches and those of his pupils. The old names—*Crell's Annalen, Thomson's Annalen, Scherer's Annalen, Liebig's Annalen*—testify to this aspect of early chemical literature. In many cases the journals died a natural death with that of the first editor and author, but in others the publication was continued under another name and in some instances, even maintained continuity until the present time. Such an instance is the *Annalen der Physik*, which commenced life as the *Journal der Physik* in 1790, became the *Neues Journal der Physik* from 1794 to 1798, and then went through the following transformations of title:

1799–1824	*Gilbert's Annalen*
1824–1877	*Poggendorf's Annalen*
1877–1909	*Wiedemann's Annalen*
1909–	*Annalen der Physik*

In such cases the volume numbers follow the series—i.e., each section is numbered *de novo*—but this is not inevitably so, as in the *Archiv de Pharmacie* which commenced Series 1 in 1822, and after 50 volumes commenced a new series *de novo* which continued until Series 2, Volume 151 (1871), after which the series number disappeared and the volume number jumped to 201 in 1872. The reason for this gap is that in 1872 it was decided to renumber the volumes *ab origine*. A similar gap occurs in the volume numbers of the *American Journal of Science* which in 1937 reached Volume 34 of Series 5, but was then numbered *ab origine*, so that the volume number of 1938 is 236.

In working out a plan of search, several factors must be borne in mind.

Purpose of the Search. Research into the older literature of chemistry is an expensive and time-consuming procedure, and must, therefore, be undertaken only when circumstances warrant it. In ordinary industrial laboratory procedure it is seldom necessary to search back beyond 1875, while even the period 1875 to 1900 often yields little of value from the standpoint of modern manufacture. On the other hand, for purposes of fundamental research, or in preparing a detailed historical survey of some field of chemical endeavor, it is often very desirable to prepare properly documented accounts of the earliest work.

Scope of the Search. As in all historical work, research in early documents can be prolonged *ad infinitum* and it is fundamentally important to know where to stop.

Thus, for example, in dealing with the history of iodine as an element, it would be proper to commence with the publication by Courtois [*Ann. chim.*, **88**, 304 (1813)] and Clement and Desormes, of what appears to be the true account of the first isolation of this element. Here again, the pitfalls which surround the searcher are apparent, for it was in 1811 (not 1813) that the discovery was first made, but Courtois although a skillful chemist had no time or money to continue the work, but passed it to his friends Clement and Desormes to develop and publish. There is always a lurking suspicion in the mind of anyone who carries out historical research in such a field, that some earlier discovery of the element recorded in an out-of-the-way place may have taken place; unless the worker is very skilled and experienced in chemical-historical searching, such feelings should be ignored, for they can lead to masses of exhausting and abortive work.

On the other hand, if one were interested in the medicinal uses of iodine and its compounds, it would be necessary to carry out quite a different kind of search, for the use of such iodine compounds undoubtedly carries back to a time long preceding the discovery of the element itself; indeed, it appears that the ancient Assyrians used crude iodide preparations for medicinal purposes, and since these early days the ashes of sponges and kelps have been systematically so used.

Thus, a search for the chemistry of the element iodine is a different matter from one for the use of the iodine-containing compounds medicinally, and would have to be differently planned.

In commencing a search for information on inorganic topics an invaluable starting point is the translation (with emendations and additions) of the original Gmelin's Handbuch, made by Watts and published by the Cavendish Society from 1848 onward. At the commencement of each section is a detailed bibliography which covers a very large part of the literature to that date. An excerpt from the bibliography of the section on iodine will illustrate many of the points mentioned in the earlier part of this paper:

Some Entries under "Iodine" in Gmelin-Watts Translation

Angelini, *Schw.*, 36, 319.
Balard, *Ann. Chim. Phys.*, 28, 178, and *Schw.*, 44, 350, *Kastn. Arch.*, 5, 126.
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Emmet, *Sill. A. J.*, 18, 260.
Fuchs, *Repert.*, 14, 276.
Hall, *N. Tr.*, 7, 2, 137.
Soubeiran, *Pogg.*, 12, 604.
Straub, *Schweiz. Nat. Anzg. Jahrg.*, 3, 59, *Brugn. Giorn.*, 19, 387.

Students of chemical literature, familiar only with modern abbreviations for journal titles, will find these very unfamiliar, and an additional disconcerting feature is that no date is given. Because the volume numbers of most of these journals are irregular, the year can be ascertained only with difficulty. Readers will be able to identify most of these journals from the list given below, and will find that the editor's name is often the clue to the title abbreviation—e.g., the *Giornale de fisica, chemica, medicina*, etc., is described as *Brugn. Giorn.* because the editor was Brugnatelli.

In checking over this list by consulting each original, further cross references will come to light and may be added to the list. Other additions will result from the careful inspection of the indexes of the various journals, although in some cases no index is provided. The catalogs of the Royal Society library (1839 and 1881–83) are rich in valuable indications of rarer material.

For organic searches the "Traité de Chimie Organique" of Gerhardt makes a good starting point and is well documented, although in common with its contemporaries, no date is included in the reference. It was published in 1853 and may be considered to cover about two thirds of the literature of the period. A most useful desk volume (or volumes) is the first edition of Richter's Lexicon and the first edition of Beilstein, both of which can often be purchased cheaply. They have the merit of being able to give the searcher an ordered account of the literature up to the 1890's.

Finally, there is no royal and simple method by which the older literature may be surveyed; it is essential for searchers in this field to make a careful and detailed study of the literature, and to make a practice of actually handling the primary sources themselves; this is no study for the man who is in a hurry.

Some Obsolete Chemical Journals of the Nineteenth Century

Title	Published from	Date	Vols.	Editors
1. *Afhandlingar i Fysik, Kemi och Mineralogi*	Stockholm	1806–18, irreg.	6	Berzelius and Hisinger
2. *Allgemeine chemische Bibliothek des Neunzehnten Jahrhunderts*	Erfurt	1801–05	5	Trommsdorff
3. *Allgemeines Journal der Chemie*	Leipzig	1798–1803	10	Scherer
Continued as				
Neues allgemeines Journal für Chemie	Leipzig	1803–06	8	Scherer *et al.*
Continued as				
Journal für die Chemie, Physik, etc.	Berlin	1806–10	9	Gehlen
2nd series	Nürnberg	1811–33	69	Schweigger
(This journal was merged with others into the *Journal für praktische Chemie*)				
4. *Almanach de la Chimie*	Rouen and Paris	1854–61	8	....
5. *Almanach für Scheidekünstler*[a] *und Apotheker*	Weimar	1780–1802	23	Gottling
Continued as				
Taschenbuch für Scheidekünstler und Apotheker	Weimar	1803–19	17	Bucholz
Continued as				
Trommsdorff's Taschenbuch für Chemiker und Pharmaceuten (cumulative index for 1780–1803)	Jena	1820–29	10	Trommsdorff
6. *American Chemical Journal* (now merged in *Journal of the American Chemical Society*)	Baltimore	1879–1913	50	Remsen *et al.*
7. *American Chemist*	New York	1870–77	6+	Chandler
8. *American Laboratory*	Boston	1875	1	....
9. *Annali di chimica* (Vol. 21 has a collective index)	Pavia	1790–1802	21	Brugnatelli
10. *Annali di fisica, chimica e matematica*	Milano	1841–47	28	Majocchi
Continued as				
Annali di fisica, chimica e scienze affini	Torino	1850	4	Majocchi and Selmi
11. *Annals of Chemical Medicine*	London	1880–	?	Thudicum
12. *Annals of Chemical Philosophy*	London	1828–29	2	Maugham
13. *Annals of Chemistry and Practical Pharmacy*	London	1843	1	....
14. *Annals of Philosophy*				
1st series	London	1813–20	16	Thomson
2nd series	London	1821–26	12	Phillips
(absorbed in *Philosophical Magazine* in 1827)				
15. *Annuaire de Chimie*	Paris	1845–51	7	Millon & Reisst
16. *Annuaire des sciences chimique*	Paris	1837	1	Berzelius
17. *Annual Reports of the Progress of Chemistry*	London	1849–55	7	Liebig *et al.*
(English translation of *Jahresberichte*)				
18. *Annuario delle scienzi chimiche farmaceutiche e medicolegal*				
Series 1	Mantova	1840	1	....
Series 2	Mantova	1841–49	9	Sembenini
19. *Archiv für Gesammte Naturlehre*	Nürnberg	1824–30	18	Kastner
Continued as				
Archiv für Chemie und Meteorologie	Nürnberg	1830–35	9	Kastner
20. *Archiv für die theoretische Chemie*	Jena	1800–02	1	Scherer
21. *Archiv für die thierische Chemie*	Halle	1800–01	1	Horkel
22. *Årsberättelse om Framstegen i Physik och Chemi till Kongl. Vet. Akad.*, etc.	Stockholm	1821–40	20	Berzelius

[a] "Scheidekünstler" = "assayer," old German for "chemist."

Some Obsolete Chemical Journals of the Nineteenth Century (*Continued*)

Title	Published from	Date	Vols.	Editors
Continued with title altered from *Physik och Chemi* to *Kemi och Mineralogi*	Stockholm	1841–47	7	Berzelius
Continued with omission of *och Mineralogi* in title	Stockholm	1847–49	3	Svanberg
23. *Auswahl aller eigenthümlichen Abhandlungen und Beobachtungen in der Chemie*	Leipzig	1786–87	5	Crell
24. *Beiträge zur Chemie*	Wien	1791	1	Wasserberg
25. *Beiträge zur chemischen Kentniss der Mineralkörper*	Berlin and Stettin	1795–1815	6	Klaproth
26. *Beiträge zur Erweiterung und Berichtigung der Chemie*	Erfurt	1799–1802	3	Bucholz
27. *Beiträge zur physiologischen und pathologischen Chemie*	Berlin	1843	1	Simon
Continued as *Archiv für pharmakologische und pathologische Chemie*[b]	Wien	1844–54, irreg.	8	Heller
28. *Berlinisches Jahrbuch der Pharmacie*	Berlin	1795–1840	43	Gehlen, Rose, *et al.*
29. *Bibliothek der neuesten physische chemischen Literatur*	Berlin	1788–95	4	Hermbstadt
Continued as *Annalen der chemischen Literatur*		1802	1	von Woolf
30. *Boston Journal of Chemistry*	Boston	1866–80	14	Nichols
Continued as *Boston Journal of Chemistry and Popular Science*	Boston	1881–82	2	....
Continued as *Popular Science News and Boston Journal of Chemistry*	Boston	1883+	?	....
31. *Bulletin des sciences mathematiques, astronomiques, physiques et chimiques*	Paris	1824–31	16	Saigey
32. *Centralblatt für Agriculturchemie*, etc.	Leipzig	1872–85	24	Biedermann
33. *Chemical Gazette*	London	1843–59	17	Francis and Croft
Became *Chemical News*	London	1860–1932	145	Crookes
34. *Chemical Review*	London	1871–84	14	....
35. *Chemical Review*, and *Journal for the Spirit, Vinegar and Sugar Industry*	Chicago	1881	1	Siebel
Continued as *American Chemical Review*, etc.	Chicago	1882–84	3	....
36. *Chemische Ackersmann*	Leipzig	1855–75	21	Stöckhardt
37. *Chemische Annalen für die Freunde der Naturlehre*	Helmstädt and Leipzig	1784–1803	40	Crell
Associated with *Beiträge zu den chemischen Annalen von L. Crell*	Helmstädt and Leipzig	1785–99	6	Crell
38. *Chemische en phijsische oefeningen voor de beminnaars der scheien naturkunde*	Amsterdam and Leyden	1788	3	Kastelyn
39. *Chemische Archiv*	Leipzig	1783	2	Crell
Continued as *Neues chemisches Archiv* and *Neuestes chemisches Archiv*	Leipzig	1784–91	8	Crell
	Weimar	1798	1	Crell
40. *Chemisches Journal für die Freunde der Naturlehre*	Lemgo	1778–81	6	Crell
Continued as *Entdeckungen* (*Die neueste*) *in der Chemie*	Leipzig	1781–86	13	Crell
41. *Chemisch-Technische Mittheilungen der neuesten Zeit*	Berlin	1846–83	33	Elsner

[b] Not to be confused with *Archiv. für experimentelle Pathologie und Pharmakologie* started in 1873.

Some Obsolete Chemical Journals of the Nineteenth Century (*Continued*)

Title	Published from	Date	Vols.	Editors
42. *Chemisch-Technisches Repertorium*	Berlin	1862–82	21	Jacobsen
43. *Chemist*				
1st Series	London	1824–25	2	....
2nd Series	London	1840–45	6	C. and J. Watt
3rd Series	London	1846–48	1	Newton
4th Series	London	1849–53	4	C. and J. Watt
5th Series	London	1854–58	5	C. and J. Watt
44. *Chemists' Journal*	London	1880–82	6	....
45. *Chimiste* (agricultural)	Bruxelles	1865–69	5	Berge
46. *Chimiste* (distillers)	Paris	1859–60	2	Simon
47. *Crell's Chemical Journal* (translation of No. 37, but with additions)	London	1791–93	3	....
48. *Edinburgh Journal of Science* (Merged in *Philosophical Magazine* in 1832)	Edinburgh	1824–32	16	Brewster *et al.*
49. *Gazzetta eclettica di chimica farmaceutica*	Verona	1831–39	7	Sembenini
50. *Gazzetta eclettica di chimica technologia*	Verona	1833–34	2	Sembenini
51. *Giornale di Farmacia, chimica* Continued as	Milano	1824–34	19	Cattanco
Bibliothek di Farmacia Continued as	Milano	1834–45	23	Cattanco
Annali di chimica applicata (This journal was carried on well into this century)	Milano	1845+	71+	Polli *et al.*
52. *Giornale di fisica, chimica e storia naturale* Continued as	Pavia	1808–17	10	Brugnatelli
Giornale di fisica, chimica e storia naturale e medicina ed arte	Pavia	1818–27	10	Brugnatelli
53. *Introduction aux observations sur la physique, sur l'histoire naturelle et sur les arts* (second publication of same material in 1777) Continued as	Paris	1771–72	18	l'Abbé Rozier
Observations et mémories sur la physique, sur l'histoire naturelle et sur les arts et métiers Continued as	Paris	1773	1	Rozier
Observations sur la physique, sur l'histoire naturelle et sur les arts Continued as	Paris	1778–94	42 [numbered] 2–43	Rozier *et al.*
Journal de physique, de chimie d'histoire naturelle et des arts	Paris	1794–1822	53 + two suppts.	la Méthérie *et al.*
54. *Jahrbuch der Erfindungen und Fortschritte auf den Gebieten der Physik und Chemie*	Leipzig	1865–84	20	....
55. *Jahresberichte der Agriculturchemie*	Berlin	1875	2	Detmer
56. *Jahresberichte über die Fortschritte der physischen Wissenschaften* Continued as	Tübingen	1822–41	20	Berzelius
Jahresberichte über die Fortschritte der Chemie und Mineralogie (translation from Swedish of No. 22)	Tübingen	1842–51	10	Berzelius
57. *Journal de chimie médicale, de pharmacie et de toxicology*	Paris	1825–34	10	Berzelius

Some Obsolete Chemical Journals of the Nineteenth Century (*Continued*)

Title	Published from	Date	Vols.	Editors
2nd series	Paris	1835–44	10	....
3rd series	Paris	1845–54	10	....
4th series	Paris	1855–64	10	....
5th series	Paris	1865–76	12	....
(Minor changes in title take place through series; journal merged with *Repertoire de pharmacie* in 1876)				
58. *Journal für Physik und physikalische Chemie des Auslandes*	Berlin	1851	3	Krönig
59. *Journal für technische und ökonomische Chemie*	Leipzig	1828–33	18	Erdemann
60. *Journal of Applied Chemistry*	New York Philadelphia Boston	1866–75	10	....
61. *Journal of natural philosophy, chemistry and the arts*	London	1797–1801	5	Nicholson
2nd series	London	1802–13	36	Nicholson
(Merged with *Philosophical Magazine* in 1814)				
62. *Kleine physikalisch-chemische Abhandlungen*	Leipzig	1858	8	Westrumb
63. *Kritische Zeitschrift für Chemie, Physik and Mathematik*				
1st series	Erlangen	1858	1	Kekulé *et al.*
2nd series	Erlangen	1859	1	Erlenmeyer
Continued as				
Zeitschrift für Chemie und Pharmacie	Erlangen Heidelberg	1860–64	4	Beilstein and Fittig
Continued as				
Zeitschrift für Chemie	Göttingen	1865–71	7	Beilstein and Fittig
64. *Laboratorium*	Weimar	1825–40	44	....
65. *Laboratory*	Boston	1874–76	2	Babcock
66. *Laboratory*	London	1867	1	....
67. *Magazin für die höhere Naturwissenschaft und Chemie*	Tübingen	1784–87	2	....
68. *Mechanic and Chemist*	London	1836–42	8	....
69. *Mélanges physiques et chimiques tires du Bulletin de St. Petersbourg*	St. Petersbourg	1854–84+	12+	....
70. *Memoirs of the Columbian Chemical Society*	Philadelphia	1813–14	2	....
71. *Naturhistorische und chemische technische Notizen*	Berlin	1854–59	11	....
2nd series	Berlin	1860–62	4	....
72. *Nordische Blätter für Chemie*	Halle	1817	1	Scherer
Continued as				
Allgemeine nordische Annalen der Chemie	St. Petersbourg	1819–22	7	Scherer
Continued as				
Magazin für die neuesten Erfahrungen, etc.	Carlsruhe	1823–31	36	Hänle and Geiger
(Merged in 1832 with *Annalen der Pharmacie*)				
73. *Penny Mechanic and Chemist*	London	1836–42	8	....
74. *Pharmaceutical Times*	London	1847–48	3	....
Continued as				
Chemical Times	London	1848–49	2	....
75. *Raccolta fisico-chimica italiana*	Venezia	1846–48	3	Zantedeschi
Continued as				
Annali di fisica	Padova	1849–50	1	Zantedeschi
76. *Répertoire de chimie et de physique*, etc.	Paris	1837–39	6	....
77. *Répertoire de chimie pure et appliquée* (Each volume consists of	Paris	1858–63	A5	....

Some Obsolete Chemical Journals of the Nineteenth Century (*Continued*)

Title	Published from	Date	Vols.	Editors
parts A and B). Became *Bulletin de la société chimique* in 1864				
78. *Repertorium für die Pharmacie*	Nürnberg	1815–34	50	Buchner
2nd series	Nürnberg	1835–48	50	Buchner
3rd series	Nürnberg	1849–51	10	Buchner
Continued as *Repertorium* (*Neues*) etc.	Nürnberg	1852–76	25	Buchner
79. *Repertorium für organische Chemie*	Zürich	1841–43	3	Löwig
80. *Revue hebdomadaire de Chimie*	Paris	1869–75	7	Mène
81. *Revue scientifique et industrielle*				
1st series	Paris	1840–44	16	de Quesneville
2nd series	Paris	1844–47	15	de Quesneville
3rd series	Paris	1848–51	9	de Quesneville
4th series	Paris	1852	1	....
Continued as *Moniteur Scientifique*				
1st series	Paris	1857–63	5	de Quesneville
2nd series	Paris	1864–70	7	de Quesneville
3rd series (merged in 1927 with *Revue de Chimie Industrielle*)	Paris	1871–1926	50+	....
82. *Scheikundige onderzoekingen, gedaan in het laboratorium der Utrechtsche Hoogeschool*	Rotterdam	1845–76, irreg.	17	Mulder *et al.*
83. *Technisch-chemisches Jahrbuch*	Berlin	1880–84+	5+	Bidermann
84. *Tekno-kemisk Journal*	Stockholm	1847–48	1	Almström
85. *Tidsskrift for anvendt Chemi*	Kjøbenhaven	1869–70	1	Holm
86. *Tidsskrift for Physik og Chemi samt disse videnskabers Anvendelse*	Kjøbenhaven	1862–70	12	Thomsen
87. *Tidsskrift voor wetenschappelijke Pharmacie*				
1st series	Voorburg's	1849–53	5	Haaxmann
2nd series	Gravenhage	1854–58	5	Haaxmann
3rd series		1859–64	6	Haaxmann
4th series	Gorinchem	1865–73	9	Haaxmann
88. *Toegepaste Scheikunde*				
1st series	Vlaardingen	1865–69	5	Opwyrda
2nd series	Vlaardingen	1870–75	4	Opwyrda
Continued as *Maandblad voor toegepaste Scheikunde*	Amsterdam	1876–80+	5+	Opwyrda
89. *Ueber die neueren Gegenstände in der Chemie*	Breslau	1791–1802	11	Richter
90. *Untersuchungen aus Liebig's Laboratorium* (mostly published elsewhere)	Wien	1872	1	Liebig
91. *Vierteljahresschrift für technische Chemie*	Quedlinberg	1859–69	10	Artus
92. *Zeitschrift für das chemische Grossgewerbe*	Berlin	1876–82	7	Post
93. *Zpravy spolku Chemiků českých.*[c]	Praze	1872–76	2	Safarik

[c] It is thought that *Časopis chemiků českých* (1 vol. 1870) is a logical predecessor of this; and there may have been sporadic numbers published after 1876.

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House Organs of Chemical Interest

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House organs present material of particular interest to chemists in the form of early publication of data on characteristics and applications of commercially available materials and apparatus. Some of these publications also present review articles, abstracts of current literature, news items, and reports of company operations and activities. A classified list of house organs is given.

Many industrial corporations issue publications which are designed to furnish their employees, customers, and the general public with information concerning their operations and products. The publications of industrial corporations are particularly important in scientific fields, because they are the original, and often for a considerable period of time the only, source of data on the characteristics and applications of commercially available materials and apparatus. Industrial publications may take the form of advertisements, miscellaneous bulletins or announcements, catalogs, or house organs. House organs are those industrial publications which are issued in a periodical series, distinguished from other, irregularly issued industrial publications by a continuity of title and type of subject matter.

House organs may be used solely as a medium for advertising, and as such are equivalent to other occasional industrial publications as a source of technical data. Many companies, however, have attempted to extend the scope of their house organ publications to that of periodicals by the inclusion of articles on their operations and activities, descriptions of the development and testing of their products, review articles on technical subjects, and notes of news items and literature of potential interest to their customers. Technical house organs have developed in this direction to such a degree that many publish articles which are favorably comparable to those issued in the regular scientific journals.

The importance of house organs as a source of scientific literature has been recognized by the leading technical abstracting and indexing services. In 1947 the *Chemist-Analyst*, a house organ, ranked second among United States journals in the number of abstracts published in the Analytical Section of *Chemical Abstracts*, being outranked only by *Analytical Chemistry*. In recognition of the importance of this informational medium, this paper points out the type of information which may be found in publications of this nature.

Applications of Materials

House organs are chiefly devoted to descriptions of the properties and applications of materials and apparatus. Information on properties of commercial materials often is not readily available in the technical journal literature for a considerable time after the first appearance of the materials on the market. Frequently, tabulations of properties

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of materials are published in house organs immediately after announcement of availability of the new material. These tabulations may be repetitions of data published in advertisements, sometimes accompanied by a description of the testing methods. In some cases, the result of an extensive series of tests may be published in a house organ, as in the case of a table of the resistance of neoprene rubber to 128 organic and inorganic chemicals, published in the July 1949 issue of the *Neoprene Notebook*.

Applications of materials are the primary subject of house organs. Few house organs are concerned with the applications of chemical intermediates, so far as the author has been able to determine. However, a number of manufacturing corporations in technical fields issue publications which describe the compounding and fabrication of chemical compounds into consumer goods.

Formulations for the preparation of paints, molding and extrusion compounds, etc., utilizing commercial materials, are a type of trade information not often published in technical journals. Several house organs, exemplified by the *Hercules Chemist* and *By Gum!* in the field of paint chemistry, and by the *Vanderbilt News* on the topic of rubber compounding, regularly feature the publication of compounding information. Formulations for other types of chemical products are also published in house organ literature—for example, *Sindar Reporter* and the *Givaudanian* discuss the preparation of perfume formulations, and a department of *Dyestuffs* supplies dye bath formulations in each issue.

A number of house organs are concerned with the working and fabrication of materials into consumer products. Particularly outstanding among this type are those in the field of plastics chemistry, such as the *Durez Molder*, *Plaskon Magazine*, and *Resinous Reporter*.

Fabricating techniques are the chief material of chemical interest published in house organs of this sort. The manufacture of plywood, for example, with some discussion of the problems of this industry, such as the causes of poor bonding, has been described in several house organs. Desiderata, characteristics, and testing of materials for fabricating also may be discussed.

Descriptions of the fabrication and application of metallic materials are published in several house organs. These may concern the machining of the material, as described for aluminum in the *Technical Adviser*. More often, service records of fabricated metals are presented—for example, *Equipment Progress* supplies information on corrosion resistance of metals under unusual conditions.

The manufacturers of chemical engineering equipment also publish service testing records in their house organs. The application of particular materials and apparatus is frequently illustrated by descriptions of industries utilizing the product, outlining the chemical processes and equipment involved. Flow sheets and descriptions of various chemical processes are also presented by manufacturers of process control instrumentation, in house organs such as *Wheelco Comments* and *Instrumentation*. Although the descriptions of chemical processes are usually not presented in great detail, the instrumentation of a particular process may be completely outlined.

Reviews

In addition to surveys of the industries utilizing their products, many house organs publish review articles, not specifically concerned with industrial products, on topics that may be of interest to their readers. These articles cover a wide field of scientific endeavor; only a few are mentioned here as representative of the quality of the material presented.

The *Chemist-Analyst* publishes reports on analytical methods and techniques. These articles are original procedures, written and contributed by scientists outside the staff of the J. T. Baker Chemical Company, publishers of this house organ. Original experimental data are also published in the Technical Section of *R.B.H. Dispersions*, a publication of Interchemical Corporation.

The majority of house organs which include technical articles present general reviews, rather than original articles. A number of such publications are issued by manufacturers of laboratory research chemicals and apparatus. *C.R.C. News* and *Cenco News*

Chats have published discussions of the theory and design of laboratory apparatus. *Scientific Apparatus and Methods*, *Announcer of Scientific Equipment*, and *Spectrographer's News Letter* regularly issue articles discussing methods and instrumentation of analytical chemistry. *Organic Chemical Bulletin* discusses analytical reagents and their applications.

In the pharmaceutical and drug field, many house organs include review articles of interest to chemists for their discussions of chemotherapeutics. *Merck Report*, *What's New*, *Lederle Bulletin*, *Seminar*, *Roche Review*, *Pharmacal Advance*, *Ciba Symposia*, *Research in the Service of Medicine*, and *Therapeutic Notes* are outstanding publications of this type. Pharmaceutical manufacturing concerns, in addition to the above-mentioned medical publications, also issue house organs, such as *Lab-Fax Veterinarian* and *Veterinary Snapshots*, containing discussions of the chemotherapeutics of the infections and nutritional deficiency diseases of farm animals. *Borden's Review of Nutrition Research* presents abstracts of literature relating to human nutritional requirements.

Various other chemical and technical subjects, not directly discussing the products of their publishing company, are reviewed in house organs. *Lubrication*, a publication devoted to discussions of the selection and use of lubricants, in the May-June issues of 1950 presented a general review of the concepts and measurements of viscosity. *Inco Corrosion Reporter* in each issue discusses the chemistry and manufacture of some corrosive material, such as fluorine, chlorine, phosphorus, or hydrofluoric acid. *Interchemical Review* has published reviews of spot test analysis, the organic chemistry of dyes, and other chemical subjects.

Abstracts

Some house organs, in addition to, or instead of, discussions of the present knowledge of a technical subject based on the published literature, present abstracts of the current literature in a particular field. *Vancoram Review* carries a lengthy section of abstracts of literature relating to vanadium. *Chlorination Topics* abstracts literature on the application of chlorine to industrial wastes. Current literature on analytical techniques is abstracted in *Perkin-Elmer Instrument News for Science and Industry*. Other house organs carry abstract sections on various scientific topics. Because these literature abstract sections are restricted to relatively limited scopes of science, comparatively obscure literature sources are sometimes abstracted and thus called to the attention of a reader who might otherwise overlook the reference.

Current news items, relating to specific topics or of general scientific interest, are also abstracted in many house organs. *Aminco Laboratory News*, featuring notes of scientific news, exemplifies the usual style. New developments may be cursorily reported, or a topic of current interest may be discussed at some length, with emphasis on recent developments and trends. The latter type of publication particularly occurs in the house organs of chemical consulting firms, such as *Research Viewpoint* and *Industrial Bulletin*. Such house organs are usually addressed to the research executive, and may stress the economics of the processes and industries discussed, as is emphasized by the title of the publication *Chemonomics*. Although house organs presenting scientific news items are not usually of value as chemical literature, they often make interesting reading.

House Organs for Employees and Stockholders

The last type of house organ to be discussed is that published by the larger corporations in scientific and technical fields for a reading audience of employees, stockholders, and the general public. Such house organs do not usually contribute to the technical literature, but rather are concerned with reporting the operations and activities of the issuing corporations. A number of publications of this type exist, such as *Du Pont Magazine* and *Monsanto Magazine* among the publications of chemical manufacturers, and *Texaco Star*, *Orange Disc*, *Lamp*, *Flying Red Horse*, *Service*, and *Sohioan*, which are representative of those published by oil companies. Such house organs are occasionally useful as sources of information regarding the varied products and interests of the larger United States chemical corporations.

Lists of House Organs

The preceding paragraphs have mentioned the names of a few publications typical of each category. In the appended bibliography, a classified list of some house organs of chemical and technical interest is given. This list should not be considered complete, but indicative of the types of publication to be found in this field. In the course of the preparation of this paper, no published list of house organs of chemical interest was found; a list of house organs mainly in the field of engineering was published in "Trade Catalog Collection," by Granville Meixell (Special Libraries Association, New York, 1934), and a substantially complete list of house organs published in the United States and Canada is available in the *Printer's Ink* "Directory of House Organs." The second edition of this publication, issued in 1947, lists over five thousand house organs, alphabetically by title and by issuing company. This publication, however, classifies house organs only by type (internal, external, or combined circulation), and not by subject matter. The bibliography appended to this paper was compiled by examination of house organs in the files of *Printer's Ink*, the New York Public Library, and the Research and Development Department of the Barrett Division, Allied Chemical & Dye Corporation, and from the writer's personal files, which were assembled on the basis of the list in the *Printer's Ink* directory.

Supplementary information on technical house organs initiated since the appearance of the second edition of the *Printer's Ink* directory in 1947 may be obtained from notices in the new literature and trade publications sections of the various trade journals. In addition, *Industrial Arts Index*, under the heading, "Magazine Notes," lists new house organs. A number of the house organs listed in the *Printer's Ink* directory have since been discontinued; however, the discontinuance or suspension of a house organ usually can be ascertained only by writing to the publisher.

Indexing and Availability

House organs are indexed by various abstracting and indexing services. The specialized abstracting services, such as *Textile Technology Digest*, tend to be more complete in their coverage of house organs than are the general indexes, such as *Chemical Abstracts*, which does not index material presenting an advertisement for specific commercial materials (private communication from E. J. Crane, May 5, 1950). Indexing of house organs by the published indexing services is by no means complete, in any case. Periodic indexes of technical house organs are occasionally published but, for the majority of these publications, a complete search can be ensured only by a page-by-page scanning of each issue.

Copies of house organs are distributed by the issuing companies to industrial corporations which may have an interest in their products. Files of back issues are available for reference at the larger college and public libraries, although such files are usually by no means comprehensive or complete. The most satisfactory method of realizing the value of this type of trade publication is collection and maintenance of a personal file of house organs. Copies of house organs are sent to interested individuals and to general and trade libraries on request. A few house organs are restricted in circulation, but no technical house organ, to the author's knowledge, falls into this category.

Bibliography

The general nature of the material of chemical or technical interest published in each house organ is indicated by the symbols: A = application, R = review, L = literature abstracts, N = news items, and O = operations and activities.

Chemotherapeutics and Nutrition

Borden's Review of Nutrition Research (L)
Labco and Vitamin Products Dept., Borden Co., New York, N. Y.
Ciba Clinical Symposia (R)
Ciba Symposia (R)
Ciba Pharmaceutical Products, Inc., Summit, N. J.

G-E X-Ray News (N)
General Electric X-Ray Corp., Chicago, Ill.
Lab-Fax Veterinarian (R, N)
Whitmoyer Laboratories, Inc., Meyerstown, Pa.
Lederle Bulletin (R)
Lederle Laboratories Division, American Cyanamid Co., New York, N. Y.
Merck Report (R, N)
Merck & Co., Inc., Rahway, N. J.
Pharmacal Advance (R)
Menley & James, Ltd., New York, N. Y.
Pulse of Pharmacy (A, N)
Wyeth, Inc., Philadelphia, Pa.
Research in the Service of Medicine (R)
G. D. Searle & Co., Chicago, Ill.
Roche Review (R)
Hoffmann-La Roche, Inc., Nutley, N. J.
Seminar (R)
Sharp & Dohme, Inc., Philadelphia, Pa.
Therapeutic Notes (R, L)
Parke, Davis & Co., Detroit, Mich.
Tile and Till (N)
Eli Lilly and Co., Indianapolis, Ind.
Veterinary Snapshots (N)
What's New (R, L)
Abbott Laboratories, Chicago, Ill.

Resins, Rubbers, and Paints

Bakelite Review (A)
Bakelite Corp., Bound Brook, N. J.
By Gum! (R, A)
Reichhold Chemicals, Inc., Detroit Mich.
Celanese Plastics (A)
Celanese Corp. of America, New York, N. Y.
Cellulosic Plastics (A)
Hercules Powder Co., Wilmington, Del.
Durez Molder (A)
Durez Plastics News (A)
Durez Resin News (A)
Durez Plastics and Chemicals, Inc., Tonawanda, N. Y.
Hexagon (R, N)
Interchemical Corp., Newark, N. J.
Kabelitems (A)
Bakelite Division, Union Carbide and Carbon Corp., New York, N. Y.
Monsanto Magazine (A, O)
Monsanto Chemical Co., St. Louis, Mo.
Neoprene Notebook (A)
E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.
Paint Progress (R, N)
New Jersey Zinc Co., New York, N. Y.
Plaskon Magazine (R, A)
Plaskon Division, Libbey-Owens-Ford Glass Co., Toledo, Ohio
Plastics Newsfront (A)
American Cyanamid Co., New York, N. Y.
Resinous Reporter (R, A)
The Resinous Products Division, Rohm & Haas Co., Philadelphia, Pa.
Vanderbilt News (A)
R. T. Vanderbilt Co., New York, N. Y.

Laboratory and Plant Equipment

Allis-Chalmers Annual Review (A)
Allis-Chalmers Manufacturing Co., Milwaukee, Wis.
Alloy Pot (A)
New Jersey Zinc Co., New York, N. Y.
Aminco Laboratory News (N)
American Instrument Co., Silver Spring, Md.
Announcer of Scientific Equipment (R)
Eberbach & Son Co., Ann Arbor, Mich., and others
Armstrong Trap Magazine (R, A)
Armstrong Machine Works, Three Rivers, Mich.

Baldwin (A)
Baldwin Locomotive Works, Philadelphia, Pa.
Cenco News Chats (R, A)
Central Scientific Co., Chicago, Ill.
Chemist-Analyst (R)
J. T. Baker Chemical Co., Phillipsburg, N. J.
C.R.C. News (R, A)
Chemical Rubber Co., Cleveland, Ohio
Deco Trefoil (metallurgy) (R, N, A)
Denver Equipment Co., Denver, Colo.
Dragon (A)
Fafnir Bearing Co., New Britain, Conn.
Equipment Progress (A)
Lukens Steel Co., Coatesville, Pa.
Facts (R, A)
Thwing-Albert Instrument Co., Philadelphia, Pa.
Flow Line (N, A)
Nordstrom Valve Division, Rockwell Manufacturing Co., Pittsburgh, Pa.
Generator (A)
Babcock & Wilcox Co., New York, N. Y.
Glass Lining (N, A)
The Pfaudler Co., New York, N. Y.
Instrumentation (R, A)
Brown Instruments Division, Minneapolis-Honeywell Regulator Co., Philadelphia, Pa.
Laboratory (R, A)
Fisher Scientific Co., Pittsburgh, Pa.
Laboratory Spotlight (A)
Harshaw Scientific Division, Harshaw Chemical Co., Cleveland, Ohio
Perkin-Elmer Instrument News for Science and Industry (L, A)
Perkin-Elmer Corp., Glenbrook, Conn.
Precisionomics (A)
Precision Scientific Co., Chicago, Ill.
Scientific Apparatus and Methods (R, A)
E. H. Sargent and Co., Chicago, Ill.
Spectrographer's News Letter (R, A)
Applied Research Laboratories, Detroit, Mich.
Testing Topics (R, A)
Baldwin Locomotive Works, Philadelphia, Pa.
Walworth Today (A)
Walworth Co., Boston, Mass.
Water Journal (N, R, A)
Pittsburgh Equitable Meter Division, Rockwell Manufacturing Co., Pittsburgh, Pa.
Wheelco Comments (A)
Wheelco Instruments Co., Chicago, Ill.
Worthite News (R, A)
Worthington Pump and Machinery Corp., Harrison, N. J.

Petroleum and Petroleum Products

Diamond of Mid-Continent Petroleum Corporation (O)
Mid-Continent Petroleum Corp., Tulsa, Okla.
Ethyl News (O)
Ethyl Corp., New York, N. Y.
Flying Red Horse (O)
Socony-Vacuum Oil Co., Inc., New York, N. Y.
Lamp (O)
Standard Oil Co. of New Jersey, New York, N. Y.
Library Bulletin of Abstracts (L)
Universal Oil Products Co., Chicago, Ill.
Link (O)
Carter Oil Co., Tulsa, Okla.
Lion Oil News (O)
Lion Oil Co., El Dorado, Ark.
Lubrication (R)
The Texas Co., New York, N. Y.
Lubriplate Film (A)
Fiske Brothers Refining Co., Newark, N. J.
Oil-Power (R, A)
Socony-Vacuum Oil Co., Inc., New York, N. Y.
Orange Disc (O)
Gulf Oil Corp., Pittsburgh, Pa.

Service (R, O)
Cities Service Co., Philadelphia, Pa.
Service Factor (A)
Sinclair Refining Co., New York, N. Y.
The Sohioan (R, O)
Standard Oil Co. of Ohio, Cleveland, Ohio
Sunray News (O)
Sunray Oil Corp., Tulsa, Okla.
Texaco Star (O)
The Texas Co., Houston, Tex.

Chemical and Miscellaneous Products

Chemical Digest (N)
Foster D. Snell, Inc., New York, N. Y.
Chemi-Notes (R)
Baird and McGuire, Inc., Holbrook, Mass.
Chemistry and You (N)
A. R. Maas Chemical Co., South Gate, Calif.
Chemistry in Action (N, O)
Truesdail Laboratories, Inc., Los Angeles, Calif.
Chemonomics (R, N)
R. S. Aries and Associates, Brooklyn, N. Y.
Chlorination Topics (N, L, A)
Wallace & Tiernan, Newark, N. J.
Ciba Review (Dyes) (R, A)
Ciba Co., Inc., New York, N. Y.
Clean-Up (N, A)
C. B. Dolge Co., Westport, Conn.
Crown (R, A)
Crown Cork and Seal Co., Baltimore, Md.
Current Abstracts of Scientific and Technical Literature (L)
General Foods Corp., Hoboken, N. J.
De-Ce-Co. Magazine (embalming fluids) (R, A)
Dodge Chemical Co., Boston, Mass.
Du Pont Magazine (A)
E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.
Dyestuffs (R, A)
National Aniline Division, Allied Chemical & Dye Corp., New York, N. Y.
Engelhard Industries News Letter (chemical apparatus and materials) (A)
C. Engelhard, Inc., Newark, N. J.
For Instance (N, A)
American Cyanamid Co., New York, N. Y.
Frontier (R, N)
Armour Research Foundation, Chicago, Ill.
Givaudanian (N, A)
Givaudan-Delawanna, Inc., New York, N. Y.
Hercules Chemist (A)
Hercules Mixer (O)
Hercules Powder Co., Wilmington, Del.
Inco Corrosion Reporter (R, A)
International Nickel Co., New York, N. Y.
Industrial Bulletin (N)
Arthur D. Little, Inc., Cambridge, Mass.
Interchemical Review (R)
Interchemical Corp., New York, N. Y.
International Digest (A)
International Graphite and Electrode Corp., Saint Marys, Pa.
Koppers News (O)
Koppers Co., Inc., Pittsburgh, Pa.
Laundry Bundle (R, A)
Pennsylvania Salt Manufacturing Co., Philadelphia, Pa.
Martin Star (O, A)
Glenn L. Martin Co., Baltimore, Md.
Nickel Cast Iron News (A)
Nickel Topics (A)
International Nickel Co., New York, N. Y.
Oakite News Service (A)
Oakite Products, Inc., New York, N. Y.
Organic Chemical Bulletin (R)
Eastman Kodak Co., Rochester, N. Y.

Perkins Glue Line (A)
Perkins Glue Co., Lansdale, Pa.
Power Specialist (insulation board) (A)
Johns-Manville Sales Corp., New York, N. Y.
Process Industries Quarterly (R, A)
International Nickel Co., New York. N. Y.
Progress through Research (A, O)
General Mills Research Laboratories, Minneapolis, Minn.
Pulp and Paper Bulletin (N)
Bulkley, Denton Pulp Co., Inc., New York, N. Y.
R.B.H. Dispersions (R)
Interchemical Corp., Bound Brook, N. J.
Research Comments, Facts and Trends (R)
Evans Research and Development Corp., New York, N. Y.
Research Viewpoint (N)
Esselen Research Corp., Boston, Mass.
Rohm & Haas Reporter (A)
Rohm & Haas Co., Philadelphia, Pa.
Silicate P's and Q's (A)
Philadelphia Quartz Co., Philadelphia, Pa.
Sindar Reporter (R, A)
Sindar Corp., New York, N. Y.
Technical Adviser (A)
Reynolds Metals, Louisville, Ky.
Think (N)
International Business Machines Co., New York, N. Y.
Vancoram Review (R, L, A)
Vanadium Corp. of America, New York, N. Y.
Witcombings (R, A)
Witco Chemical Co., Inc., New York, N. Y.

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Searching for Unpublished Data

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During the earlier days of chemistry, scientific information was transmitted largely through personal correspondence. Today when so much published material is available, this source is often overlooked. There are, however, many purposes for which a search for unpublished information proves to be exceedingly worth while. The best guides to unpublished data are the literature, society meetings, and personal contacts. Data for limited circulation which have been typed, printed, or mimeographed can often be made available if the searcher knows where to look. Several examples and sources of such information are given. Graduate theses are a fruitful source of information. Although these manuscripts are usually printed and parts of them are often published in chemical periodicals, they are very frequently buried in the libraries of the institutions at which they were prepared. A number of bibliographies which list titles of these are given.

The chemist of today has at his disposal a much greater choice of media for publication than did Robert Boyle in 1660 when he wrote to his nephew, Lord Dungarvan (*9*):

That our air either consists of, or at least abounds with, parts of such a nature, that in case they be bent or compressed by the weight of the incumbent part of the atmosphere, or by any other body, they do endeavour, as much as in them lieth to free themselves from that pressure, by bearing against the contiguous bodies that keep them bent; and, as soon as those bodies are removed, or reduced to give them way by presently unbending and stretching out themselves, either quite, or so far forth as the contiguous bodies that resist them will permit, and thereby expanding the whole parcel of air these elastic bodies compose.

At the time this statement of the famous Boyle's law was written, there were no scientific publications and information was necessarily transmitted through personal communications. The Royal Society was not founded until two years later and its journal, *The Philosophical Transactions of the Royal Society*, was first published in 1665. Even though a number of scientific journals were introduced during the 18th and early 19th centuries, personal letters remained an important means of communicating scientific information. Much of Scheele's work, for example, was transmitted in this way. At present, only infrequent references to "private communications" or "unpublished data" are found.

It could be questioned whether personal communications have any place in the transmittal of scientific information today when *Chemical Abstracts* covers 4500 periodicals and publishes about 49,000 abstracts a year. With this volume of technical literature

available, it might appear that all chemical information is now being published. There are, nevertheless, data which either never will be published or will be delayed in publication but which are available through private communication. Ordinarily, it is assumed that completion of the conventional exhaustive search through *Chemical Abstracts*, other compendia relevant to the subject, the original articles, and patents absolves the searcher of any further responsibility. In many instances, however, he may find it worth his while to call his ingenuity into action and look for unpublished data.

A chemist engaged in research may need data or methods which are not found in the literature. Conditions may be such that any laboratory work on his part to obtain the information would be too lengthy, too costly, or impossible with the laboratory facilities available. In any of these instances, he would do well to correspond with other chemists who may have done this work. A search for unpublished data may also reveal why certain data are not available; one may find that a method of experimentation gave negative results.

In compiling tables or other compendia, extreme caution must be taken to prevent them from being badly out of date by the time they are published. Here it is also important to obtain data that have not yet been published.

Scientific Meetings

Once the need is established, the problem arises as to where to look for these unpublished data. The principal clues are scientific meetings, published literature, and personal contacts, and the main sources are the individual chemist's notebook, typed or mimeographed material having limited circulation, and theses and dissertations which are buried in the libraries of the institutions at which they were written. Many chemists have the misconception that unpublished data consist entirely of material that is unavailable for reasons of national security or will later be used in obtaining patents and is therefore being kept confidential. This discussion is limited to the types that are available.

Society meetings offer many clues to unpublished data. In fact, a knowledge of unpublished data is one of the best answers to those skeptics who ask "Why are we attending this meeting anyway?" One can find a lead to unpublished data in the oral presentation of papers. A high percentage of meeting papers are eventually published, but one may need the information in the intervening time. Moreover, this gap of time is increasing with the ever-growing volume of manuscripts submitted to scientific periodicals. Furthermore, a few papers never will be published. Some would-be authors are too busy and others too lazy to do the final polishing that is necessary before papers can be accepted by the editors.

A discussion often follows the presentation of a paper. Here is another very worthwhile clue. The actual value of discussion lies not only in the technical information obtained but also in learning who is working on what and his particular angle of approach. A knowledge of who is working on the subject of interest is the real key to all sources of unpublished data.

Another great asset gained from meeting attendance is the opportunity for a wide variety of personal contacts. Discussions outside the formal sessions frequently give insight into the whereabouts of unpublished data. These personal contacts also form a sound basis for personal correspondence with other scientists.

Finally, if one does not go to a meeting or hear many papers, he has the opportunity to use abstracts as a clue. If, for example, the melting point of a particular compound is sought that does not appear in the literature but has been the subject of a recent paper, the chances of obtaining it within a short time by writing to the author are very good. The paper will, in all probability, be published 6 months or a year later, but that is of little value if the information is needed immediately.

The published literature shows who the workers in a given field are. From the articles themselves, one can get some idea of related data which are not in the article but may have been determined by the authors. The ever-growing volume of work submitted has necessitated the abridgment of articles to essentials. For example, an analytical pro-

cedure or method of purification may have been omitted if it is not essential to support the general conclusions of the article or if it is felt that interest therein would be slight, yet it may be precisely the information for which one is looking.

Data for Limited Circulation

Another classification of unpublished data is that which has been typed, printed, or mimeographed for limited circulation. Although such material is frequently confidential, there are instances in which it can be made available. The problem of the searcher is to learn that such information exists. A case in point is the unclassified information accumulated by the Atomic Energy Commission (*10*). This category includes reports on researches which were originally unclassified or nonsecret and reports which have been declassified because results no longer require security control. Although individual scientists have been encouraged to seek publication in existing scientific and technical periodicals, a great number of reports remain unpublished. The Atomic Energy Commission and Manhattan District reports may be obtained at present from the A.E.C. Document Sales Agency, Oak Ridge, Tenn., which publishes lists of available documents. The *Nuclear Science Abstracts*, which is issued twice monthly at Oak Ridge, serves as a guide to these unpublished reports as well as to other information on atomic energy. These abstracts are available on an exchange basis to universities, hospitals, medical schools, research institutions, and scientific societies.

A good example of available but unpublished data in the industrial field is the results of the American Petroleum Institute Fundamental Research projects. Although eventually published, use can be made of the data prior to publication so long as the one using them does not in turn publish them. Results are circulated to many petroleum companies which sponsor the research projects. A person working in another field such as pharmaceuticals or food, however, may be saved a great deal of time by knowledge of the properties of a new compound which has been prepared by one of the projects. He can obtain them on request from the American Petroleum Institute or the director of the project.

A source of information in the paper field is the Instrumentation Reports prepared by the Institute of Paper Chemistry for the American Pulp and Paper Association. These reports are eventually published but, in the meantime, are available through the association. The Forest Products Laboratory also has reports which are mimeographed and available on request prior to publication.

Information may be available on a similar basis from institutes functioning in other fields. The problem here is again one of finding out who knows. A National Research Council bulletin (*4*) lists such organizations along with the addresses of their headquarters, and contains a subject index which includes the names of organizations serving any given subject of interest.

Abandoned patent applications may also be a source of unpublished data. Some of them are available for inspection, or photostat copies may be obtained. These may be located through digests published in the *Official Gazette of the United States Patent Office.* By order of that office, dated January 25, 1949 (*7*), abstracts of abandoned patents are published by request of the applicant or owner.

Theses and Dissertations

For all practical purposes, theses and doctoral dissertations can be classified as unpublished data. They are a fruitful source of information and should not be overlooked. Few of these are published in full, some in part, and less than half are printed at all. Nevertheless, copies are available in the libraries of the institutions at which they were written. The problem is to discover that a dissertation exists on a particular subject of interest. It has been essentially solved by the annual appearance of "Doctoral Dissertations Accepted by American Universities" (*1*), first published in 1933. It lists the doctoral dissertations in all fields. Under each subject classification, the institutions at which the dissertations were prepared are listed in alphabetical order with subsequent listing by author. Although the classifications are broad, a subject which involves two or more fields can be located easily through the alphabetical subject index. This index, of course,

does not enable one to locate specific information as readily as is possible through the detailed *Chemical Abstracts* indexes. The classifications of information related to science are:

Physical Sciences	Earth Sciences	Biological Sciences
Astronomy	Geography	Agriculture
Chemistry	Geology	Anatomy
Engineering	Metallurgy	Bacteriology
Mathematics	Meteorology	Biochemistry
Physics	Mineralogy	Botany
	Paleontology	Entomology
	Seismology	Genetics
		Horticulture
		Medicine and surgery
		Pharmacology

These classifications have remained the same throughout except for biochemistry, which was not given a separate listing from 1933 to 1937.

During World War II, the titles of many dissertations were merely listed as secret research, under the appropriate classification. Since 1947, however, many of the titles for dissertations previously listed as secret have been given. Every volume contains a table showing the policy of each institution in regard to printing requirements, loans, and microfilming. A list of periodic university publications which abstract dissertations is also given.

Before publication of the list of dissertations, recordings of dissertations were fragmentary and haphazard, although somewhat more regular in science than in other fields. *Science* published such lists from 1898 to 1915 and *School and Society* in 1916. The National Research Council took over publication in 1920 and the annual science list appeared in its Reprint and Circular Series through 1933, with the exception of 1924 and 1925 (*6*). The listings are arranged alphabetically by subject and under subject by institution and author. Dissertations on chemistry in 1924 and 1925 are listed by Hull and West (*5*).

The Library of Congress published "A List of American Doctoral Dissertations" covering the years 1912 to 1938 (*11*). This is an annual list of publications actually acquired by the Library of Congress. A subject index is included in each volume.

Another valuable reference to dissertations is "Guide to Bibliographies and Theses, United States and Canada" by Palfrey and Coleman (*8*). A guide to earlier work in France, Germany, and Russia as well as the United States is found in Bolton's bibliography (*2*), which lists only dissertations that have been printed. *Chemistry in Canada* began listing theses from Canadian universities in 1949. This listing includes both doctor's and master's theses in chemistry, biochemistry, and chemical engineering, and notes where copies can be obtained (*3*).

In presenting this paper, the author does not profess to have cited all sources of unpublished data. A search for unpublished data varies with the specific problem involved. Its successful conclusion depends almost entirely on knowing who is who among chemists.

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(3) *Chemistry in Canada*, **1**, No. 8, 156–7 (1949).
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(8) Palfrey, T. R., and Coleman, H. E., Jr., "Guide to Bibliographies and Theses, United States and Canada," Chicago, American Library Association, 1936.
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Methods and Sources in Chemical Market Research

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Market research contributes to all functions of enterprise, from laboratory to sales. Four specific cases are outlined to illustrate some of the many methods available for obtaining market information. The contributions of domestic journals, government publications, foreign journals, and other sources are analyzed. The significance of one-time publications is discussed with particular reference to congressional hearings, court actions, and the activities of the Tariff Commission.

Market research in the field of chemicals consists of obtaining facts and figures, then correlating them to arrive at answers necessary to the conduct of business. Methods of obtaining the basic data as well as the identification of sources are fundamental means to the end. Execution embraces whatever is necessary in order to answer all or some of the following questions: who, what, when, where, why, how, and how much? The remainder is common sense.

When attention is confined to industrial chemicals, consumer-product research may be excluded. Thus, data relating to consumer surveys, population trends and shifts, gross national product, and psychological factors need be considered only in a few isolated cases. Specialists have developed the necessary techniques and have available an exhaustive statistical literature. Thus, industrial chemicals are rarely consumer goods; antifreeze is an exception. Markets usually depend upon other industries which are often far removed from the ultimate consumer. In addition, special and peculiar problems are presented. The scattered, cryptic, and sketchy information, to be made useful, necessitates a lively ingenuity based upon a technical background.

As in any other research, what is wanted must be exactly defined in terms of scope, accuracy, time, and budget. This is comparable in many ways to the usual laboratory, pilot plant, and commercial unit sequence. Market research serves the stages of production and development. For instance, the following questions may be asked: Should the laboratory investigate methods of making a specified new chemical? Does a chemical prepared by the research department have economic promise? Should a plant be built to make a chemical new to the producer and, if so, how large and where should it be? What is the potential market for a new use of an old chemical? Where and to whom can a chemical be sold and in what amount? What is the competitive position of a company within its immediate industry and in relation to allied products, now and in the future? There are a thousand questions all incidental to making and selling chemicals at a profit. Sources of information are just as diverse and even more numerous.

Information is of two kinds, fact and figure. Fact—a pound of something is needed to make a ton of something else, and figure—how much of the chemical was made at some time? Inasmuch as the two are interchangeable, the statistical approach to market

research may be direct or derived. The results are qualified by various factors including acts of Congress, foreign relations, wars, depressions, strikes, lawsuits, and many others.

Examples of Market Researches

Suppose that a small superphosphate plant in Alabama needs new outlets for the by-product, fluosilicic acid, and that the laboratory claims it can make sodium fluoride at a profit to supply the steel industry. Questions immediately arise concerning the extent of the local market and the location of existing suppliers. "Thomas' Register" will yield the names of dealers. For actual producers, the "Buyer's Guide" or the "Green Book" may be consulted. If greater certainty is desired at least two government agencies will be helpful, the Chemical Division of the Office of Domestic Commerce, and the Bureau of Plant Industry at Beltsville, Md. However, as no official statistical information is published respecting production and use, data must be derived. The simplest solution is to set up an equation—how much sodium fluoride is consumed per ton of what kind of steel, and how much of that steel is made in Alabama. Then find the man who knows. Inasmuch as the Iron and Steel Institute is the prime source of these statistics, a member of the technical staff will most likely have the information. Alternatively, the same data are available in the Iron and Steel Division of the Office of Domestic Commerce. The values are equated and the answer can be presented in a one-sentence memorandum.

A maker of fine chemicals may be considering production of diacetyl for consumption in oleomargarine. As costs are favorable in relation to price, the magnitude of the market is of immediate concern. The annual publication, "Synthetic Organic Chemicals," published by the Tariff Commission, promises a quick answer. The chemical is listed, but the amounts made and sold are not given. Oleomargarine is taxed by our Government; the public record will include the tax-dollar return or actual amount. One of the publications of the Bureau of Internal Revenue will provide this information. Unfortunately, it is difficult to identify which publication without some special knowledge; however, the local office of the Bureau of Internal Revenue can supply the answer. It is soon learned that the amount of diacetyl consumed is reported by the Miscellaneous Tax Unit every month and the summary may be found in the semiannual *Cumulative Bulletin* as well as the *Internal Revenue Bulletin*. The investigator's findings may then be condensed into a single table.

Because the figures indicate a growing market of significant size, a rough forecast may be requested. Some consideration must be given the competitive items, butter culture and butter flavor, which are revealed in the same sources. A story is suggested, but the meaning is buried in the technology and politics of oleomargarine. Who will know and be at liberty to tell? Although telephoning is practical, the surest way to find out is to go to Washington. The task is to identify qualified industrial experts. The Miscellaneous Tax Unit laboratory is a logical first choice, followed by the Department of Agriculture. It is soon learned that diacetyl is slowly losing favor with manufacturers, while the trend in government taxation of oleomargarine promises to result in a major production increase in the near future, all efforts of the dairy states notwithstanding. The probabilities are, therefore, that the market for a newcomer is favorable for the near term and unattractive after a few years. The necessary statement of the factors involved concludes the report.

For several years, 1-naphthaleneacetic acid, used especially to control fruit drop, sold at a very high price and so drew the attention of many in the fine chemical business. It seemed to be a profitable item and promised to become more important with time. As the literature included only technical articles and a few comments, some verification of reports was needed. The commercial origin of the compound was the Boyce Thompson Institute for Plant Research at Yonkers, N. Y., an excellent starting place for the investigation. Numerous facts were quickly available—trade channels, royalty for consumption in uses as patented, producers, and approximate amounts made (the latter a guess by inference). Because the chemical was new with a relatively small tonnage, no one in th Government knew much about it. Purchasing agents are invaluable in such circumstances; several in farm cooperatives were consulted. From this type of trade sampling,

production over a 3-year period was approximated, with the conclusion that this interesting organic had seen its best days. This was later confirmed when the price broke sharply and continued to fall.

Perhaps the most difficult task is tracing the cause of commercial failure of a chemical having great paper promise. An actual case has been chosen, although the compound may not be revealed. A patent was issued claiming a use. A number of years later, another member of the industry reviewed the claims made and tested a sample. Value was as stated originally. The immediate concern was the market record or an explanation if none existed. The Tariff Commission publication, "Synthetic Organic Chemicals," and other sources made no mention of the material. It was not for sale anywhere, even in experimental amount. Clearly, there was no commercial record. Upon the assumption that testing laboratories somewhere had tried it, a search was undertaken. The third attempt proved fruitful and the technologist reported that the chemical decomposed rapidly and, as received, was no better than another product selling at one tenth of the price. The second producer undertook a technical investigation which resulted in material for strong patent claims. An economic failure was salvaged from the limbo of forgotten chemicals. The market procedure was the only uncomplicated part of the episode.

These four small chemicals presenting limited areas of inquiry illustrate five broad methods of obtaining market information. The questions were all straightforward and the answers were found by identifying proper authority, whether person or publication. Facts and figures were obtained directly, by inference, and by derivation. Results were expressed as unadorned statements of fact. Figures and conclusions followed inevitably. With major chemicals, the investigator employs numerous techniques, using nearly all possible sources. The amount of data is generally great and the presentation too often becomes complex. Methods remain much the same. The task consists of defining the main problem and then each minor one as it appears, locating the source of information, and obtaining it. As in any other research, the trail must be followed; the answer is always waiting.

Requirements and Definitions

The trail is a logical progression from one source of information to another. Publications of government, trade associations, technical societies, and companies are the dominant sources of both background material and news. The first requirement is to supply the investigator with an adequate library, kept up to date. However, this is impractical. The cost in time and money is prohibitive, the result is unwieldy and clumsy, and the intellectual capacity is unequal to an adequate grasp of the knowledge assembled. The reason soon becomes apparent. With very few exceptions, chemicals are not sold to the ultimate consumer. They are converted into something else, often many times over, and consumed in, and for, all sorts of things. This applies to all industries, from soap to novelties, from fertilizer to fibers, anything and everything. Almost every industry is supplied with chemicals in some form and is of interest to the investigator. To keep informed to such an extent—all segments of the national economy—is too great a task for any group.

A very reasonable compromise, born of necessity, consists in keeping the published record of chemicals as complete as possible while maintaining only rudimentary and orienting references on an industry level. From within the chemical fence, the investigator looks to industrial experts for direction and fact.

Over 7000 different chemicals and dyes were listed during the past few years in "Synthetic Organic Chemicals" as compiled by the Tariff Commission. Producers were given in most cases, while values for production or sales appeared for only 12%. Other government agencies regularly contributed some statistical data for about 1500 different chemicals, including fats and oils, fertilizers, and such raw materials as salt, fluorspar, and zinc oxide. The prime sources were the Department of Agriculture, the Bureau of Mines, the Bureau of the Census, the War Assets Administration, the Office of International Trade, the Office of Domestic Commerce, and the Bureau of Internal Revenue. In

all cases the results were based upon surveys of the producers. This is the great body of official statistics, complete to varying degrees and frequently not published consistently.

Without attempting to define the word "chemical," a smaller and more flexible universe may be considered. This excludes dyes, plastics, resin combinations, fats and oils, and such raw materials as are not converted into specific chemicals of commerce in a single operation. Thus, common salt, pyrites, and propane remain while ores, most metals, and agricultural by-products are eliminated. A serious attempt may be made to obtain all the literature of market interest relating to this true chemical group. Items are not only figures, but they are also statements and observations. The results are shown in Table I.

Table I. Market References to Chemicals[a]

References per Chemical, Monthly	No. of Chemicals in Reference Groups		Total References by Reference Groups	
	Monthly	Annually	Monthly	Annually
7–35	90	90	1040	12,500
2–6	135	135	390	4,700
2	400	1800	325	3,900
Total	600	2000	1755	21,100

In this and subsequent tables references exclude dyes and plastics, but include chemicals for these products.

Table I is a record of the dynamic chemicals—those about which most is being done and about which economic interest is greatest. The first group includes the heavy chemicals, the major aromatics and alcohols, and such compounds as formaldehyde and DDT. Information is complete in nearly all cases: capacities, plants, producers, uses, production, exports, imports, and many others. The second group is mixed—old established chemicals and new ones which are rapidly growing. Toluene and hexachlorobenzene are examples. Data are incomplete and for the most part sketchy. The last group includes chemicals about which there is only an occasional reference—Chicago acid, for instance—and compounds for which there is only a hope of finding a use. In any event, the active market literature relates to relatively few chemicals in comparison with the total. In addition, the citation is given equal value whether it is a figure or a statement having only inferential significance.

Citations exceeding 20,000 annually come from everywhere and range in authority from dependable government figures to the doubtfully valid printed guess. In any case, both must be evaluated. For instance, production of carbon bisulfide is reported by two separate government agencies. One gives the returns of all producers, the other only a fraction. Again, only a portion of the output of tall oil was published by another government agency for several years until members of the industry brought it to the attention of proper authority. Published gossip is often of first importance. Tables II, III, and IV show something of the incidence of market news in terms of source during the past 8 months.

Significance is subject to qualification and definition. For instance, by news is meant the first report of recent occurrences but restricted to items of market interest relating to chemicals as defined herein. A daily is in best position to be first with an account or comment. A publication appearing once a month may note the same thing as soon as possible, but this may of necessity be several weeks later. Recent means most recent in relation to events or statements for the reason that only live news is considered. The chemical survey, as valuable as it is, may thus contribute only a single item. The statement may consist of a single number (obtained from a table) which states the production of some chemical. This has equal value marketwise with some other number taken from the text of an exhaustive article discussing technology. The broad character of the sources, therefore, is in no way defined by the incidence of items, whereas the relative value of the sources cited in the tables is pretty well evaluated in terms of news contributions within the meaning of news as defined.

In looking for news there are two distinct points of view. The first approach is

Table II. Chemical Market Information from Trade Journals[a]

	Citations[b] No. per month	Citations[b] % of total	Publication Frequency	Type of Market Information[c]
Leading six domestic Journals	633	36.1		Major chemicals, some specialties
Chemical and Engineering News			Weekly	All types news
Chemical Engineering			Monthly	All types news
Chemical Industries			Monthly	All types news
Industrial and Engineering Chemistry			Monthly	Most types except foreign
Journal of Commerce (N. Y.)			Daily	All types news except reviews
Oil, Paint & Drug Reporter			Weekly	All types news except reviews
British journals (4)	158	8.9		
Chemistry & Industry			Weekly	Foreign news, uses
Chemical Trade Journal			Weekly	Foreign news, uses
Manufacturing Chemist			Monthly	Foreign news, uses
Soap, Perfumery & Cosmetics			Monthly	Foreign news, uses
Other domestic journals				Consumer industry
Group 1 (9)	8	5.1		
Agricultural Chemicals			Monthly	Uses, new products
American Dyestuff Reporter			Bi-weekly	New products, uses
American Perfumer & Essential Oil Review			Monthly	Uses, consumers
Daily News Record			Daily	Textiles, uses, consumers
Drug & Allied Industries			Monthly	Uses, new products
Drug & Cosmetic Industry			Monthly	Uses, consumers
Food Industries			Monthly	Uses, consumers
Soap & Sanitary Chemicals			Monthly	Uses, consumers
Wall Street Journal			Daily	Major chemicals, some specialties
Group 2 (10)	21.5	1.2		
Chemical Engineering Progress			Monthly	Processes, supplies, uses
Chemical Processing			Monthly	Consumers, uses
Drug Trade News			Bi-weekly	Consumers, new products
India Rubber World			Monthly	Uses, new products
Industrial Equipment News			Monthly	Uses, consumers
Modern Packaging			Monthly	Uses, consumers
Modern Plastics			Monthly	Consumers, new products, uses
Products Finishing			Monthly	New products
Rubber Age			Monthly	Uses, consumers
Tide			Weekly	Marketing, uses
Group 3 (14)	7	0.4	Various	Mostly uses
Total (43)	908	51.7		

[a] Selection of items is representative of one market research group. Incidence will vary according to personnel factor, total of journals examined, and interval selected—for example, over 50 during period July 1949–50 as in survey herein described.
[b] Relative value of items is not necessarily indicated.
[c] Broadly descriptive of citations included in survey; not in any way descriptive of total content of journals.

Table III. Other Sources of Chemical Market Information[a]

	Citations No. per month	Citations % of total	Type of Market Information
House publications	5.4	0.3	
American Cyanamid Co.			Chemicals: new, uses
Celanese Corp. of America			Chemicals: new, uses
Eli Lilly Co.			Pharmaceutical chemicals
Esso Standard Oil Co.			Petroleum products: new, uses
Givaudan-Delawanna, Inc.			Cosmetic chemicals
Monsanto Chemical Co.			Chemical products: new, uses
Tennessee Eastman Corp.			Chemicals: new, uses
Other (15)[b]			Specialties: new
Society and technical journals[c]	10	0.6	Chemical research: promising new uses
Financial sources	37	2.1	
Standard and Poor's	32		Producer activity, news
Corporate prospectuses	4		Producer activity
Corporate annual reports	1		Producer activity
Total (40)	52	3.0	

[a] Most productive sources of market information are cited by groups; based on period July 1949–February 1950; qualifications stated in Table II also obtain.
[b] Carbide and Carbon Chemicals Corp.; Linde Air Products Co.; Foote Mineral Co.; Dow Chemical Co.; Borden Co.; Crown Cork & Seal Co.; Koppers Co.; Foster D. Snell, Inc.; Minnesota Mining & Mfg. Co.; Solvay Sales Div.; National Distillers Co.; Hercules Powder Co.; Mathieson Chemical Corp.; Philadelphia Quartz Co.; Mefford Chemical Co.
[c] *Science* (A.A.A.S.), *Economic Botany* (N. Y. Botanical Garden), *Tappi* (Technical Assoc. of Pulp & Paper Industry), *Contributions of Boyce Thompson Institute of Plant Research*, *American Journal of Botany* (Botanical Society of America), Annual Report of Mellon Institute for Industrial Research, *The Chemist* (American Institute of Chemists), etc.

focused upon the chemical and everything that follows—production, producers, consumption, consumers, foreign trade, capacity, uses, regulations, and controls. The obvious sources are those which treat chemicals as proper subjects, a rich field. However, the weakness lies in the areas of use, new and competitive, and anticipated consumption

rates by industry. The second approach is supplementary. It consists in following the literature which relates to specific industries—cosmetics, petroleum, soap. These industries are interested in how to make their products better, the extent of the market, and prospects. They are, therefore, interested in all chemicals constituting the supply as well as by-products. Sources of information are extremely diverse.

Domestic Journals

The contents of *Chemical and Engineering News* are well known. The *Oil, Paint & Drug Reporter* is perhaps unique. This weekly records general news of most kinds. It reports on chemicals by departments. This means that stress is placed upon editorial comment and trade opinion on both industry and specific chemical levels. Summaries of recent events appear also, but accounts are short and in newspaper style. Chemicals are but one interest of the *Journal of Commerce*, and treatment is not so systematic. News summaries, when they appear, are often more detailed. Both the chemical and industry aspects are given. The other members of the leading six journals (Table II) are

Table IV. Chemical Market Information from Government Sources[a]

	Citations			
	No. per month	% of total	Publication Frequency	Type of Market Information
Economic Cooperation Administration	166	9.4		All chemicals
Small Business Circulars	15	..	Periodic	Foreign buying
Releases	128	..	Periodic	Foreign purchase plans
Commodity Supplier Data	23	..	Periodic	Foreign transactions under ECA
Bureau of Internal Revenue	2	0.1		
Internal Revenue Bulletin	0.3	..	Bimonthly	Chemicals in oleo
Alcohol Tax Unit		..		
Statistics, ethyl alcohol	1	..	Quarterly	Detailed information
Uses, ethyl alcohol	0.5	..	Annually	Detailed information
Facts for Industry	74	4.2		
Tariff Commission				
Series 6–2, synthetic organic chemicals		..	Monthly	Production, 41 chemicals
Series 6–10, synthetic plastics		..	Monthly	Production and sales
Bureau of the Census		..		
Series M19A, inorganic chemicals		..	Monthly	Production, 36 chemicals
Series M17-1, fats and oils, production		..	Monthly	All; production, consumption, stocks
		..		
Series M17-2, fats and oils, uses		..	Monthly	All
Series M13B, softwood plywood		..	Monthly	Includes consumption of glues
Private publication		7.6		
U. S. Government Advertiser	133	..	Weekly	Government; bids, awards, etc.
Government Printing Office		..		
U. S. Government Publications, catalog	0.6	..	Monthly	All government publications listed
Bureau of the Census	162	9.2		
Census of Manufactures, 1947	16	..	One time	Printing by groups
Foreign Trade Statistics Notes	1	..	Monthly	News and regulations
FT 110, 410—imports, exports	145	..	Monthly	Statistics only
Office of International Trade	223	12.7		
Foreign Commerce Weekly	112	..	Weekly	News and statistics
Current Export Bulletin	58	..	Periodic	Export quotas and news
World Trade in Commodities	52	..	Periodic	Reviews by product and country
Other releases	1	..	Various	Foreign news
Office of Domestic Commerce		0.6		
Industry Reports	10	..	Monthly	General statistics, reviews, news
Department of Commerce		..		
Business Service Checklist	0.5	..	Weekly	Brief abstracts of Dept. Commerce publications
		..		
Department of Agriculture	2	0.1		
Bureau of Agricultural Economics		..		
Fats and Oils Situation	0.4	..	Monthly	News, statistics
Naval Stores Report	0.5	..	Quarterly	Review, statistics
Casein	1	..	Monthly	Production
Bureau of Mines	17	1.0		
Monthly Coke Report	4	..	Monthly	Statistics
Monthly Petroleum Statement	1	..	Monthly	Statistics
Mineral Industry Surveys	4	..	Various	Statistics, review
Monthly Lead Report	1	..	Monthly	Statistics
Information Circulars	0.8	..	Periodic	Reviews, statistics
Releases	0.3	..	Periodic	
New Publications	0.3	..	Monthly	Brief abstracts
Reports of Investigations	2.5	..	Periodic	
Preprints (of Yearbook)	3	..	One time	Reviews, statistics
Congress of the United States		0.2		
Hearings (House, Senate)	3	..	Periodic	Highly variable
Other[b]	3.5	0.2	Mostly one time	
Total (46)	796	45.3		

[a] Most productive sources of market information cited by government agency, except *Facts for Industry;* based on period July 1949–February 1950; qualifications as noted in Table II also obtain.
[b] Includes other publications of minor value of cited branches of Government; also "Annual Report" of Tennessee Valley Authority.

primarily concerned with chemicals and nearly all aspects of them. Included are descriptions of methods, technology, reports of conventions, general economics, lists of publications, prices, reviews—anything of interest to the chemist and chemical engineer. Each has its field of stress, but reports on an industry level are relatively uncommon

To supplement the information, especially respecting uses, 37 additional journals contributed items during the 8-month period, July 1949 to February 1950. These publications were almost entirely restricted in appeal to some specific industry.

Table III presents a heterogeneity of sources. House publications often contribute invaluable information respecting new chemicals, uses, and plant construction. The Society and technical journals are often first with the news. The difficulty is to separate the theoretical from that having economic promise. The publications of standard and Poor's or Moody's relate to corporations and products. These sources contribute much of corporate plant activities as related to chemicals. Corporate prospectuses and annual reports as submitted to the Securities and Exchange Commission bring the data to a producer level.

The major journals of greatest circulation must present that information which is of greatest interest to most readers. Such chemicals are easily named: soda ash, caustic soda, the mineral acids, benzene, phthalic anhydride, aniline, phenol (90 are given in Table I). About 59% of all market news relates to these 90 chemicals. Almost any three of the ten leading journals will contribute information on most of them. The industry report of the Office of Domestic Commerce, *Chemicals and Drugs*, and the *Facts for Industry* series of the Tariff Commission and the Bureau of the Census will also contribute information.

To obtain a representative amount of news relating to the second chemical group of 135 members means an expansion of sources, while still retaining the six already selected. The very nature of these chemicals implies this—sodium fluoride, *p*-dichlorobenzene, oleic acid, oxalic acid, and some of the barbiturates. Consider sodium fluoride. It is used in toothpaste, insecticides, water treatment, and steel manufacture. Usually, the first, best, and only accounts are to be found in the journals which appeal to these specific trades: *Drug and Cosmetic Industry*, *Water Works Engineering*, *Steel*. The first reference to the application in steel appeared in 1944; in 1949 this item was requoted by one of the leading six journals (Table II). By any definition, this is not news. If it is wanted, for this group of chemicals most sources specified in the tables must be used. The library expands.

Finally, there remain specialty and the new chemicals, contributing less than 20% of the total information. For this relatively small share, no source may be disregarded. Trade journals, house organs, society publications, and government publications contribute over half. A tremendous amount of reading is necessary to ensure that nothing is missed. There is no doubt respecting value. Each new or specialty chemical may be an outlet for another chemical which is a raw material or processing agent. They are opportunity chemicals; the industry grows because of them. Failure to keep up to date means loss of potential business. The widest library of current market sources is a modern imperative.

Government Publications

The government publications constitute the great body of statistical information on production, consumption, sales, foreign trade, stocks, foreign news, reviews, and trade comment. In Table IV, an attempt is made to describe each citation in a few words. However, the comments relate only to the major content of market interest. An approximation of the citations was made by sampling about 10% of the record with the following result:

Statistics only (official)	26%
Domestic (including *U. S. Government Advertiser*)	14%
Foreign (including domestic exports and imports)	12%
News items only (unofficial statistics and statements)	74%
Domestic (predominantly from the trade)	53%
Foreign (mostly from government sources)	21%

Most items can be reduced to figures and, sooner or later, are expressed as such. Official numbers are regarded as statistics and are reported by the *Facts for Industry* series, and the monthly citations of exports and imports. If a trade journal states, "it is believed that a million pounds of X will be made in year Y," it is a statement. If the journal states "the million pounds is said to have been made in year Z", it is an unofficial statistic, although classified as a news item. The classification is inadequate and arbitrary. In any event, the character of news for the 8-month period is not necessarily typical. The relative importance of foreign items is subject to radical change in the future just as it has been in the past. Contributions of the government have never been as great as in the past few years. This trend promises to continue in spite of threats of budget curtailment.

There are several other valuable sources of information, the most important of which are the *Industry Reports* of the Office of Domestic Commerce, hearings of the Congress of the United States, the several established commissions of the Congress, and actions of the Antitrust Division of the Department of Justice.

The Office of Domestic Commerce releases at regular intervals of a month or two *Industry Reports* relating to almost all commodities. Those of greatest interest to the chemist are *Chemicals and Drugs*, *Rubber*, *Sugar*, *Leather*, and *Fats and Oils*. These are not prime sources; they are mostly review sources. Statistics of production, imports, exports, and value relating to several hundred chemicals appear regularly together with a summary of the present trade situation, prospects for new supply, foreign news, and government actions. In addition, official surveys of specific chemicals appear every month. *Chemicals and Drugs* represents an invaluable source of information highly concentrated in one place.

The two prime sources of statistics relating to fats and oils are *The Fats and Oils Situation* of the Department of Agriculture and *Canned Fish and By-Products* of the Fish and Wildlife Service. The latter gives production of oils obtained from fish and marine mammals together with such by-products as kelp products, agar, and glue. *The Fats and Oils Situation* is rich in comment, news, and statistics.

For exhaustive reviews relating to chemicals, it is difficult to surpass the publications of the Tariff Commission. For instance, the "Tariff Hearings" of 1929 and 1947 are indispensable sources of information; the "Trade Agreement Digest" which appeared in November 1946, and the "Summaries of Tariff Information" made available 2 years later are unique in the statistical literature.

Of a more specialized nature and on a company level are the prospectuses and registrations reported to the Securities and Exchange Commission. All are within the public domain and are available to all at the offices of the commission. The information is entirely reliable and will vary from complete descriptions of the operations of a corporation and plans for the future to rather cryptic and nebulous statements from the viewpoint of chemical interest. Often operations are noted for the first and only time in these documents. The Rohm & Haas Co. prospectus is a case in point.

Congressional hearings are perhaps the most difficult and trying of all reading. It takes something of an expert to obtain them and then secure the wheat from the chaff. The task is obligatory, for again the chemical story is often revealed for the first time. For instance, if one is interested in ethyl alcohol, the current "Gillette Hearings," available only in transcript, are invaluable as a review of events, tentative plans, and statistics. The "Bone Hearings" of 1942 form much of the background for many of the antitrust cases now pending; they are classics of their kind relating to a long list of chemicals. The "Kilgore Hearings" of 1944 are comparable. There is almost no limit to this type of source. It is unfortunate that a thousand pages only too often yield only an item or two of value. Just as often, the value is beyond price.

The actions of the Antitrust Division and of the Federal Trade Commission are also part of the public record. All documents relating to a case, whether pending or adjudicated, are available in the court of trial. A complete list of antitrust cases was published by the Commerce Clearing House, Inc., January 15, 1947, under the title, "The Federal Antitrust Laws." This is the only known index available and gives abstracts of all cases

together with the court of record. Using this as a key, the dockets may be examined at the court or, if available, at the docket room of the Antitrust Division in Washington or district offices. As the Federal Trade Commission is its own court, its docket room encompasses the complete record of past and present activity. In addition, the trial attorneys are available to discuss some of the cases.

Foreign Journals

Perhaps the greatest changes are to be anticipated in the foreign journals. At present only four contribute significantly to the market news; all are British: *Chemical Trade Journal, Manufacturing Chemist, Chemistry and Industry,* and *Soap, Perfumery, and Cosmetics.* Others which present commercial items are the *Chemisch Weekblad* of Holland, *Chimica Industria* of Italy, *L'Industrie Chimique Belge* of Belgium, and *Canadian Chemistry and Process Industries.* Germany is now publishing two major journals of this type, *Chemiker Zeitung,* and *Chemie Ingenieur Technik.* Also of interest are the *South African Industrial Chemist, Chemia* of Argentina, *Gazetta Chimica Italiana,* and *Chemistry in Canada.*

These periodicals undoubtedly will assume greater importance for the United States in time. This is dependent upon two factors at least. Foreign lands must succeed in reestablishing or creating significant chemical and chemical-consuming industries and once more become active in research and development. Also, the reports from government sources must be sharply curtailed; this is unlikely to occur in the immediate future. At present the United States is the acknowledged world leader in chemicals. Great Britain is active and consequently the British journals are newsworthy. Except for the British journals, government publications supplemented by the domestic trade journals appear to be entirely adequate for chemical market research.

Summary

The sources outlined herein are those which contributed items of market interest to the domestic chemical economy during the 8-month period, July 1949 to February 1950. This period was chosen because it was recent and the examination of publications was both broad and consistent. Undoubtedly, a similar examination of the available literature for some other period in the past or future will show changes. Not only may the relative importance of the generic sources change but the relative importance of the specific publications. Some will drop out; others will be added.

Chemical market news is where you find it—and you find it everywhere. The statement that it is possible to keep up to date with most of the chemicals by exhaustively reading a half dozen or a dozen publications is not true. The 17% of the total news represented by 115 sources is, very conservatively, of equal value to the 83% contributed by the 15 or so sources of greatest numerical significance.

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Chemical Trade Literature and Its Usefulness

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Much of the available information concerning chemical raw materials and derived products, as well as that concerning equipment of interest in the chemical field, cannot be found in the normal scientific or technical literature. Instead, it must be sought in various manufacturers' releases and related types of information loosely grouped under the designation of technical trade literature. The types of literature and the problems and techniques associated with obtaining and using it are analyzed in detail.

Expansion of the American chemical industry and the increasing diversity of its markets have led to the organization and growth of numerous companies supplying an increasingly large number of raw materials of varying degrees of purity, and formulated products. Such derived products, including widely varying items such as inks, adhesives, pigments, coatings, pharmaceuticals, cosmetics, solvents, insecticides, surface-active agents, plasticizers, ceramic compositions, corrosion inhibitors, sanitary supplies, foundry sands, hydraulic fluids, textile treating agents, insulating materials, lubricants, and leather chemicals, have multiplied rapidly. It is logical, therefore, that concurrently there has developed a great and increasing demand for technical information concerning these raw materials and finished products, as well as for methods and equipment for processing them.

Until a relatively few years ago the volume of technical trade literature was relatively small. A few pioneering companies such as the R. T. Vanderbilt Co. and the Du Pont Co. issued mimeographed or printed bulletins or trade releases at regular or irregular intervals. These contained a variety of useful information from specific information concerning the publishers' products and their properties or applications to general engineering data.

The consumer of chemicals or of chemically derived products has been confronted during the past 15 years with an ever increasing number of materials which are presented for his attention. The advertising and promotion of these chemical products are, on the whole, conservative. Nevertheless, the chemical consumer is bound to feel bewildered by all the claims made for various competitive materials. It is only natural that he should attempt to secure some definite information concerning new raw materials before he undertakes to work with them. The same holds true with regard to equipment used with these materials.

It is obviously impractical for each consumer to obtain in his own plant or laboratory all the basic information concerning each material, process, or piece of equipment. Consequently, leading suppliers started supplying such information, and their competitors soon began imitating the practice. At the present time a veritable contest is taking place in certain fields to see who can supply to the customer more information, or better data, or a prettier package for it. This literature is supplied by trade associations and government agencies as well as individual companies.

Types of Trade Literature

There is one significant difference between technical trade literature and the orthodox or formal chemical literature found in the scientific journals and publications. Although the usual scientific book or article is written for a somewhat limited audience, it is given as wide distribution as the sale of the publication will permit, and it may be promoted heavily by the publishing house. Furthermore, copies of it will be available in various public and other libraries, depending again upon the subscription or sale of the particular publication. In addition, it may be abstracted in *Chemical Abstracts* or other abstracting services. It will be indexed in numerous places and photographic or other copies of it will be available through various channels if the reader does not have direct access to an original copy.

The published commercial technical literature, however, does not usually fit any of the above specifications. It is usually distributed gratis to a select audience. Few libraries will normally obtain copies and some of these will not be filed or indexed. It is seldom abstracted or indexed in the usual places. There is often no satisfactory method for the searcher to learn that such a publication exists. If he does learn that there is such a publication, its content may not be indicated.

The following descriptions and examples represent several distinct types of technical trade literature:

1. General trade journals in various fields, some sold on subscription

Electrical Manufacturing	*Iron Age*
Paper Trade Journal	*Food Industries*
Rubber Age	*Soap and Sanitary Chemicals*
Modern Plastics	*Ceramic Industry*
Oil and Gas Journal	*Textile World*

Others distributed gratis on controlled circulation basis

Chemical Processing	*Steel Processing*
Graphic Arts Monthly	*Plastics World*
Drug and Allied Industries	*Production Equipment*
Pipe Line News	*Quick Frozen Foods*
Packaging Parade	*Organic Finishing*

2. Regular technical publications issued by suppliers and sent gratis to consumers (one illustrated in Figure 1)

Synthetic Organic Chemicals (Eastman Kodak)
Chemist-Analyst (J. T. Baker Chemical)
Activator (N. J. Zinc)
Lubrication (Texas Co.)
Columbian Colloidal Carbons (Columbian Carbon)
Compounding Research Reports (Naugatuck)
Lead (Lead Industries Association)

3. External house organs of more general character

Dow Diamond (Dow Chemical)	*Interchemical Review* (Interchemical)
Royle Forum (John Royle and Sons)	*Research Today* (Eli Lilly)
Plastic News-Front (American Cyanamid)	*By Gum* (Reichhold)
Witcombings (Witco Chemical)	*Givaudanian* (Givaudan-Delawanna)

4. Regular catalogs issued by suppliers of materials and equipment, some containing extensive technical information (two illustrated in Figure 1)

Knightware Chemical Equipment (Maurice A. Knight)
Industrial Alcohol (U. S. Industrial Chemicals)
Industrial Insulation (Philip Carey Mfg. Co.)
Special Steels for Industry (Allegheny Ludlum Steel Corp.)
Industrial Chemicals (Commercial Solvents)

5. Books, both bound and loose-leaf, dealing with special products or subjects (two illustrated in Figure 1)

Hycar Blue Book (B. F. Goodrich Chemical)
Canned Food Reference Manual (American Can)
Marine Lubricants (Shell)
Vistanex Compounding Manual (Enjay)

Figure 1. Examples of Books, Catalogs, and Regular Company Technical Publications

6. Printed bulletins of less than book size dealing usually with limited subjects (illustrated in Figure 2)

Philblack Bulletins (Phillips Chemical)
Titanox Pigments (Titanium Pigment Corp.)
Plasticizers (Tennessee Eastman)
EPI-Resins (Jones-Dabney)
Neo-Fat (Armour)
GR-S Latex, Type V (Rubber Reserve)
Dow-Corning Fluids (Dow-Corning)
Vinylite Resins-Dispersion Coatings (Bakelite)
Cabot Pine Products (Godfrey L. Cabot)
Cardolite Resins (Irvington Varnish)
Oils Chart (Archer-Daniels-Midland)
Application of Synthetic Tanning Materials to Leather (Rohm & Haas)
Pliolite S-5 (Goodyear)
Why Glycerine for Textiles (Glycerine Producers Association)
Newport Zinc Resinates (Newport Industries)
Armstrong Steam Trap Book (Armstrong Machine Works)

7. Unbound announcements of one or more pages covering practically all companies and products

Stamford "Factice" Vulcanized Oil Solutions (Stamford Rubber Supply)
Harflex Plasticizers for Vinyl Plastics (Binney and Smith)
Corpolin—Hygroscopic and Plasticizing Agent (Heyden)
Diamond Chlorowax Manual (Diamond Alkali)
Petrolite Emulsifiable Waxes (*Petrolite*)
Furfural (Quaker Oats)
Dicalite Filtraids (Dicalite)

8. Advertisements or copies of them, especially those appearing in trade journals

Victor Chemical Works
Hardesty Chemical Co., Inc.
Ohio-Apex, Inc.
Celanese Plastics Corp.

9. Wall charts presenting a variety of useful information and supplied by a large number of companies. Also informative types of calendars, blotters, notebooks, and similar promotional material
10. Letters of transmittal or answers to inquiries, often the sole source of information concerning a given subject
11. Internal reports of interviews with salesmen, conferences, phone conversations

Some of these types of literature present only limited information. Others, however, are very elaborate. Many of the house organs and books or bulletins published directly by various companies are extremely well edited and profusely illustrated with charts, photos, and cartoons. (Items 1, 10, and 11 in the foregoing list are borderline cases; they represent substitutes for technical trade literature as it is normally considered.)

In addition to these direct sources, there may be available to the searcher abstracts of any of these types of trade literature. The regularity of occurrence and location of such abstracts are variable, depending upon the particular subject involved. Sometimes an individual or a library will prepare abstracts or bibliographies within a limited or specialized field and these may then be utilized by the searcher within the organization.

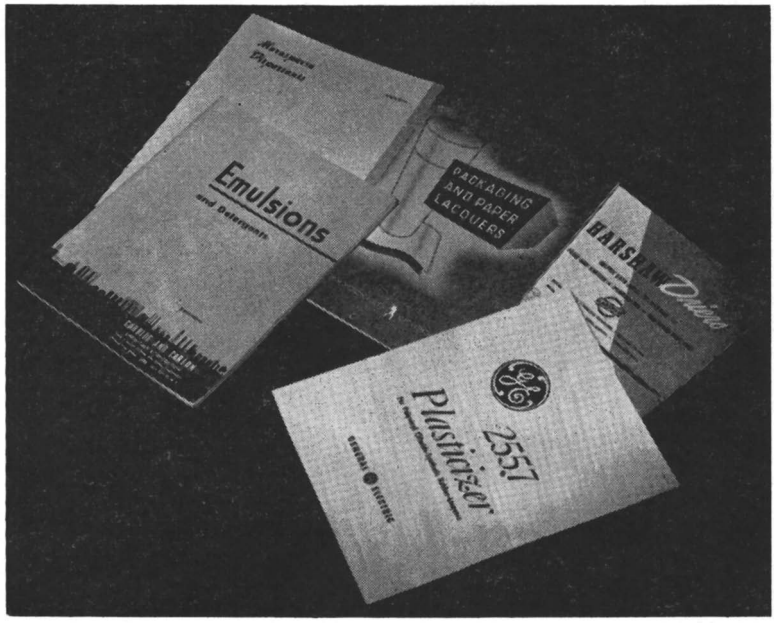

Figure 2. Typical Bound and Printed Bulletins on a Variety of Subjects

In some fields the trade journals prepare and publish abstracts of pertinent information within the field including a certain amount of technical trade literature. At least one specialized abstracting service (the *Summary of Current Literature*, a British publication devoted to the subjects of rubber and related fields including plastics) includes abstracts of appropriate technical data or information appearing in advertisements. The *Industrial Arts Index* and *Chemical Abstracts* will frequently report data appearing in trade journals and similar types of publications.

Obtaining Trade Literature

The searcher for technical trade information may have available files and library shelves as a starting point. However, frequently his problem involves some new type of information which is unlikely to be on hand, or the data on hand may be incomplete. In these instances the first objective is to learn the identity and source of literature which should contain the desired information.

One of the most satisfactory methods is a direct request to companies which are known to manufacture or sell the products in which the searcher is interested. The names of such companies may already be known to the searcher or to the personnel of his purchasing department. Otherwise, listings of appropriate companies can be found in catalogs and directories such as "Thomas' Register," "Chemical Engineering Catalog," "Chemical Industries Buyers Guide," "Green Book of the *Oil, Paint, and Drug Reporter*," "Modern Plastics Encyclopedia," "Rubber Red Book," "Post's Paper Mill Directory," and numerous other specialized reference books issued chiefly by trade journals at regular intervals. Actual copies of many catalogs can be found in "Sweet's Catalog File." At least a representative selection of such sources should either be in or readily available to every laboratory. Another valuable source of names of appropriate companies is the advertisers in various trade journals and magazines, especially those specializing in the field in question. Most companies advertise on a definite schedule but not necessarily a consecutive one; consequently, several issues should normally be consulted. The trade publications are also valuable as sources of announcements of new products or services, even when the company in question is not an advertiser. Recently a number of magazines have featured an inquiry card, whereon the busy reader may check the items on which he desires further information and the journal does the rest. A recent issue of a leading magazine in the chemical field listed 396 items which the reader could request. This service is a useful one, but frequently the use of such inquiry cards from several magazines leads to a duplication of requests, owing to inadequate descriptions. This is more often the fault of the company which released the product news than of the periodicals.

Salesmen will frequently leave technical information or arrange to have it sent. Company policies vary widely. Some distribute information widely, both by mail and by sales contacts. Others prefer to have all their literature distributed by their representatives, on the premise that they can get a better idea of the needs or problems of the customer. The salesman or technical representative will determine what literature should be furnished. In some instances this policy of direct contact is part of an attempt to control the use of the product. Some companies are so anxious to protect certain customers that they are extremely reluctant to distribute technical information to others. Some even protect exclusive customers by signed agreements limiting the type of usage of their products. Others often require the purchase order to state the end use of the material being purchased.

Those in attendance at conventions and trade shows are frequently afforded an opportunity to pick up literature in connection with exhibits. Many companies which issue technical bulletins and other literature will, on request, place the reader's name on a regular mailing list to receive material automatically as it is issued. Sometimes the lists are classified so that the individual recipient is sent only information which is of specific interest to him. Some of these mailing lists are seldom revised, whereas other organizations send out check-up cards every few months.

Some companies do not publish any standard data sheets or bulletins but prefer instead to furnish the appropriate information by letter. This is especially true with regard to experimental samples or products. Some firms claim that their lines change so rapidly that any standardized information would become obsolete soon after distribution. Still other companies send out samples and literature without any hint to the customer that the sample represents only pilot plant production. Furthermore, frequently these same materials are removed precipitously from the market at a later time without any announcement to the numerous people who have the literature in their files or who have actual samples of the material. The author has found literature in active files concerning products which had been removed from sale several years previously.

Searching the Files

Most people read or note technical trade literature as it is received. Some then discard it, whereas others cram their own desks or files with those items of interest to them. Some material is routed to associates, in which case it may readily get lost along the line, depending upon the diligence with which these people read it and send it along. Fre-

quently it takes a long time for the literature to make the rounds. It takes only one nonconscientious reader or one person out of town for a prolonged period to upset the entire sequence. Eventually the literature, if not intercepted or discarded earlier, reaches a central file or library. It is there and in the personal files and mail baskets of his associates that the searcher must usually look for the information.

Books and regularly published house organs do not present much of a problem. They will usually be located in the same area as the regular or orthodox literature. If the library is large enough, they will probably be catalogued by subject and author, if any, in the usual manner. This will be true especially in company libraries, where the volume of such material is likely to exceed that found in the public-supported libraries. Some city or university libraries will contain valuable publications of this general type, especially on subjects of local interest.

Printed and mimeographed bulletins and data sheets of smaller size are much more difficult to locate. Partly because of their size, they are more likely to be lost. Furthermore, whereas books and large bulletins are logically sent to or placed in a relatively public location, single sheets or small bulletins are more likely to be placed in an individual's files and are thus less accessible, generally. Material in this classification is almost never found in a public library.

Letters, reports, and memoranda will normally be located in their appropriate spot in the files and the relative ease or difficulty of locating them will be a function of the adequacy of the filing system and the skill with which the filing is done. Such material is usually not found in a public library.

A well-organized filing system greatly facilitates the search for information. If information is missing from an orderly file, the searcher has a reasonable basis for assuming that it is not in the file, and for continuing his search elsewhere. Many companies, both large and small, do not possess a well-organized system. In addition, the actual filing is frequently entrusted to inexperienced or untrained personnel, with the result that information is frequently easier to find outside the file than inside it.

The type of filing system employed is important in determining the availability of information to the searcher. Some companies file everything under the company name and may segregate these into categories such as suppliers and customers. Frequently the technical data sheet, bulletin, or other item of trade literature is not accessible to the searcher who does not know the name of the company manufacturing the product or providing the service in question.

On the other hand, a functional type of filing system is not adequate for handling the heterogeneous information found in much technical trade literature. Many bulletins, memos and letters are devoted to a single subject and are thus easily indexed in a functional system. An equally great number, however, are devoted to more than a single subject and are not readily filed or located in a functional file unless a satisfactory cross-indexing system exists and the custodians of the file are gifted with an appropriate amount of imagination.

Conclusions

There exists a large body of useful information within the general field known as technical trade literature. A large amount of this information is not duplicated elsewhere in the chemical literature and much of it is current, especially information concerning materials, processes, and applications of relatively recent origin. The acquisition and use of the information involve specialized techniques and many unusual problems. The searcher for technical data from these sources must be willing and able to look widely in libraries, files, and other likely locations and to engage in a considerable amount of correspondence. The success of the quest for information will frequently depend upon the imaginative resources and perseverance of the searcher.

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FIAT Review of German Science

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The FIAT Review of German Science covers the period of years 1939–46. It was compiled by German scientists with the assistance of the Military Governments of the British, French, and American zones of occupied Germany. A complete list of titles and authors is given, and types of references, content, and distribution are discussed.

A discussion of the Field Information Agency, Technical (FIAT) Review of German Science is appropriately a part of a Symposium on Searching of Chemical Literature, for the reviews cover a period of years, 1939–46, during which the normal interchange of scientific information was seriously disrupted. In addition, it is only recently that practically the whole series of volumes has been completed in printed form and has become available to scientific libraries.

Early in the postwar investigations of German industries, it was realized that the results of many fundamental scientific researches carried out during 1939–46 in Germany were liable to be lost, owing to the forced termination of scientific publications and dislocation of personnel. Even those results which had been published were not of full value because of limited availability. The need for some plan to circumvent these difficulties was recognized and the proposal was made that rather comprehensive reviews in the physical and biological sciences be compiled by the German scientists themselves, because they were the most familiar with the phases which should be covered. This plan was received with great interest by the German scientists and accordingly was carried out under the auspices of, and with the assistance of the Military Governments of the British, French, and American zones of occupied Germany. Direct responsibility for this program was that of the scientific branches of the Field Information Agency, Technical organizations of Great Britain, France, and the United States.

Titles and Authors

The success of this undertaking exceeded expectations. In all, the review series comprises 84 printed volumes of approximately 200 pages each, covering 47 separate fields of physics, chemistry, medicine, mathematics, biology, and sciences of the earth. The following is a complete list of major titles with notation of the number of parts or volumes of each title. Eighty-two of the 84 volumes have been published; Volume VI of "Inorganic Chemistry" and one other are yet to appear.

Physics

Nuclear Physics, Cosmic Rays (I and II). W. Bothe and S. Fluegge
Physics of the Electron Shells of Atoms and Molecules. K. Kopfermann
Physics of Solids (I and II). G. Joos
Physics of Liquids and Gases. E. Kappler
Hydro- and Aerodynamics. A. Betz
Electronics Including Fundamental Emission Phenomena (I and II). J. Goubau and J. Zenneck

Geophysics and Geodesy (I and II). J. Bartels
Meteorology and Physics of the Atmosphere. R. Muegge
Astronomy, Astrophysics and Cosmogony. P. ten Bruggencate
Biophysics (I and II). B. Rajewsky and M. Schoen

Chemistry

Inorganic Chemistry (I to VI). W. Klemm
Analytical Chemistry. W. Klemm
Physical Chemistry. K. Clusius
Theoretical Organic Chemistry (I and II). W. Hueckel
Preparative Organic Chemistry (I to III). K. Ziegler
Biochemistry (I to IV). R. Kuhn
Pharmacology and Toxicology (I to III). F. Eichholtz
Chemotherapeutics. F. Schoenhoefer
General Metallurgy. M. Hansen
Nonferrous Metallurgy (I and II). M. Hansen

Mathematics

Pure Mathematics (I and II). W. Suess
Applied Mathematics (I to V). A. Walther

Medicine

Internal Medicine (I and II). R. Schoen
Paediatrics. H. Kleinschmidt
Neurology (I to III). G. Schaltenbrand
Psychiatry. E. Kretschmer
Tropical Medicine and Parasitology. E. G. Nauck
Hygiene, Including Preventive and Industrial Medicine, Epidemiology (I to III). E. Rodenwaldt
Surgery, General and Special. K. H. Bauer
Obstetrics and Gynecology (I and II). H. Martius
Radiology, Diagnostic and Therapeutic. H. Holthusen
Physiological and Pathological Chemistry Including Nutrition. E. Lehnartz
Pathology (I to IV). F. Buechner
Bacteriology and Immunology. H. Schmidt
Virus Diseases of Man. R. Bieling and H. Heinlein
Physiology (I to III). H. F. Rein
Anatomy, Histology, and Embryology. P. Stoehr

Biology

Biology (I to IV). E. Buenning and A. Kuehn

Sciences of the Earth

Geography (I to IV). W. Tuckermann and H. v. Wissmann
Geology. L. Rueger
Mineralogy. H. Steinmetz
Petrography (I to II). K. H. Scheumann

The names opposite the titles are those of the senior authors. They alone did not do the entire compilation but were free to select co-authors competent to cover more limited phases of the field. This collaboration greatly expanded the scope of the reviews, and several hundred German scientists contributed, each in his particular specialty. Each of the senior authors is eminent in his field, as are the co-authors, and the integrity of the reviews reflects that of the authors. The reviews as printed have not been rewritten, censored, or edited by anyone but the authors themselves.

In format, the reviews follow that of already familiar publications based on senior author and co-author compilation. With minor deviation, standardization similar to Gilman's "Organic Chemistry—An Advanced Treatise," the annual reviews of the Chemical Society, and the *Chemical Reviews* was adopted. Each volume has a table of contents (printed in French, English, and German, the only multilingual part—the text is in German language) and each chapter or subdivision of a volume has its table of

rung der Kapillarresistenz durch Citrin und andere Flavone (Hesperidin, Heperetin, Quercitrin, Quercetin, Eridyctol, Rhamnetin) beim. berichtet KOHL[949] über Erfolge mit Citrin.

[939] H. J. KÖHLER, Dtsch. zahnärztl. Wschr. **1939**, 773.
[940] A. SÜSSENGUTH, Pharmaz. Ind. **9**, 221 [1942].
[941] L. KROEBER, Pharmaz. Ind. **9**, 6 [1942].
[942] E. W. LEXER, Dtsch. Z. Chir. **258**, 602 [1942].
[943] O. LUDWIG, Med. Welt **1942**, 1181.
[944] F. BOCK, Klin. Mbl. Augenheilk. **109**, 531 [1943].
[945] K. KAETHER u. P. SLANY, Z. klin. Med. **137**, 702 [1940].
[946] E. F. SCHÄBER, Münchener med. Wschr. **1941**, 986.
[947] H. HÜLLSTRUNG u. K. HACK, Dermatol. Wschr. **117**, 447.
[948] H. HÜLLSTRUNG u. K. HACK, Z. Immunitätsforsch. exp. Therap. **103**, 327 [1943].
[949] H. KOHL, Mschr. Kinderheilk. **86**, 273 [1941].

Figure 1. Methods of Listing References, "Pharmacology and Toxicology," Part I, Vitamins, Page 137

contents. Depending on the desires of the senior author, a conventional decimal system was superimposed upon these sections and integrated with the text. Author and subject indexes are also included. They appear in the last volume of a given major field where multiple volumes have been printed.

References

There are two methods of referencing, both of which are orthodox. Some authors chose to list the references at the bottom of each page and to number them serially throughout the volume subdivision. Others collected them at the end of the subdivision after annotating them in the text. In this respect, the medical series deviates even further and sometimes has an entire reference list serving the added role of an author index.

RAMANSPEKTREN UND ORGANISCHE ANALYSE

Technische Einzelheiten wie Empfindlichkeit des Nachweises, Zeit- der RAMAN-Spektralanalyse als ergänzende Untersuchungsmethode von Ölen aller Art dürfte durch die bisherigen Versuche erbracht sein.

Die absolut notwendige Grundlage der qualitativen Analyse mit Hilfe der RAMAN-Spektren bildet die sichere Kenntnis der Spektren der Einzelsubstanzen und der Gesetzmäßigkeiten der Spektren von homologen Reihen von Kohlenwasserstoffen usw. Im Rahmen dieser Untersuchungen wurden von GOUBEAU und Mitarbeitern[91] neben den im Teil 8.1.1 und 8.1.6 dieses Berichtes bereits mitgeteilten Kohlenwasser-

[89] J. GOUBEAU u. E. LELL (unveröff.).
[90] H. LUTHER (unveröff., Anorg. Chem. Inst. Universität Göttingen).
[91] J. GOUBEAU u. E. LELL, E. TSCHENTSCHER (unveröff., Anorg. Chem. Inst. Universität Göttingen).

Figure 2. Method of Referencing Unpublished Data, "Theoretical Organic Chemistry," Part II, Raman Spectra, Page 81

The references give a further clue to the significance of the FIAT Reviews—for example, thoroughness is indicated by Figure 1 taken from the chapter on vitamins in "Pharmocology and Toxicity." About 940 references are listed. Another feature of note is the attempt to incorporate important unpublished results. Figure 2, chosen from the

chapter on Raman spectra, illustrates how this feature is accomplished. Follow-up on such unpublished references is of necessity by personal communication between the reader and author when common interest exists or further details are needed.

NATURFARBSTOFFE I

von

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INHALT

1. Allgemeines; Methodik

Übersichtsberichte: BROCKMANN[1], Neuere Methoden der präparativen Chemie. Die chromatographische Adsorption. — HESSE[2], Die Adsorptionsmethode im chemischen Laboratorium. — TRENDELENBURG[3], Der Gesichtssinn (Grundzüge der physiologischen Optik). — v. FRISCH[4], Über nervöse und hormonale Regelung des tierischen Farbwechsels.

BROCKMANN und SCHODDER[5] gewinnen Aluminiumoxydsorten mit definiert abgestuftem Adsorptionsvermögen durch Entwässern von handelsüblicher Ware und nachfolgendes Schütteln an feuchter Luft Die Prüfung des Aktivitätsgrades geschieht durch Adsorption jeweils

[1] H. BROCKMANN, Angew. Chem. 53, 384 [1940].
[2] G. HESSE, W. de Gruyter, Berlin 1943.
[3] W. TRENDELENBURG, J. Springer, Berlin 1943.
[4] K. v. FRISCH, Angew. Chem. 54, 193 [1941].
[5] H. BROCKMANN u. H. SCHODDER, Ber. 74, 73 [1941].

Figure 3. Listing of "Uebersichtsberichte," "Biochemistry," Part I, Natural Pigments I, Page 67

One characteristic not usually associated with the review of a scientific topic has been inaugurated in this work. It is a paragraph entitled "Uebersichtsberichte" which is found in many sections. Listed herein are pertinent books or other reviews published in Germany during the years 1939–46 which, in the opinion of the author, constitute valuable complementary or background sources. A representative example is given in Figure 3, taken from the biochemistry review section on natural pigments.

Content

No discussion of the FIAT Review of German Science would be complete without attempting to give at least an insight into the content—a difficult task because of the great scope (about 16,000 printed pages). This task can be partially accomplished by confinement to the chemical topics; however, this does not eliminate the other volumes from the interest of chemists. Subjects like biophysics, physics of solids, physiological and pathological chemistry, bacteriology, and immunology undoubtedly touch related items of use. Familiarity with the whole series is to be stressed in spite of the emphasis of the subsequent paragraphs.

No limitation was placed on a senior author's choice of content or method of presentation other than to exclude military topics and industrial processes which were covered extensively by allied investigation. Consequently, in the rather classical breakdown of

those volumes dealing with chemistry, authors varied the scope and method of presentation at will. "Inorganic Chemistry" is six volumes in length and brings together everything to which Klemm and his colleagues had access. "Theoretical and Preparative Organic Chemistry," two and three volumes, respectively, differ in that they treat specialized topics where significant advances were realized—for example, the former covers topics like constitution and physical properties, absorption spectra, Raman spectra, stereochemistry and reaction processes; the latter has sections, among others, dealing with the chemistry of acrylonitrile, copolymerization and polycondensation products, advances in synthetic dyes, reactions with molecular oxygen, automatic microanalysis of elements, organometallic compounds, and cellulose.

Many times the point has been made that the reviews were 4 years in being published and cover an even earlier period of the preceding 7 years. True, to be sure, but this fault is somewhat mitigated by the circumstances of the past decade. It is well to remember also that there is little or no reason for disregard of older literature, especially where fundamental study is involved. Even the past 10 years is a very short period to limit a literature search which, if extended, may very likely disclose information pertinent to a contemplated undertaking.

INVERTSEIFEN UND TETRAZOLIUMSALZE

von

Dietrich JERCHEL
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In normalen Seifen ist ein langer, hydrophober Alkylrest mit einer hydrophilen, negativ geladenen Carboxylgruppe verbunden (I). Lang-

I $R-COO^-$
R = langer Alkylrest

II $R-\overset{+}{N}\begin{matrix}R_1\\R_2\\R_3\end{matrix}$ R = langer Alkylrest; R_1-R_3 = Alkylreste oder andere Substituenten

kettige Verbindungen, deren hydrophile Gruppen eine positive Ladung tragen, bezeichnet man als invertierte Seifen, kurz als Invertseifen (II).

Die Bedeutung der Invertseifen beruht auf ihrer vielfältigen technischen Anwendung: Sie werden als Wasch-, Netz-, Emulgier- und Schaummittel verwendet; als Desinfektionsmittel, als Konservierungsmittel, ferner zum Mottenschutz und zur Bekämpfung von Pilzen in den Handel gebracht. Dies hat zur Folge, daß die Technik eine große Zahl der verschiedensten Invertseifen in der Patentliteratur beschrieb. Im folgenden wird über eine Reihe von Invertseifen berichtet, die Gegenstand spezieller biochemischer Erforschung und Anwendung geworden sind.

Bekannt als Desinfektionsmittel war eine 10-proz. Lösung verschieden

Figure 4. Representative Topic—"Biochemistry," Part I, Invert Soaps and Tetrazolium Salts, Page 59

Considering the reviews in this light, the biochemistry volumes are helpful. There can be found discussions containing unpublished works of Hans Fischer on chlorophyll. The subdivision on invert soaps and tetrazolium salts shown in Figure 4 is more timely; both subjects are of current biological interest, particularly the latter, since these compounds are of great assistance in the determination of seed germination. An eye-catching topic is that on "Blastokoline," and very appropriately the opening paragraph starts, "Was sind Blastokoline?" (Figure 5). These naturally occurring substances are a new class of growth inhibitors. Their presence may explain why some seeds germinate rapidly and others slowly, and how seeds can remain dormant for long periods in certain environments. The isolation, identification, and synthesis are included; the compounds are rather simple unsaturated lactones.

BLASTOKOLINE

von

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(Mit 4 Abbildungen)

1. Was sind Blastokoline?

Vor mehr als 50 Jahren erörterte WIESNER[1] die Frage, warum die Samen in fleischigen Früchten nicht auskeimen, obwohl sie zur Zeit der Fruchtreife so wasserreich sind, daß ihrer Keimung nichts im Wege zu stehen scheint. WIESNER vermutete eine keimungshemmende Substanz im Fruchtfleisch oder im Schleim. Eine ausführliche Darstellung des Problems verdanken wir OPPENHEIMER[2], der bei Moosen und Blütenpflanzen das Vorkommen keimungshemmender Stoffe beschrieb. Diesen Stoffen gab KÖCKEMANN[3] den Namen „Blastokoline" (βλαστάνειν = keimen, wachsen, χωλύειν = hindern). Der von KÖCKEMANN in

Figure 5. Representative Topic—"Biochemistry," Part I, Blastocholines, Page 186

Many other topics could have been selected to call attention to other specific biochemical researches, and just as interesting investigations are recorded in any of the other fields given in the title list. The need for critical, individually published, book reviews in the AMERICAN CHEMICAL SOCIETY journals is recognized; they would be helpful in further publicizing the contents. In some instances this is being arranged and it will augment this brief, general, noncritical discussion.

Distribution

The foregoing rapid trip over the FIAT Review of German Science possibly raises questions on how and where to obtain the entire series or separate sections of it. Eleven hundred complete sets were printed in Germany by the Military Governments, the distribution of which gave 250 copies to Great Britain, France, United States, and Germany, with the remaining 100 becoming the property of UNESCO. Within the United States, further distribution has been made by the armed services and the Office of Technical Services, Department of Commerce. The latter has sent copies to 100 university, government, and public libraries. A limited supply of the Military Government printing is available from the Department of Commerce, which will also furnish microfilm or photo-

stat copies. Finally, the manuscripts were given to a committee of German scientists headed by Freudenberg of the University of Heidelberg; the intent was to print another edition to be used partially for export purposes.

Summary

The FIAT Review of German Science represents a major contribution to scientific literature. As reference works they should be of value to a research scientist whether he be associated with a university, industry, or a research institute. The least to be expected from their use is that disclosures and summaries of data on many researches of the period 1939–46 in Germany save time in literature searching as well as assist in bridging a gap in the continuity of scientific publication.

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Preparation of Literature and Patent Surveys

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Surveys of the literature and patents in various fields are made by the technical libraries of The Texas Co., prior to laboratory research. These surveys are made from as broad a viewpoint as possible and are mainly noncritical, as they are later critically reviewed by the individuals who are to do the research work. A detailed account is given of the techniques employed in making these surveys.

The value of library research as a foundation for laboratory research is becoming increasingly acknowledged. Its importance, which has been discussed in previous AMERICAN CHEMICAL SOCIETY Symposia on Library Techniques, has frequently been emphasized by leaders in research (*1*, *2*).

This paper presents a description of the techniques employed by the technical libraries of The Texas Co. in making extensive patent and literature surveys as a background and basis for laboratory research. These techniques are fundamentally applicable for most chemical and petroleum searches.

Noncritical Surveys

The comprehensive surveys made by The Texas Co. libraries are entirely noncritical; all references to the subject are included and arranged in a form which offers the reader the most convenient access to the greatest amount of information. These reports are passed to the project leader of the laboratory research problem, who can then prepare a critical review with his recommendations as to the most promising course for the laboratory work. This has been found to be the most suitable and profitable procedure, because it not only saves the time of the laboratory worker but also yields a more comprehensive search, prepared in minimal time by personnel adapted and trained for this particular phase of research. Usually when the laboratory investigator prepares his own survey it is of such a restricted, critical nature that it may not be at all suitable if the course of the investigation is changed or if its scope is broadened. Also, the project may be transferred to another man who has different ideas as to the mode of attack. The searching done by the predecessor, which is frequently not discussed in his report or even recorded in his notes, must then be repeated. The trained searcher also includes references of possibly minor interest from the research standpoint but which may be of considerable interest to the legal department in the prosecution of patent applications.

Scope. For this type of survey the scope is made as broad as time will permit because it is too often the unhappy experience that, near or after the completion of a search, the scope of the research work is extended, thus rendering it necessary to repeat most of the literature search to relocate references previously omitted. If a request is received for literature and patents on the chlorination of methane, for example, an attempt would be made to extend the scope to the chlorination of the lower paraffins, and, if possible, to the halogenation of all paraffins. This is especially desirable if later, as a result of laboratory research, a new angle of approach or related compounds appear

more promising, or patent applications are considered; often the general field or even a specific modification of the process or product is of more interest than that originally suggested.

Collection of Abstracts. After the scope of the search is established and outlined, the next step in its preparation is the collection of all abstracts already available in the library's extensive card files. The Texas Co. library has been abstracting the literature and patents in the chemical, petroleum, and related fields for the past 30 years and as a result has approximately 400,000 abstracts which are filed according to a detailed, classified system developed by the library. In spite of extensive cross references for the abstracts, it is not possible to go to any one section and have all the abstract information on a specified subject in that one subdivision, although at least 90% would be found there. It is, therefore, necessary to check a number of sections to assemble all of the abstract cards on a given subject. Literature and patent surveys previously made on related subjects are also examined for abstracts of interest; these are copied on cards and added to the collection. For a survey on desulfurizing, for example, a check would be made through any surveys made on processes known to be used for sulfur removal, such as refining with solvents or with clay. All these abstract cards are then arranged in two groups—articles and patents—the former alphabetically by first author and the patents numerically for each country. Anonymous articles are arranged according to the journal title.

In order to render it unnecessary to use the cards themselves for checking against new material, all references are entered in a loose-leaf notebook by author or by patent number. A highly abbreviated form of reference is sufficient—for example, "Brown, Am 2053" indicates an article by Brown in the *Journal of the American Chemical Society* on page 2053. It is not necessary to give the volume number or year for journals that use consecutive paging throughout a volume, inasmuch as it is highly unlikely that another article by the same author on the same subject would appear in the same journal on the same page of two separate volumes. Only in the case of journals paging each issue separately is it necessary to add the date. The abbreviated form used in the notebook is simple to prepare and enables the searcher to check much more rapidly and conveniently, especially when checking references in related fields in other libraries, such as The Chemists' Club or the New York Academy of Medicine. Two simple code marks are used in this notebook; a dash before the page number of the reference indicates that a satisfactory abstract has not yet been obtained, and an X after the page indicates that checking the original article proved that the reference is not of interest for the search. The latter mark avoids much repetition, especially during the course of an extensive search. When supplements to the survey are later prepared this notebook is of particular utility for rapid checking.

Selection of Sources. When these abstracts have been assembled and the references have been listed in the notebook, the next step is the selection of the sources to be checked. These are chosen from four main groups, as follows: (1) the major abstract journals, (2) classified patents, (3) a thorough catalog of books and pamphlets, and (4) a rather extensive list which the library has compiled of special sources of information, each bearing a brief note as to the field covered, especially of types of information not readily apparent. A few of the many sources listed, with a comment on the usefulness of each, follow:

Abderhalden, "Handbuch der biologischen Arbeitsmethoden." Despite its title this treatise contains excellent reviews on such topics as halogenation, saponification, sulfonation, alkylation, and organometallic compounds.

Ellis' triology, "Synthetic Resins" (1935), "Hydrogenation" (1935), and "Chemistry of Petroleum Derivatives" (1934), and Volume II (1937). All three are checked for various topics.

Engler and Hoefer, "Das Erdoel," first edition (1913–25) and second edition (1929–30). These books contain hundreds of references to the early literature. The searcher should consult not only the volume which relates to the specific subject but also the indexes of the other volumes—for example, the volume covering utilization as well as the volume on treating should be checked for acid treating.

Journal of the Institute of Petroleum. This periodical contains excellent articles and lengthy abstracts but the index is poor. Because the abstracts are arranged by subject groups, however, checking by sections is not too laborious. The searcher should also consult the annual "Reports on the Progress of Naphthology" which appeared in the journal during 1923–34 and the subsequent separate publications "Reviews of Petroleum Technology" which cover 1935–47.

"Gesammelte Abhandlungen zur Kenntnis der Kohle" (1915–30). This series contains good reviews on hydrocarbon oxidation, acetylene polymerization, etc.

Naphthali, "Leichte Kohlenwasserstoffoele" (1928). This book is good for cracking and treating; the table of contents and subject index are surprisingly good.

Petroleum Zeitschrift für die gesamten Interessen der Erdöl-Industrie und des Mineralöl-Handels. The subject index is useless but the annual surveys made by Singer and others in the early years should be checked. Kissling's annual reviews which appeared in *Chemische Umschau* should also be consulted.

Sedlazcek, "Automobiltreibmittel" (1927). This periodical contains a section on treating.

Seifensieder-Zeitung in Gemeinschaft auf Kriegsdauer mit Allgemeine Öl- und Fett-Zeitung und Mineralöle. This journal contains many references to naphthenic acids, soluble oils, lubricating greases, etc.; for a German publication it has a fairly good subject ndex.

Wagner, "Jahresbericht ueber die Leistungen der organischen Chemie" and Liebig-Kopp, "Jahresbericht ueber die Fortschritte der Chemie." These annual reviews dating from around 1850, covering applied and pure chemistry, respectively, contain excellent abstracts of patents and literature, some of which are not to be found in *Chemisches Zentralblatt;* the subject index is fairly adequate. Wagner has a rather complete German patent number index in the chemical field.

The selected sources are then evaluated—that is, those sources expected to give the most information are listed first. This order would naturally depend on the subject being surveyed, because in one case *Chemical Abstracts* would be first, in another, some special treatise on the subject, either a monograph, such as Bailey's "Retardation of Organic Reactions" (1937), or perhaps a series of journal articles of a bibliographical nature, such as Pritzker's survey of synthetic lubricating oils which appeared in the *National Petroleum News* during 1946 and in *Petroleum Processing* in 1947, or the annual fatty oil surveys made by Piskur and published in *Oil and Soap* might be checked first.

Concurrently with the preliminary arrangement of source materials, a list of key words is compiled for use in checking the abstract journals—for example, although *Chemical Abstracts* has a fine subject index, the searcher must nevertheless look under a number of headings. In the case of the chlorination of methane, one cannot rely solely on the entries under "methane" and "chlorination," but must check "halogenation," "paraffins," "hydrocarbons," "natural gas," and all the products that might be obtained by the reaction. This list of key words must often be revised and amplified during the course of the search, especially when checking indexes covering a wide range of years, or various abstract journals, particularly British or foreign language publications. In many instances the most pertinent divisions of *Chemical Abstracts,* or other abstract journal, are also checked item by item. The foregoing is not to be construed as a criticism of *Chemical Abstracts,* for the impossibility of arranging all subject listings under one heading is obvious. The same caution applies to a far greater extent to other abstract journals such as *British Abstracts, Chemisches Zentralblatt, Fuel Abstracts, Synthetic Liquid Fuel Abstracts, Science Abstracts,* the Office of Technical Services Bibliography of Technical Reports, etc.

In addition to the abstract journals, the available indexes of the TOM (Technical Oil Mission), the FIAT (Field Information Agency, Technical), and the BIOS (British Intelligence Objectives Sub-committee) are checked; the indexes of journals specializing in the field of the search are also checked. In many instances these journals are leafed through page by page. For a search on refining fatty oils, for example, the *Journal of the American Oil Chemists' Society* would be paged.

Patent Searching. For patent references, in addition to those obtained from the abstract sources, selected classes of United States patents, which are maintained by the Patent Department in the same subclasses as in the United States Patent Office,

are checked. Besides the classes selected by means of the currently revised United States Manual of Classification, the classes of a number of representative patents obtained from the abstracts or other sources are checked. The Patent Office cross references, as well as all patents cited by the Patent Office against the more pertinent patents, are also checked. Supplementary sources in the patent field that should be consulted are Worden's "Chemical Patents Index" (1927–34), "Abstracts of Chemical Patents Vested in the Alien Property Custodian" (1944), and von Hohenhoff's "Bibliography of Journals, Books and Compilations Which List and Abstract Patents" (1936).

Before the search is completed, the originals of practically all articles and patents are examined, not only to amplify the abstracts, particularly by adding details on the special field of interest, but also to check any references cited by the author.

Preparation and Arrangement of Abstracts. Unless the article is of a review nature, lengthy abstracts are prepared in which particular notation is made of any data and graphs; a descriptive title is written, and key words in the abstract are underlined. In all cases the company or university affiliation of the authors is shown as it often indicates the basis for their viewpoint or the link from one work to another. On the abstracts of the United States patents, corresponding foreign patents (not necessarily equivalents) are recorded.

After the abstracts have been edited, the next step is to determine how they should be arranged in the report—alphabetically by author, chronologically, or subdivided by subjects. In case subdivision by subjects is used, the abstracts within each division may be arranged either chronologically or alphabetically. Patent abstracts may be grouped together at the end of each year and are often arranged according to the assignee. In all cases, those who will have occasion to use the survey are consulted to determine what would be the most suitable arrangement for them, because each system has obvious advantages.

If the survey deals with finished petroleum products such as cutting oils, quenching oils, or slushing compounds, a separate section is added covering tests on competitive products. These data are taken from a special library card file containing such information obtained from various sources.

Preparation of Indexes. A very important part of the survey is the preparation of indexes of three types—author and company, patent number, and detailed subject index. Sometimes special classified sections are included such as lists of commercial processes or capacities of commercial units in operation. The subject index is very necessary since some of the surveys may comprise 600 or 700 pages. In one case where the report proper contained 950 pages, the indexes thereto comprised 136 additional pages. In such a case the subject index is also broken down into divisions—for example, in the case of hydrocarbon oxidation, there might be divisions for hydrocarbons, oxidizing agents, catalysts, products, and utilization. The basic idea underlying the preparation of such lengthy indexes is that a survey hundreds of pages in length not only deserves a very detailed index but in fact cannot be conveniently used without one. With adequate indexes it is more valuable than a series of annual surveys on the selected topic.

The last step in the preparation of these surveys is writing the introduction; it reviews the scope of the survey, with particular mention of its limitations and omissions, and gives a list of the source materials checked.

Critical Surveys

In addition to these thorough, noncritical surveys, the libraries of The Texas Co. are frequently requested to make brief searches of the literature and/or patents on various subjects. For those critical surveys, the problem is discussed with the inquirer to define its scope as clearly and within as narrow bounds as possible. These searches for information may require from a few hours to several weeks and are frequently limited to checking the more obvious sources of information. They might require, for example, the earliest references on oil-base drilling muds, the effective ranges of various adsorbents, the chemical reactions of a new reagent, the carcinogenic action of hydrocarbons, or all company patents on a special subjects such as boron trifluoride. The report for this type of sur-

vey frequently comprises a critical discussion to which are appended the pertinent abstracts in the usual form. The length and nature of the report will determine the types of indexes required.

Facilities for Library Research

The ready availability of sufficient and suitable source material is a very important requirement. While some libraries have available on their shelves only the abstract journals and the main reference sources and rely on public and other outside libraries for other publications, yet it would appear that this procedure would be very costly in time of personnel. Typing facilities are not available at most public libraries and it is necessary to write in longhand the data required; often, on checking the information later, it may be necessary to make another trip to the library to supplement the data first obtained. Consequently, it has been the aim to have available in The Texas Co. libraries not only all the main abstract journals, American, British, French, and German, reference works, and encyclopedias, but also practically all texts relating to the particular fields of interest of The Texas Co. In the main library prints of reels 1 through 305 of the Technical Oil Mission reports and a collection of reports of the Publication Board, BIOS, FIAT, etc., are retained in loose-leaf binders.

It is not sufficient merely to have such material on the library shelves; it must also be carefully indexed. All new books and pamphlets received are examined carefully for information that would not ordinarily be expected in such publications. In "The Chemistry of the Non-Benzenoid Hydrocarbons" (1922) by B. T. Brooks, for example, there are references to naphthenic acids, production of fatty acids by wax oxidation, and synthetic lubricating oils. In Volume VI of "Colloid Chemistry" (1946) edited by Jerome Alexander, there are chapters on the Geiger-Müller x-ray spectrometer, electron microscopy, catalysis and its industrial applications, soil stabilization, polythene, and potential nuclear energy. Such information is typed on 3 × 5 cards; on some books as many as forty or fifty cards may be required. In this way an extremely useful file of information has been built up that might otherwise be overlooked as valuable data sometimes appear in unexpected places.

Abstracting and Filing Systems

The library issues a semimonthly abstract bulletin. These abstracts are prepared from two different viewpoints—to furnish the reader information on current developments, and to accumulate data to be used later in the searches. Consequently it has been found necessary to make rather lengthy abstracts, especially to achieve the second aim. All abstracts are reproduced on 5 × 8 cards and are filed by author, company, and classified subject. One abstract may be filed under as many as ten or twelve subject classifications. The filing system is the classified type (not alphabetical) and covers the entire field of science and technology. The cards made by cataloging new books, are filed in a separate file but according to the same classification system, one alphabetical index serving both. Consequently, in beginning a search or looking up data, the alphabetical index is consulted to locate the decimal number of the classified file. This number is the same both for abstracts of articles and patents and for cards containing references to specific items in the books on the shelves. The information already available thus serves as an excellent basis for the searches.

For the patent searching, in addition to the numerous subclasses of patents maintained by the Patent Department, many of the attorneys have special collections of patents, both United States and foreign, on the specific fields in which they are interested, such as solvent refining, well logging, and alkylation, which are accessible to the library staff.

Summary

Because the preparation of these lengthy surveys usually requires months, and the information is generally desired for immediate use, the logical procedure would be the constant preparation of basic surveys on the fundamental processes, products, and reac-

tions of interest in order to have them available when needed. All specialized topics could not be anticipated, but a great deal of information from these basic reports could be used which would expedite the preparation of these special reports. Basic surveys could be made, for example, on the halogenation, oxidation, nitration, and sulfonation of hydrocarbons, refining processes such as sulfur and wax removal, additives for improving the properties of various products, and preparation of motor fuels from heavier and lighter fractions and their rearrangement by isomerization. As long as hydrocarbons serve as the building blocks, information will be desired on these reactions and processes, whether the hydrocarbons originate from petroleum, oil shale, coal, or natural gas.

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PRESENTED before the Division of Chemical Education, Symposium on Chemical Literature, at the 111th Meeting of the AMERICAN CHEMICAL SOCIETY, Atlantic City, N. J.

Library Techniques in Searching

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In searching for the information already in existence on a particular subject, library techniques are but a fragment of a much bigger problem that demands corrective action. A competent central organization is needed, whose function it would be to coordinate the publication and indexing of technical literature, to ensure a complete and accurate single index. The increasing volume of printed technical literature must be made more quickly and more certainly available to the research worker. The availability of knowledge promotes the progress of civilization.

It has been said that the cheapest research is that done in the library; every chemist can probably confirm this statement from his own experience. Such an instance occurred in the author's library a few years ago, when one of the research men came in to express his appreciation after a paper bearing on his immediate problem had been called to his attention. The paper was in a recent foreign periodical and contained data which the laboratories were seeking and which would have cost several thousands of dollars to secure in the laboratory. It is because all know of similar instances that most chemists never think of embarking upon a new problem in the laboratory before they have ascertained what information already exists that may have a bearing upon their problem. The value of library research has been ably discussed (*10*, *11*, *19*, *21*, *27*, *39*).

Many articles and even books describe the numerous tools and techniques available to the searcher in any well equipped library. A partial list of these is appended to this paper. Outstanding among these are three—those by Crane and Patterson (*14*), Mellon (*27*), and Soule (*37*)—in each of which indexes to the chemical literature are listed and their use is explained. The importance of systematic planning of the search is emphasized and helpful suggestions regarding the mechanics of successful searching techniques are given. It would be difficult within the limitation of this paper to add anything new to these excellent treatises or to improve upon the techniques suggested. A brief review of some of these procedures as they have been applied in the author's library may, however, be helpful.

In this organization the research man comes to the library for the prior art—journal articles, patents, books, etc.—that will assist him in his work. He is free to use the library files, which he often does, or he may ask the library to gather the information for him. Sometimes a team is formed composed of library searchers and the technical men who will subsequently use the information found. Requests for art come to the library in so many different ways, the points of view are so varied, and the sources of published references are so divergent that it is difficult or impossible to formulate procedure for searching that will cover all cases.

A library search may be made for various purposes. The patent attorney may want to know if the invention he is trying to protect in a new application has sufficient novelty to be patentable, and he asks for a novelty search. He may wish to know whether a

contemplated use of a certain product, process, or piece of equipment is already covered by an existing patent and use of it would therefore infringe; so an infringement search is requested. He may know of a patent which does cover an invention the company wants to use. He then asks for a validity search to determine the value of the existing patent. He may ask only for an index search to determine what patents or writings have been published over the name of a particular individual or company. He may request a complete report of published articles and patents relating to a general field. If so, the request is for an art search and the task of the library is to collect all the published information possible, in books and periodicals, or in the patent literature, which is relevant to the field defined.

Figure 1. Reading Room of Standard Oil Development Co.

The various types of searches and the techniques and sources best adapted to each have been ably discussed by others (*30*, *38*). This paper discusses only the art search, which is the type most commonly requested or made by the research worker. But the volume of literature for even a very limited field is today so great that it is appalling. The method of attack and the time to be spent, therefore, must depend upon the importance of the problem. If the problem is of sufficient importance, the extended time required to make the search complete will be justified, but a less important problem may demand that the searcher merely scan those sections of the art most likely to contain pertinent references. In any search, however, the initial step is the same, the problem must be analyzed and the sources to be examined determined.

It is essential that the searcher understand the nature of the problem. He asks himself or the author of the request what the elements of the request are. Is it a question of a single-step process or a simple compound, or are there many steps with varying degrees of dependence, and if so what are they? If it is a product, is it a new species or is it generic in nature? How broadly must the search be made to cover all relevant material? What analogous procedures or equivalent products must be considered? It is usually helpful, unless the request is very simple, to reduce the analysis to a written outline accompanied by a brief list of the sources to be examined before the actual search is begun.

Hypothetical Art Search

Let us consider a hypothetical request for an art search as it might come to the author's library, and the procedures that would be followed in the prosecution of the search. Assume that Dr. John Doe has come for help in connection with research he is about to start on the Fischer synthesis. He says he wants the art on hydrogenation. This is a very broad field indeed, with numerous references in all major sources—books, monographs, general and special texts, encyclopedias, etc.; indexes such as *Chemical Abstracts* and *Engineering Index;* special files such as card file indexes and clipping files; and patents. Dr. Doe has not realized, until he sees the thousands of references in the card file index on hydrogenation, how broad a field of search he is requesting. Table I shows how this field has been subdivided.

Table I. Hydrogenation Classification

Hydrogenation of
1. Specific materials
   - *a.* Animal and vegetable oils
   - *b.* Mineral oils
     - (1) Petroleum
     - (2) Shale oils
     - (3) Bitumens
   - *c.* Coal, lignite, peat, etc.
   - *d.* Oxides of carbon (Fischer-Tropsch process)
   - *e.* Miscellaneous carbon compounds
   - *f.* Inorganic compounds (ammonia manufacture, etc.)
2. Use of hydrogen
   - *a.* As a reducing agent in chemical reaction
   - *b.* In purification processes
3. Raw materials and their production
   - *a.* Hydrogen
   - *b.* Synthesis gas, etc.
4. Use and/or properties of hydrogenation products
5. Apparatus
6. Catalysts

He sees the necessity, therefore, for stating his question more explicitly, in order to reduce the scope of the search to only such art as is likely to pertain to his particular problem. He explains that his problem is concerned with the Fischer-Tropsch synthesis. This is still a broad field, as may be seen from the outline in Table II.

Table II. Fischer Synthesis

1. Processes
   - *a.* Fixed bed catalyst
   - *b.* Fluidized catalyst
   - *c.* Other
2. Operating conditions
   - *a.* Temperature
   - *b.* Pressure
   - *c.* Contact time, flow velocity, etc.
3. Products
   - *a.* Hydrocarbons
   - *b.* Oxygenated compounds
     - (1) Alcohols
     - (2) Aldehydes, etc.
   - *c.* Properties
   - *d.* Refining
4. Raw materials and their preparation
5. Apparatus
6. Catalysts

Eventually Dr. Doe admits that he is interested only in the wax products obtained in the synthesis reaction and, finally, that his problem is to study the effect of catalysts on the yield of such products. His problem is now defined and the searcher can proceed with the analysis and outline of material to be examined as described above.

The analysis will result in an outline something like that shown in Table III.

Table III. Effect of Catalyst Composition on Yield of Wax Product in Fischer Synthesis

1. Nickel catalysts
2. Cobalt catalysts
3. Iron catalysts
4. Promoters
5. Other catalysts and catalyst mixtures
6. Catalyst preparation
7. Catalyst regeneration
8. Economic studies

With the question defined, the next step is to outline the art to be examined. Here the searcher's training and experience are important. He ascertains from Dr. Doe that economic data are not required at the present time and the field to be examined may be

limited to the technological aspects of the problem. The searcher will recall from memory a few of the books, monographs, encyclopedias, or general texts that should be examined in the search, but he will not depend on memory alone in preparing this section of his outline. He will consult the library catalog. If, as in this library, a special card index is available, he may consult this first and possibly find enough information there to avoid the necessity for consulting further sources. But if the card index is not sufficiently complete, or if he wishes to acquire more background in preparation for the search, he will go first to the monographs, encyclopedias, and general texts on the subject as located through the catalog.

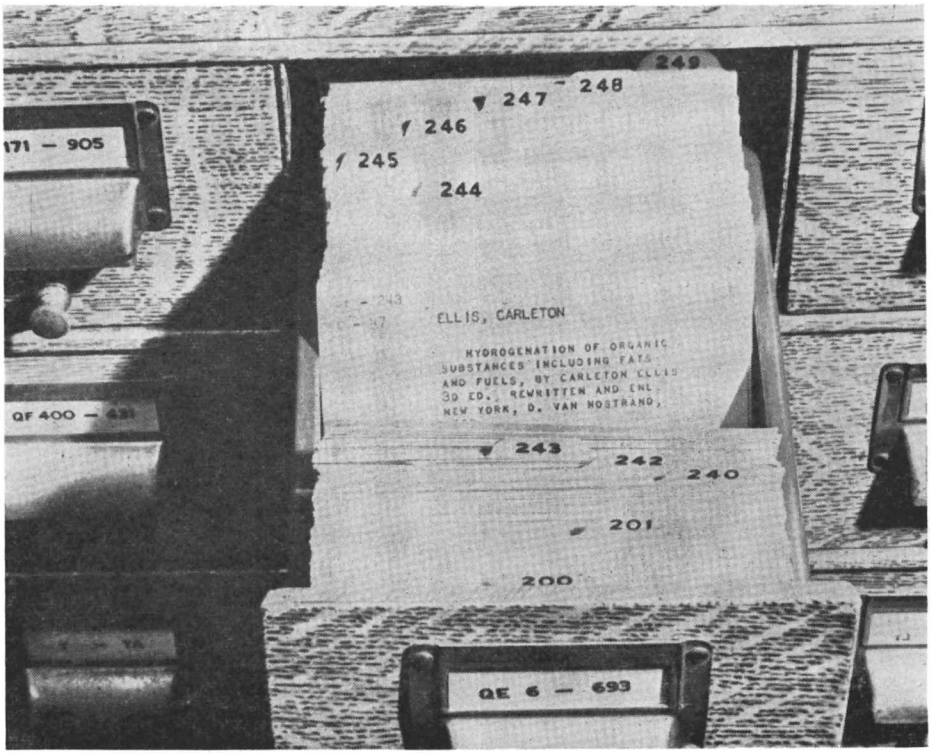

Figure 2. Shelf List of Card Catalog

Most chemists are familiar with the library catalog. It consists of a card or cards carrying bibliographic data only for each title on the library shelves. It may be a dictionary catalog containing cards filed alphabetically for each author and subject, or it may be only an author index to the books plus a shelf-list section. This shelf-list consists of one card for each title, arranged in the same classification order in which the books are filed on the shelves.

Examination of the catalog shelf-list section for titles in the field of hydrogenation reveals a number of tests in this field (Figure 3). Perhaps the most useful one to start with would be Ellis' "Hydrogenation of Organic Substances." Chapter 55, "Reduction of Carbon Oxides," is specific to the problem in question. All the other texts listed in this section should, of course, be examined also, as well as the encyclopedias like Ullmann and Thorpe and the books on catalysis.

Many leads for further searching will be found in these books, both as to related fields of subject matter that should be examined and to specific references to the prior literature in books, periodicals, and patents. These may be numerous, and if so it is wise

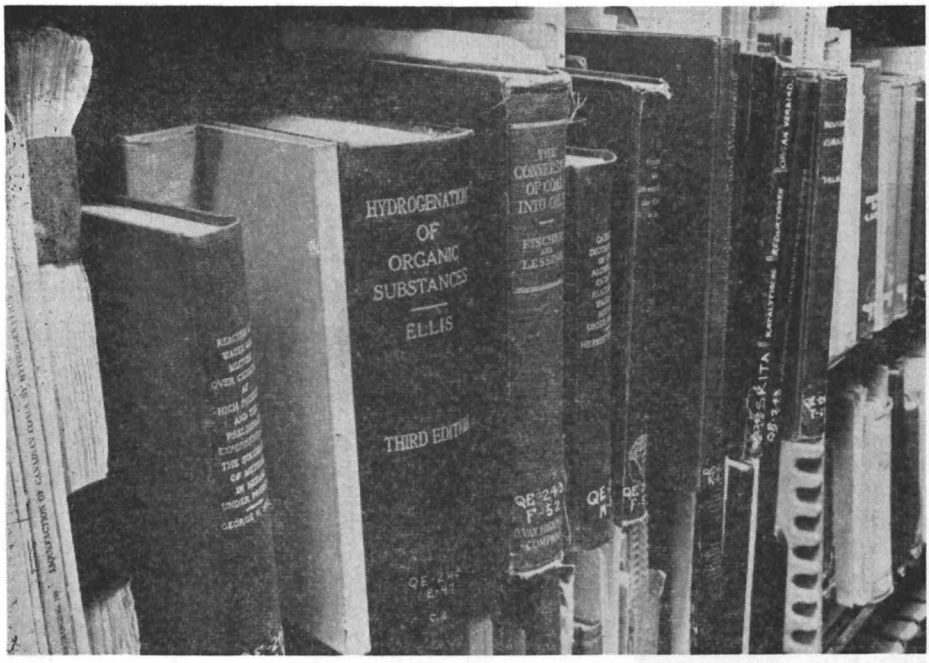

Figure 3. Books on Hydrogenation

to record each pertinent reference as noted, preferably on a separate card, so that the cards can be kept in alphabetical order by author, or in numerical order by patent number, and serve as a check list as the search progresses. Time wasted in recording duplicate references can be eliminated with such a check list.

In recording references during a search it is wise to make a complete record of each reference as it is noted for the first time, so as to avoid, in so far as possible, the necessity of going back again for additional data. In an extensive search such as that discussed here a 4 × 6 inch card is preferred for each reference. Complete bibliographical data together with an abstract are recorded, as will be noted in Figure 4.

In the upper left-hand corner is indicated the author or authors for a literature reference, and the patent number, inventor, assignee, or patentee for a patent. If significant dates—filing, issue, published, or convention date—are given one or more of these with the names is usually included in this corner of the card. The abstract should contain all the significant data likely to be included in the final report. If the reference is noted from another publication, the publication reference should be indicated. It is important to put down complete bibliographical reference data, and abbreviations that are not fairly obvious should be avoided. Others may have to use these notes sometime, and the few additional seconds required in making the reference clearly understandable may save hours in searching for it later on. The abstract may be brief or extended, according to the preference of the searcher, but it should at least indicate the type of information contained in the article, and why the reference is considered to be pertinent. In this company's library the abstract is preferably worded so that it can be copied in the final report.

When the examination of the textbooks and monographs has been completed, the searcher should be sufficiently oriented into the search to permit preparation of an adequate list of subject headings for use in examining the various literature indexes. Such a list for the hypothetical case considered here might start about as indicated in Table IV.

With such a list of subject headings the searcher is now ready to begin the examination of the journal and patent literature. Assume that he wishes to start with the journals.

The original list of indexes to be examined should be reviewed at this point and revised if necessary. In fact, both the list of sources to be examined and the subject headings to be used should be repeatedly checked and revised as the search progresses. The searcher may want to start the indexes with the special card index in the library, if this is sufficiently complete. In the case of Dr. Doe's problem, a very comprehensive collection of references could be assembled by merely copying the abstracts found on the cards in the author's library. This would not, of course, be complete. If a more exhaustive search were required the searcher would start from here with the most comprehensive indexes available.

Table IV. Subject Headings

Catalysis	Hydrocarbon synthesis
Catalysts	Hydrogenation
Carbon oxides	Iron
Cobalt	Nickel
Fischer-Tropsch	Ruthenium
Hydrocarbons	Synthesis

Most technical libraries will have at least one index such as *Chemical Abstracts*, *Chemisches Zentralblatt*, *British Chemical Abstracts* and its predecessors *Journal of the Society of Chemical Industry* and *Journal of the Chemical Society*, *Wagner's Jahresberichte*, *Liebig-Kopp's Jahresberichte*, *Science Abstracts*, *Physikalische Berichte*, and *Engineering Index*. In the examination of each of these indexes, or even in going from one volume to another in the same index, the list of subject headings which the searcher has compiled must be reviewed constantly and checks made of all the cross references noted in the indexes, to make sure that the right subject headings are being used each time. This is necessary because the editors who prepare these indexes revise their subject headings from year to year and the heading used in one index for a given subject may not be used at all in another index.

There are many routines by which this examination of the indexes can be systematized. The one preferred by the writer consists in listing at the top of a sheet of paper all the headings to be used for the volume being examined. Space should be left for the insertion of additional headings as the need for them may be discovered later. The page references

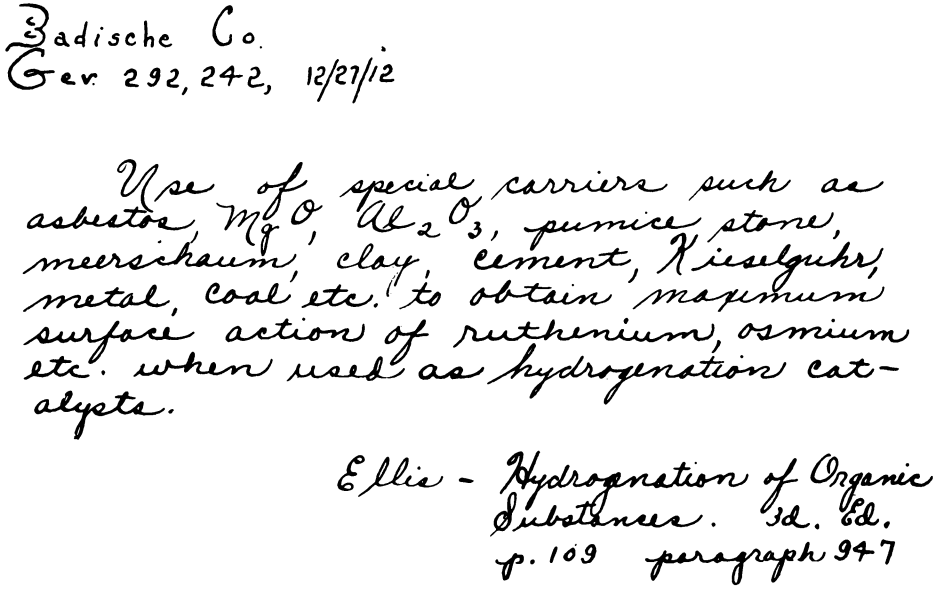

Figure 4. Sample Abstract

as indicated in the index are then tabulated on the sheet, spaced sufficiently to permit arrangement in numerical order as additional pages are noted under the successive headings in the index. When all the pages have been listed in this way, in at least approximate numerical order, the searcher can go through the volume systematically and examine each reference listed, checking it off as he does so. A specimen check sheet of this sort is shown in Figure 5. In this instance the references in a volume of *Chemical Abstracts* are listed in approximately numerical order. Such a sheet can usually be easily expanded to contain all the references noted in a cumulative index, such as the *Chemical Abstracts* Decennial Index.

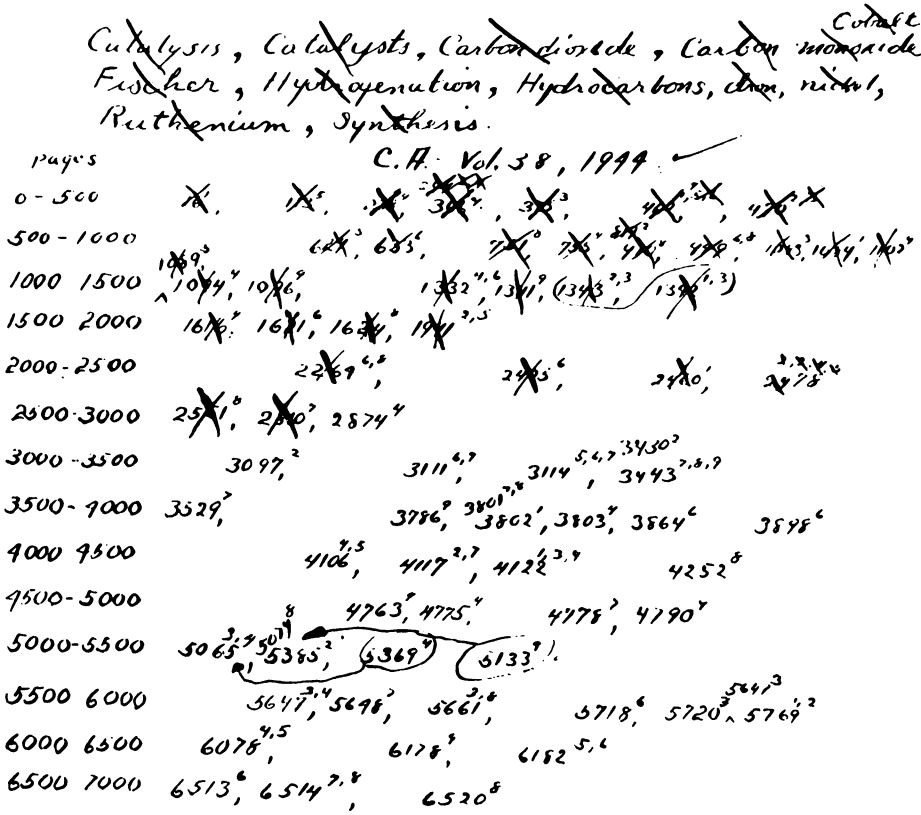

Figure 5. Work Sheet for Examining *Chemical Abstracts*

If the subject is very important, the searcher cannot afford to depend on the printed indexes. He will have to page the volume itself, or certain portions of it. He may even have to page certain original periodicals that are most specific to the field of the search.

When all the references noted from these indexes have been added to the growing file of pertinent references, the original articles have been consulted for additional information whenever in the judgment of the searcher this is necessary, and additional references have been noted from the bibliographies and footnotes in the original articles, a final check should be made to determine if there are any other bibliographies, indexes, trade catalogs, government documents, theses, etc., that should be examined.

Patent Literature

A point is finally reached where the searcher decides that all the indexes, books, pamphlets, and periodical literature have been examined, in so far as the importance of

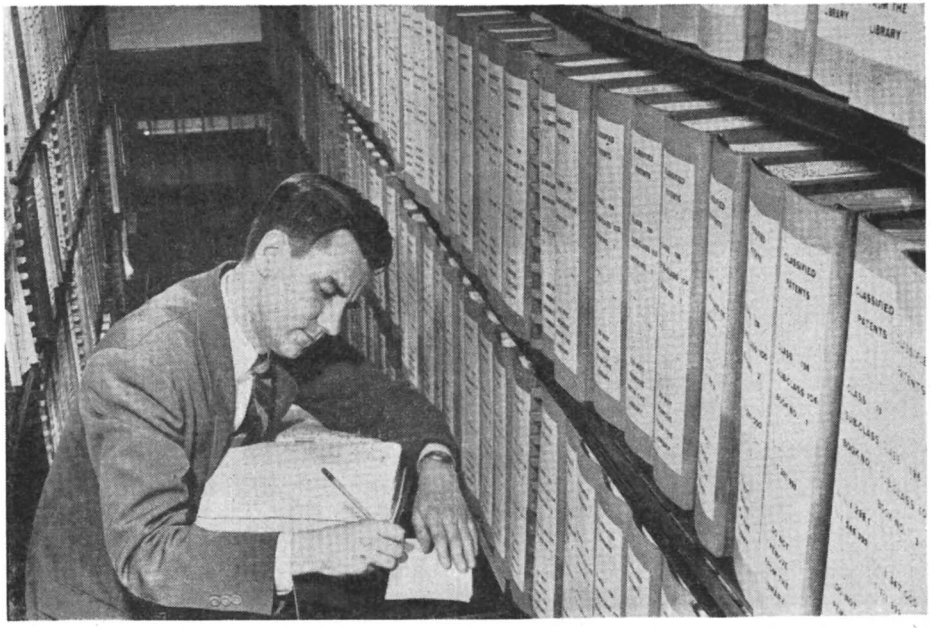

Figure 6. Files of Classified Patents in Standard Oil Development Co. Library

the search justifies the time spent upon it. There still remains a most important body of art—the patent literature, which may be divided into domestic and foreign categories.

In the words of Smith (*34*), "Patents constitute the principal technical literature of the industrial world." Technical men are becoming more and more aware of the importance of the patent literature. Evidence of this is seen in the improved coverage that *Chemical Abstracts* instituted for both United States and foreign patents several years ago, and the numerous patent services that have sprung up in various parts of the country.

Over 2,500,000 United States patents have been issued and are arranged in subject files at the Patent Office in Washington, D. C. These cover every conceivable kind of subject matter from safety pins to harvesting combines, from hand lotions to processes for cracking petroleum, and making synthetic rubber and nylon stockings. If one wishes to develop something new in any field of product, process, or mechanical art or device, he cannot ignore the patent art, and particularly the United States patent art, for there is almost always something there which is similar to his new idea, even if it does not anticipate it completely.

How does one examine this enormous body of art? It is not as complicated as it may seem. In the chemical field much of it is well indexed in the abstract journals such as *Chemical Abstracts*. Therefore much of the patent art may have been gathered when the indexes to these journals were examined.

It is not wise, however, to rely solely on abstracts or abridgments for the collection of patent art. The patent copies themselves should be examined.

The U. S. Patent Office classifies its patents into some 320 main classes, each of which is divided into many subclasses. Cochran (*9*) tells us that there are now about 43,000 of these subclasses. Titles of the classes and subclasses are listed in the "Manual of Classification of Patents" (*41*). Revision of this classification is a continuous process, and as classes are revised and new definitions for them written, these are published first in the *Official Gazette of the U. S. Patent Office* and later in the *Classification Bulletin* issued at six-month intervals by the Patent Office.

To search the United States patent art, therefore, the first step is to examine the

"Manual of Classification," together with the definition furnished in the *Classification Bulletin* and determine, if possible, which classes will contain the art to be examined. The only sets of classified patents available to the public in this country are in the Patent Office in Washington. Some companies, therefore, maintain partial sets in their own libraries. This company has in its library approximately 550 subclasses covering those fields of most direct interest to its business (Figure 6).

Reference to the classification manual reveals class 260, and subclasses 449, 449.5, and particularly 449.6, which are directly pertinent to Dr. Doe's problem. More subclasses may, perhaps, be selected from the manual. In going through the patents in any particular subclass the searcher will find cross-reference patents from other classes. These often reveal important classes to search which had not appeared obvious from the list of classes in the manual. Sometimes, too, additional classes to be searched are located by looking up the classification of a relevant patent which has been discovered by accident or recalled from memory.

Some searchers have been known to rely upon abstract publications for patent references, but this is not safe. An important patent reference may be missed completely in the abstract publication, or the abstractor may have failed to indicate the clue that permits recognition of the relevancy of the original patent to the point being searched. The disclosure in the patent may be so incidental or obscure that the abstractor could not be expected to have included it in his brief condensation. The reverse may also be true. The abstract may contain a statement, overlooked by the searcher when he examined the original, which may make the patent a valuable reference. In a thorough search the original patent copies in the classified sets should be examined, and the abstracts to these same patents should be noted as they are found in the abstract publications. This serves as a check to ensure against overlooking relevant references.

When the United States patents have been examined, the foreign patent art remains to be covered. Here again the only sets of classified foreign patents available to the public are to be found in the U. S. Patent Office. The Scientific Library of the Patent Office maintains both numerical and classified sets of patents from most of the foreign countries which print them. These include Austrian, French, Dutch, German, and Swiss. The patent copies in these classified sets are arranged as originally classified in the country of origin, and manuals explaining these classifications are available in the Scientific Library. The procedure for using them is the same as for examination of the United States patent art. Dependence upon abstracts of foreign patents is even more to be avoided than in the case of United States patents.

Eventually the searcher finds that he has examined every source which his experience tells him is likely to contain valuable references. He has assembled his list of references with such data for each one as he plans to report.

The report can now be written. It should contain a clearly stated definition of the object of the search and a description of the sources searched, sufficiently detailed to permit the future reader of the report to decide whether additional searching should be attempted and if so to avoid searching again the sources already covered. How the references themselves are to be reported depends upon the searcher's preference and his understanding of the preferences of those who will later use the report. The report should indicate, either in a separate discussion or in the abstract of the individual reference cited, why each reference is cited. Usually also included in the abstract are some of the most important data and an indication of what other data or subject matter the reader should expect to find in the original article.

Table V. Steps in Conducting a Search

I	Define the problem to be searched, preferably in writing.
II	Outline the sources to be examined; list the most important ones first.
III	Set up a list of subject headings and revise it as the search progresses.
IV	Enlarge the scope as necessary by adding new sources indicated by the clues that appear as the search progresses.
V	Systematize the references as they are collected.
VI	Assemble the references and make the report.

Such an exhaustive search as is here outlined briefly is time-consuming and is justified only by extreme importance of the problem. Most searches are shorter and less thorough, but whether short or long, the elements are the same (Table V).

Most chemists at some time or other conceive patentable inventions. Patent memoranda describing these inventions are usually written to establish the necessary record for subsequent prosecution, by the patent attorney, of application for letters patent upon the invention. It is necessary for the attorney to know the closest art, if he is to obtain the best possible coverage in the claims he uses to describe the invention. The inventor should, if possible, therefore, supplement his patent memorandum with a few references which define the art closest to his invention. Some companies require this procedure.

The ability to search accurately and efficiently is a special one and inherent rather than acquired. A knowledge of subject matter and the best sources for specific subjects can be acquired, as can the routines to be followed in making the search. But the ability to recognize infallibly and quickly the relevancy or nonrelevancy of subject matter examined depends upon an alert and imaginative mind and discriminating judgment as well as upon technological skill. If the search is being made at the request of another, the scope of the search should be clearly defined, so that time will not be wasted in gathering irrelevant or unnecessary art. An adequate background should be provided by the one who requests a search, so that the searcher will understand why the required information was requested and how it will be used. This is essential if he is to apply his imagination in recognizing the relevancy of the references to be examined.

This view has been confirmed by others. Thus Lewton (*26*) states the qualifications of a searcher as follows:

"Quite apart from a complete knowledge of sources, foreign as well as domestic, and ability to evaluate them, the type of work demands of the searcher extensive technical training, and understanding of research concepts and viewpoints. The gift of applying the general to the specific, imagination to form the nonobvious correlation and see possibilities, and ability to interpret abstract scientific ideas into terms of commercial understanding are required to carry on desk research. In fact, it takes the same qualities and processes of mind-analysis of problems into factors, outlining of logical steps in mode of attack, evaluation of tools and techniques to be employed as is required by a leader or director of research.

Adams (*1*) states that some of the qualifications of a research bibliographer are an analytical mind, active interest in reading, love for creative thinking, and technical training. Deller (*16*) believes that the librarian, to aid the patent attorney, should be familiar with the fundamentals of patent law and should have an analytical mind in order to make proper, clear, and concise abstracts.

The Larger Problem

The topic we are considering here is but a fragment of a much bigger problem which demands corrective action in the near future. We know that the recorded experience as it now exists in the literature is not well organized—indexes are often incomplete, incorrect, and in many cases entirely lacking. Many indexes must be consulted and the same references considered repeatedly because of the overlapping. These and other faults make difficult the searching of the existing art. As the art increases in volume, and this is occurring at an accelerating rate, the difficulties become greater. Creation is long overdue of some competent central organization to coordinate the publication and indexing of technical literature so as to ensure to the searcher a single index so complete and so accurate that it could be relied upon for most, if not all, of the searches he must make. A way must be found in the not too distant future for handling the increasing volume of printed technical information to make it more quickly and more certainly available to the research worker of tomorrow, and prevent repetition of the work it represents. The availability of knowledge promotes the progress of civilization.

A start in this direction might well be made by our Federal Government in the publication of government documents. It is literally impossible today to ascertain what public documents have been published in a given field because of the multiplicity of

bureaus and agencies, each with its own publication arrangements. How much more useful these publications could be if some arrangement were made so that all government documents, whether printed or mimeographed, were issued from the common printing office, listed in the common list of government documents, and adequately indexed in a common index? Why must we have so many chemical abstract publications? Why cannot the efforts be combined to produce in a single publication more complete and better indexes than any of the present ones?

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Techniques Employed in Making Literature Searches for a Patent Department

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Methods and sources employed in making literature and patent searches for the patent department of a chemical research organization are discussed. Searches are classified according to the purpose they are designed to serve and the techniques employed vary accordingly. Patent searches to determine patentability, state of the art, infringement, and validity are described.

The rapidly increasing mass of scientific literature has made the problem of searching through it for a particular compound, reaction, or process, one to be handled only by a specialist. In the literature-searching groups described, specialization is carried to such a point that patents are searched by the staff of the patent library while all other literature is covered by the members of the technical library staff, who also make literature searches for other divisions of the research organization.

Members of the staffs of both libraries are chemists who are well trained in organic chemistry and who have a reading knowledge at least of French and German. In practice, most foreign languages in which scientific articles appear can be read by some member of the staff. The personal characteristics of the people doing this type of work are most important, inasmuch as perseverance, integrity, good judgment, ability to analyze a problem, and ingenuity or chemical intuition are just as necessary as proper academic background. It has been said that "the first great principle in learning to use a library is to acquire the knack of saving time" (*5*). Individuals with the characteristics mentioned gradually develop this knack, which is made up of familiarity with the tools, skill in using indexes or patents, knowledge of how to take short cuts safely, judgment in what should be included, the ability to read rapidly, and increased ease in handling foreign languages.

Most of the requests from the patent department for literature and patent searches fall into four general classes: patentability, state of the art, infringement, and validity. Because patentability searches are requested most frequently they are considered first and in considerable detail.

Patentability Searches

When the results of laboratory research reach the patent department in the form of a memorandum, the patent attorney to whom the case is assigned usually requests both patent and literature searches. The patent department is divided into three sections—organic chemistry, petroleum exploration and production, and petroleum technology. Each section is headed by a group leader. Requests for searches originate with the member of the patent department to whom the case has been assigned and are approved by the group leader, who has an over-all picture of the work being done in the section as well as in the research under way in the laboratories. Thus it is sometimes

possible to combine several searches, or broaden one search so that it can take the place of several which might otherwise have been necessary later. Requests are made on standard forms; all information already available to the patent attorney is indicated in the request, so that the searcher may build up the picture as quickly as possible. After the request for a search has been assigned to a particular member of either library staff, the first step is always a complete survey of the problem, using company reports, correspondence, and general references to supply the background. A conference with the patent attorney requesting the search follows. This rounds out the picture and gives the searcher an understanding of the scope of the investigation, points to be emphasized, and related material to be included.

In the patent library the first step in this type of search is to consult an index of searches already completed, and in some cases it proves necessary only to bring an earlier search up to date. An extensive collection of United States and foreign patents is classified and filed according to the system of the United States Patent Office, so that searches are conducted in this library as they would be in Washington. Each patent is abstracted upon receipt and these abstracts are indexed under patent number, inventor, and assignee, as well as in a cross-reference file arranged according to the classification used for patents. Special indexes are kept on subjects of particular interest in cases where the patents themselves may be widely scattered. After the index of earlier searches and the special indexes have been checked, the files of the patents themselves and the cross-reference file of abstracts are systematically searched in subclasses selected by reference to the "Manual of Classification of Patents" and the Classification Bulletins. If too many patents appear to be pertinent, another conference may be needed to narrow the field further. Upon completion of the search, the patents found are arranged in numerical order by countries and sent to the patent attorney with a report in which they are listed. If a large number of patents are sent, they are arranged logically—for example, in the case of a catalytic process the patents may be arranged according to the catalyst used. A duplicate copy of the report is indexed and filed in the patent library for future reference.

Techniques. Patentability searches conducted by the library staff are of two types—a brief preliminary examination, and a regular patentability search in cases where the subject is of sustained interest. Techniques involved in making regular patentability searches are common to most types of searches and so may well be described first and in detail.

In the technical library the starting point of all searches is the file of index slips which the library has accumulated. This file includes references in periodicals, government publications, material put out by associations and societies, trade literature, books, literature searches previously made, and miscellaneous material. As in the case of patent searches, an earlier investigation brought up to date may take care of the request or some portion of it. Standard reference works in the field in question are then consulted. Abstract journals are covered next. This step in the search is of the greatest importance, as it serves as a key to the periodical literature. An abstract is not regarded as a substitute for the article abstracted; in all but a brief preliminary examination the original reference is read if at all possible.

Sources. The nature of the problem determines which of the abstract journals and indexes should be used, and in a regular patentability search it is usually necessary to use several different ones. The principal abstract journals and indexes to be consulted for a particular search are carefully selected from a list which includes *Chemical Abstracts*, *Chemisches Zentralblatt*, *British Abstracts*, *Engineering Index*, and *Industrial Arts Index*. Other tools which might be mentioned are the abstracts appearing in the *Journal of the Institute of Petroleum* and in *Petroleum Refiner*, the *Bibliography of Petroleum and Allied Substances* (compiled for a time by the United States Bureau of Mines for a search in the field of petroleum), and *Experiment Station Record*, *Biological Abstracts*, *Bibliography of Agriculture*, and *Agricultural Index* for problems dealing with agriculture.

Abstracts of interest are located through patent, author, formula, and subject indexes.

In his book (*2*) "The Literature of Chemistry" Crane says, "Skill in searching involves skill in index using and index using is an art in itself, a thing to be acquired." Patent indexes are relatively simple to use. The Special Libraries publication, "Index to Patents in Chemical Abstracts 1907–1936," makes it possible to find the abstracts in *Chemical Abstracts* in the years before a patent index was included in that journal. The patent index of *Chemisches Zentralblatt* is particularly useful in finding equivalent patents in foreign countries. Author indexes are used in a regular search only when the work of one or two men has been found to be of particular interest. Formula indexes, found in both *Chemical Abstracts* and *Chemisches Zentralblatt*, are most useful at the beginning of a search in the field of organic chemistry as an aid in working out the nomenclature of the compounds under investigation. One whole class of complex compounds was found by a member of the library staff to be known after the laboratory chemist, less skilled in the intricacies of indexes, had concluded that it was novel. A complex compound with a number of functional groups may be classified in the subject index under any one of several different headings, and for patentability searches the formula index of *Chemical Abstracts* is usually used to find the proper entry in the subject index. The formula and subject indexes of *Chemisches Zentralblatt* are both used for all compounds. The proper use of subject indexes calls for a broad knowledge of chemistry, a complete understanding of the problem under investigation, familiarity with the particular subject index, and considerable ingenuity. Each subject index has its own idiosyncrasies and this is particularly true of the index of *British Abstracts*, where the entries are key words rather than subjects.

In conducting a patentability search in the field of organic chemistry *Chemical Abstracts* would be used, first starting with the latest volume and working backward. This would be followed by *Chemisches Zentralblatt*, using the formula index first and then the subject index of the latest volume and working back to 1919. This year was selected because the main volumes of Beilstein cover the period up to that time, and because in that year *Chemisches Zentralblatt* began a wider coverage of technical articles. When the abstract journal indicates that something of interest may be found in the original article, the reference, together with the *Chemical Abstracts* or *Chemisches Zentralblatt* reference, is copied on a slip together with a brief note of the information to be sought in the original article. Patent references are omitted in patentability searches unless the request specifies that they should be included for some particular reason, inasmuch as parallel searches are usually conducted in the two libraries. After work with the first abstract journal has been completed, the working slips are sorted by periodical to eliminate duplication and for convenience later in consulting the originals. As the search progresses other abstract journals, bibliographies, footnotes, and review articles provide more references for this collection of "to be read" slips. If a reference to a certain article is found in *Chemical Abstracts*, *Chemisches Zentralblatt*, and Beilstein, all three references are noted. It is understood that in all searches except those of a preliminary nature the original is to be read and, in the relatively small number of cases where the article cannot be obtained or where the language is one that cannot be read, the written report indicates that the information is based on abstracts. In such a case all available abstracts are read; *British Abstracts* is particularly helpful, as its abstracts are much longer and more detailed than those of the other abstract journals. References in periodicals not available locally are secured on microfilm and an extensive file of such material is gradually being built.

Search Report. The search report submitted by the technical library to the patent attorney after all the references have been read consists of extracts pertinent to the problem taken from the original article. Extracts are usually arranged in order of importance. Related material is often included at the end of the report. The only general rules for assembling the material are that the arrangement be a logical one and one which will make the material as easy as possible for the attorney to use. A chronological arrangement is used only when it is significant—for example, in the literature dealing with the development of a certain process. If there is much material it is separated according to subject matter and a table of contents is included.

Often it is necessary to say "no material found." This is a source of satisfaction to the patent attorney in the case of patentability searches, but never to the library staff The original articles are not sent with the report, but are available to the patent attorney upon request. The reports are not critical, except for the fact that apparent errors are noted.

Brief Form. The preliminary examination or brief form of the patentability search calls for greater skill and experience on the part of the searcher, because much less time is allotted to it and only the most promising sources are consulted. Familiarity with the various periodicals and works of reference and well developed skill in using the indexes of the abstract journals are essential. In this type of search, if the problem is one of novelty, one single good reference showing that the compound or process is already known is sufficient. Books, especially those like "Hydrogenation of Organic Substances" by Ellis and "Catalytic Oxidation in the Vapor Phase" by Marek and Hahn, encyclopedias such as Thorpe, Ullmann, and Kirk-Othmer, bibliographies such as "Bibliography of Organic Sulfur Compounds" by Borgstrom and others, are particularly important in this type of search. Occasionally the answer may even be found in a book like "The Chemical Formulary." If no material is found in the brief preliminary examination, a regular patentability search may be requested later but, because of records kept by the library on all searches, no duplication of effort is involved.

State-of-the-Art, Infringement, and Validity Searches

The foregoing gives a general idea of how searches are conducted in our libraries. State-of-the-art searches may be considered as extended patentability searches and are made in a similar manner. They are much more time-consuming because of the broader field to be covered. Infringement searches are carried out in the patent library by checking the claims of United States patents issued in the last 17 years. Infringement and validity searches, because of their importance, are carried out by the most experienced members of the group. Validity searches in both libraries call for the most exhaustive investigation. Every patent and every footnote which might possibly have bearing on the case is investigated. Early works such as *Dinglers Polytechniches Journal*, *Fortschritte der Chemie*, Fehling's "Neues Handwörterbuch der Chemie," Erlenmeyer's "Handwörterbuch der Chemie," and Muspratt's "Theoretische, practische und analytische Chemie in Anwendung auf Künste und Gewerbe" are given special attention. In validity searches it is sometimes necessary to go through an early or obscure periodical on the particular subject page by page. In this type of investigation the publication date is of paramount importance. If a good reference is found which does not bear a sufficiently early publication date, investigation may produce a still earlier brief announcement or note concerning the work in another periodical. In one validity search where a technical article was important evidence, it was necessary to have affidavits prepared showing the date on which this publication was actually available to the public in the libraries of the area, since this important date is sometimes much later than that appearing on the magazine itself (*4*).

Miscellaneous Searches

In addition to the four general types of searches discussed, other types of information are frequently requested by the patent department. Such requests are not usually made on the regular search blanks but are made and answered informally. While the regular searches are assigned according to a flexible schedule, these other requests for information usually require an immediate answer if the information is to be of use; they are handled accordingly. Notes on the replies to these questions are filed just like searches. They are usually brief, but experience has proved that their very informality makes it desirable to record them for possible future reference. In the patent library these requests may take the form of a request for a specific patent when the information concerning it is incomplete or incorrect. Lists of patents by a certain inventor or patents assigned to a company on a particular process may be requested. The inventor and assignee files of index slips are invaluable in answering these requests.

In the technical library these brief requests are of various kinds, some of which may be of interest. It is sometimes advantageous in connection with interference actions to have a chronological pattern of the activities of a man whose patent application is involved in the interference, in order to approximate the period of invention. When the technical library receives such a request it may be answered quickly if the man is listed in "American Men of Science" or other similar biographical works. If he does not appear in any such volume, the path to be followed is tortuous. A large collection of lists of memberships of scientific and technical societies covering a period of years is most useful in finding the affiliations of the person in question. Patents and periodical articles also give such information. Even such odd references as city and telephone directories may be used. It is an interesting game to fill in the blank periods and present a continuous picture of a man's activities. Company relationships and ownership are of interest to the patent department as well as to the other members of the research organization. All current periodicals and other publications are reviewed as they are received in the technical library, and among the types of information recorded on index slips is anything which would add to our knowledge of the structure of companies in the chemical and petroleum fields. Index slips, filed under the names of all companies involved, cover information obtained from such diverse sources as news items in periodicals, company correspondence, congressional hearings, and statements filed with the Securities and Exchange Commission. Questions involving ownership can usually be answered by the index slips together with Moody's Industrials or Standard-Poors.

Members of the staff of the technical library rapidly become experts on matters of nomenclature, and many questions concerning structure, formulas, and naming of compounds reach this group. Often the composition or manufacturer of a trade-named product is requested. In addition to such sources of information as the lists in "Thomas' Register" and Chemical Industries "Buyer's Guidebook," Zimmerman and Lavine's "Handbook of Material Trade-Names," the Special Libraries Association's "Trade Name Index," and Gardiner's "Synonyms and Tradenames," the supplementary index compiled by the technical library over a period of years is most useful. In answering requests for physical properties of compounds, references such as International Critical Tables, Landolt-Börnstein, Seidell, Lecat, Beilstein, dictionaries, and handbooks are consulted first. If the information is not found through such sources, it may be necessary to check the abstract journals. Such special collections on the properties of hydrocarbons as those of Doss, Egloff, and Faraday and the work of the American Petroleum Institute and the National Bureau of Standards usually make it unnecessary to go to the abstract journals for information in this field. In order to decide in which foreign countries patents should be filed, the technical library may be asked to prepare a brief review of the economics and development of a certain industry in the foreign countries where filing is doubtful. Definitions or statements of fact may be needed to support a point or convince a patent examiner. Dictionaries and reference books are usually used for such information as it is important that answers be obtained from well-known and authoritative sources.

Summary

Thus searches made by the two libraries have a direct bearing on the effective production of the patent department. Such a simple bit of information as azeotropic composition may be needed to convince the patent examiner that a separation process will function as claimed in the patent application. It is reported (*1*, *3*) that 30 to 50% of the patents applied for fail to become patents and that most of the applications rejected were found to be anticipated by or did not distinguish in a patentable sense over prior art. In addition to preventing the filing of applications which would be rejected on patent or literature references, good patentability searches are needed by the patent attorney to aid him in judging the proper scope of his claims, so that the result will be a strong patent which cannot be proved invalid later.

A state-of-the-art investigation is of great value when the whole field of activity is being reviewed, because it gives a picture of the patent situation and industrial development in the field, and shows potential competitors and their economic and patent position.

Validity searches are made to gage the strength of a patent offered for sale or a patent which is blocking activity in a field of interest to the organization. Most exhaustive of all searches are those validity searches called for when court action has been taken in a case of claimed patent infringement. Here, as in the other cases, success may depend on the close cooperation of the two libraries with the patent department and millions of dollars may hinge on one reference in an obscure journal, or an old foreign patent.

Literature Cited

(1) Connolly, A. G., *J. Chem. Education*, **20**, 531–3 (1943).
(2) Crane, E. J., and Patterson, A. M., "The Literature of Chemistry," New York, John Wiley & Sons, 1927.
(3) Rossman, J., "The Law of Patents for Chemists," Baltimore, Williams & Wilkins Co., 1934.
(4) Sabrosky, C. W., *Science*, **98**, 473 (1943).
(5) Soule, B. A., "Library Guide for the Chemist," New York, McGraw-Hill Book Co., 1938.

PRESENTED before the Division of Chemical Education, Symposium on Chemical Literature, at the 111th Meeting of the AMERICAN CHEMICAL SOCIETY, Atlantic City, N. J.

Continuous Collection and Classification of Data as an Aid in Preparing Surveys

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This paper outlines a scheme which has been found to offer facilities for preparing literature and patent surveys with a near minimum of time expenditure and a high degree of completeness. Described briefly, the scheme consists primarily of the continuous collection, classification, and filing of current literature and patents. As a result of this operation, surveys may be prepared directly from filed material without the necessity for arduous searching through the abstract journals. Stenographic personnel may be utilized for much of the work in order to reduce the cost of the operation and to conserve the time of the technical personnel.

If literature and patent surveys are to serve as guides for research programs, it is frequently essential and always highly desirable that they be prepared in the shortest possible time, so that the speedy development of an idea will result in a competitive advantage. A patent may be obtained or a market may be captured if a process can be brought to completion before a competitor's, yet a hastily contrived survey may be useless. Some reference overlooked may contain the key to success or failure.

Thus it would appear that the two main requirements of literature and patent surveys are that they be sufficiently comprehensive and that they be completed within as short a time as is consistent with the requirement of adequate coverage. These two requirements are, by nature, somewhat opposed, and it is possible to satisfy both simultaneously only by conducting a survey in the most efficient manner possible.

Inasmuch as the collection of material usually constitutes by far the largest amount of time consumed in the preparation of literature and patent surveys, and entirely determines the coverage, increasing the efficiency of the collection step is of paramount importance. The purpose of the present paper is to outline a scheme which has been found to offer facilities for preparing surveys with a near minimum of time expenditure and a high degree of completeness. Described briefly, this scheme consists primarily of the continuous collection, classification, and filing of current literature and patents.

Classification

The smooth functioning of this scheme involves the teamwork of several sections and a number of individuals, each section contributing its services according to its facilities and each individual according to his particular training. The backbone of the entire scheme is the index classification system that has been developed by Gulf Research & Development Co.'s fellowship at Mellon Institute; it is by use of this system that both the literature and the patents are classified and filed for ready reference. This classification system is now undergoing revision, and a full discussion of it must be reserved for a

later date. However, for present purposes, a brief outline will suffice to illustrate its contribution to the over-all plan.

At present, the system consists of the nineteen main divisions shown in Table I. Divisions B through J serve to classify material pertinent to the various products of petroleum, while the other divisions provide classifications for all other material relating to the petroleum industry.

Table I. Main Divisions of Mellon Institute File Index System

A. Miscellaneous	L. Chemistry and chemical composition
B. Gas	M. Physical properties
C. Gasoline and other motor fuels	N. Testing, analysis, and specifications
D. Kerosene	O. Equipment
E. Gas oil, fuel oil, and fuels	P, Q, R. Open
F. Lubricants and lubrication	S. Production, pipe lines, and storage
G. Wax and petrolatum	T. Distillation
H. Asphalt and coke	U. Treating chemically
I. Crude oils	V. Treating physically
J. By-products and miscellaneous petroleum products	W. Cracking

Each of these main divisions is subdivided into as many classes as are required by the amount and type of information to be classified. Table II shows the breakdown of the lubricants and lubrication division of the present system. The first letter in the file designation for each class is that of the main division, in this case F for lubricants and lubrication. The second letter in the file designation indicates the particular class within the main division. A number of classes are provided for the various lubricant products, while others exist for classification of information relating to their production, specifications, testing, etc. Each class is further divided as extensively as has proved to be useful. Since the system was initiated prior to 1927, it is not surprising that a number of subclasses have since been added, as, for that matter, have some classes and even a few main divisions. The rapid progress of petroleum technology in recent years has compelled the revision now under way.

Table II. Breakdown of Typical Main Division of File Index System

F. Lubricants and Lubrication

FA. Miscellaneous, general	FJ. Open
FB. Nonviscous oils. Textile oils	FK. Open
FC. Turbine oils	FL. Open
FD. Industrial lubricants	FM. Greases and soaps, transmission, chassis, extreme pressure lubricants
FE. Motor oils	FN. Properties and composition
FF. Open	FO. Theory of lubrication
FG. Cutting and emulsifying oils	FP. Specifications (of petroleum lubricants)
FH. Cylinder and bright stocks, car journal, black oils	FR. Preparation
FI. Compounded lubricants, thickened lubricants, additions	FS. Equipment

Table III shows how the classes are broken down into subclasses. The FI class has been taken as an example to continue the account of the breakdown of the F main division. The subclasses are designated by number and further divisions by lower case letters. The paragraph just under the class heading indicates briefly and rather incompletely the type of material filed under the class. However, subclasses may be added as needs dictate.

Filing

Both the literature and patents are continuously classified and filed by use of this classification system. A card file, a reprint file, and a patent file are maintained. The card file contains references to all or almost all of the existing material on each subject; the reprint file contains the full text of a large number of the best articles on each subject;

and the patent file holds all pertinent patents classified by subject matter. Thus it is possible, at a moment's notice, to extract the classifications desired, and find instantly at hand all the material necessary for a complete survey.

Table III. Breakdown of Typical Class of File Index System

FI. Compounded Lubricants, Thickened Lubricants, Additions
(See also MC–4a, GB–2a, LH–4)

Additions of compounds for improving lubricating oils, viscosity improvement, increasing film strength, pour-point depression, oiliness agents, compounded oils, synthetic oils, fatty acids as lubricants, linseed oil, rapeseed oil (including blown), castor oil and castor oil blends, rubber in lubricants, tin compounds, Exanol, Paratone, Vistones, etc., penetrating oils, electrochemical oils.

FI–1 General (miscellaneous)
FI–1a Graphite lubricants
Aquadag, Oildag, graphite, analysis, theory of graphite lubrication
FI–2 Improving viscosity and viscosity index
FI–3 Oiliness, extreme pressure, film strength
FI–4 Anticorrosion agents
FI–5 Antioxidants
FI–6 Detergents
Sludge dispersers
Carbon preventives
FI–7 Anti-ring-sticking agents

Although these files are great timesavers when a survey is to be prepared, they require surprisingly little time to maintain in current condition. Division of effort prevents taking more than a small fraction of any one person's time, and stenographic help is employed as far as possible.

Selection of Material

At Mellon Institute, the senior fellow makes selections from a number of outstanding periodicals, including *Chemical Abstracts, Journal of the American Chemical Society, Industrial and Engineering Chemistry, Chemical Engineering, Petroleum Refiner, S. A. E Journal, Petroleum Engineer,* and *Petroleum Processing.* He indicates whether a card is to be made for an article, whether it is to be clipped and added to the reprint file, or both. This work is done in his odd moments. Another member of the fellowship, who also heads the library at Gulf Research & Development Co., classifies the senior fellow's selections according to the index system described. Taking *Chemical Abstracts* as an example, about 2 hours of classification are required per issue, and an average of around 100 abstracts are classified. This amounts to only a little over 1 minute per abstract.

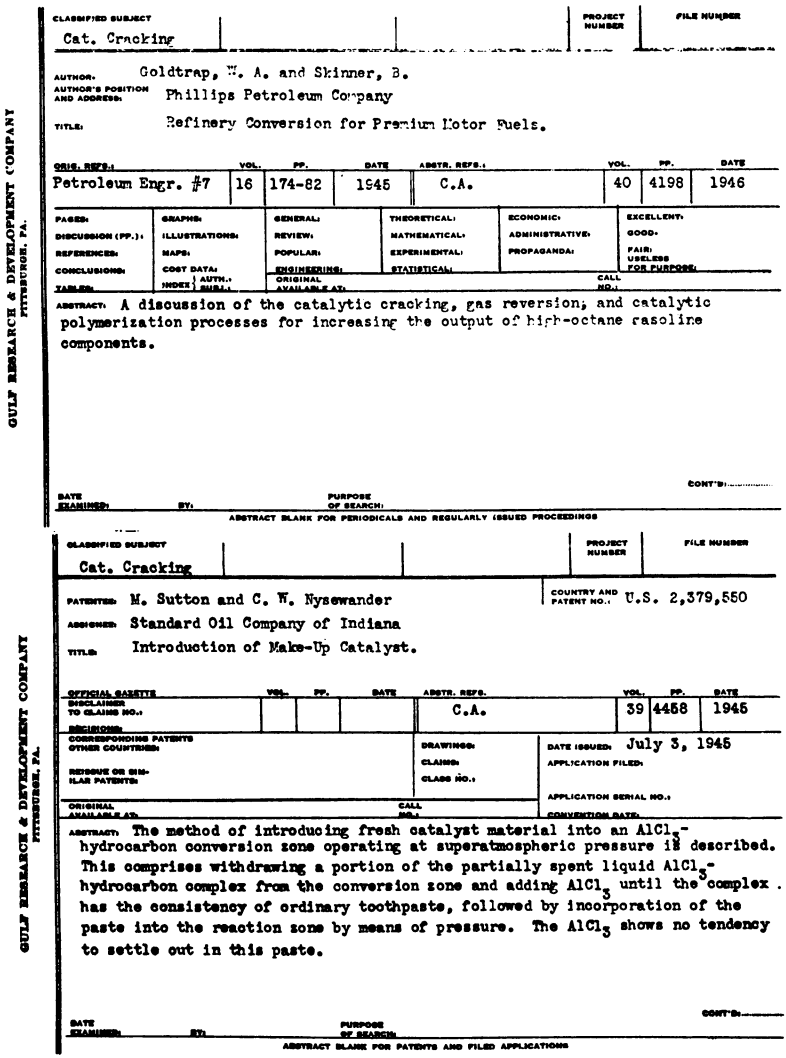
From this point, the additions to the files become a stenographic job. For articles in journals other than *Chemical Abstracts,* the procedure is as follows: Cards listing the bibliographic data, but containing no abstract, are made and filed under the indicated classification, and selected articles are clipped and filed. In the case of *Chemical Abstracts,* the abstracts themselves are clipped, pasted on cards, and filed according to classification. These *Chemical Abstracts* cards replace the cards containing only bibliographic data, the latter serving an interim purpose in keeping the file up to date. Thus, as far as the literature is concerned, the card file is as complete as the coverage of *Chemical Abstracts,* and the reprint file contains articles from the leading journals in the field.

The patent phase of the work is handled somewhat differently but in an equally efficient manner. The head of the Patent Section of Gulf Research & Development Co. examines each copy of the *Official Gazette of the United States Patent Office* for patents of interest. He then obtains copies of the patents, roughly classifies them, and sends them to various qualified persons at the research laboratories for abstracting. Since each man receives only patents which directly pertain to his specialty, the abstracting involves a minimum of mental effort—hence time. The patents, accompanied by copies of the abstracts, are then sent to Mellon Institute for classification and filing in a manner analogous to the way in which the literature is handled. This completes the account of how the central reference files have been established and are kept current.

Information Bulletins

These procedures serve a number of purposes in addition to maintaining the files. For example, the selections made in *Chemical Abstracts* are checked for completeness of coverage both at Mellon Institute and at Gulf Research, and a mimeographed bulletin is prepared for each issue; it contains all the abstracts considered by the selectors to be of interest to Gulf Research personnel. This bulletin, prepared by the information section, is so arranged that individual abstracts can be clipped from it, pasted on file cards, and added to each man's personal file. The patent abstracts are published monthly in a mimeographed bulletin put out by the patent section. Thus, the entire technical personnel of the company is kept abreast of current developments in the field, and each man may build a personal file to suit his particular needs.

The information section, whose chief function is the preparation of literature and



GULF RESEARCH & DEVELOPMENT COMPANY PITTSBURGH, PA.

CLASSIFIED SUBJECT: Cat. Cracking | PROJECT NUMBER | FILE NUMBER

AUTHOR: Goldtrap, W. A. and Skinner, B.

AUTHOR'S POSITION AND ADDRESS: Phillips Petroleum Company

TITLE: Refinery Conversion for Premium Motor Fuels.

ORIG. REF'S:	VOL.	PP.	DATE	ABSTR. REF'S:	VOL.	PP.	DATE
Petroleum Engr. #7	16	174-82	1945	C.A.	40	4198	1946

PAGES:	GRAPHS:	GENERAL:	THEORETICAL:	ECONOMIC:	EXCELLENT:
DISCUSSION (PP.):	ILLUSTRATIONS:	REVIEW:	MATHEMATICAL:	ADMINISTRATIVE:	GOOD:
REFERENCES:	MAPS:	POPULAR:	EXPERIMENTAL:	PROPAGANDA:	FAIR: USELESS FOR PURPOSE:
CONCLUSIONS:	COST DATA:	ENGINEERING:	STATISTICAL:		
TABLES:	INDEX: AUTH.: SUBJ.:	ORIGINAL AVAILABLE AT:			CALL NO.:

ABSTRACT: A discussion of the catalytic cracking, gas reversion, and catalytic polymerization processes for increasing the output of high-octane gasoline components.

DATE EXAMINED: BY: PURPOSE OF SEARCH: CONT'D:

ABSTRACT BLANK FOR PERIODICALS AND REGULARLY ISSUED PROCEEDINGS

GULF RESEARCH & DEVELOPMENT COMPANY PITTSBURGH, PA.

CLASSIFIED SUBJECT: Cat. Cracking | PROJECT NUMBER | FILE NUMBER

PATENTEE: M. Sutton and C. W. Nysewander | COUNTRY AND PATENT NO.: U.S. 2,379,550

ASSIGNEE: Standard Oil Company of Indiana

TITLE: Introduction of Make-Up Catalyst.

OFFICIAL GAZETTE	VOL.	PP.	DATE	ABSTR. REF'S.	VOL.	PP.	DATE
DISCLAIMER TO CLAIMS NO.:				C.A.	39	4458	1945

REISSUES:

CORRESPONDING PATENTS OTHER COUNTRIES: | DRAWINGS: | DATE ISSUED: July 3, 1945

REISSUE OR SIMILAR PATENTS: | CLAIMS: | APPLICATION FILED:

CLASS NO.: | APPLICATION SERIAL NO.:

ORIGINAL AVAILABLE AT: | CALL NO.: | CONVENTION DATE:

ABSTRACT: The method of introducing fresh catalyst material into an $AlCl_3$-hydrocarbon conversion zone operating at superatmospheric pressure is described. This comprises withdrawing a portion of the partially spent liquid $AlCl_3$-hydrocarbon complex from the conversion zone and adding $AlCl_3$ until the complex has the consistency of ordinary toothpaste, followed by incorporation of the paste into the reaction zone by means of pressure. The $AlCl_3$ shows no tendency to settle out in this paste.

DATE EXAMINED: BY: PURPOSE OF SEARCH: CONT'D:

ABSTRACT BLANK FOR PATENTS AND FILED APPLICATIONS

Figure 1. Standardized Abstract Forms for Periodical and Patent References

patent surveys, utilizes all the previously mentioned facilities and, in addition, has adopted several other aids. One of the most valuable of these is the use of standardized abstract forms in conducting a search. Separate forms are available for periodical, book, and patent references. The periodical and patent forms are illustrated in Figure 1.

Abstract Forms

The fact that each item of information always appears in the same place on the abstract form simplifies, by systematization, both the collection of the information and its subsequent utilization. Much of the "leg work" and "pencil pushing" connected with the collection of search information may, therefore, be relegated to stenographic personnel. When it becomes necessary to make a detailed search for abstracts pertaining to some given subject, a technical man needs only to consult an index—for example, the *Chemical Abstracts* index—jot down the page number of each pertinent abstract, and hand it to a copy girl who locates each abstract for him by marking the places with bits of paper. He then quickly skims the abstracts to judge their pertinence and by supplying authors' names or patent numbers indicates which abstracts are to be copied on forms. Figure 2 typifies the information provided on the completed notation sheet. The copy girl types the selected abstracts on the standard forms and files the completed forms in loose-leaf binders for future use. The loose-leaf feature permits arrangement of the literature references alphabetically by author and the patent references by country and patent number;

SYNTHINE SURVEY
CHEMICAL ABSTRACTS 38 (1944)

238[4] – MELLER
~~266[4]~~
~~275[3]~~
470[2] – GER. 728, 766
470[3] – GER. 729, 290
~~624[4]~~
633[6] – GER. 731, 295
751[3] – GER. 732, 719
949[6] – FISCHER
~~1085[3]~~
~~1086[4]~~
1089[5] – FISCHER, ROELEN, FEIST
1094[4] – GER. 733, 749
1096[9] – GER. 733, 841
~~1102[5]~~
~~1352[4]~~
1342[1] – EIDUS
1343[2] – GER. 734, 993
1343[3] – GER. 734, 218
~~1616[4]~~
1621[6] – FISCHER
~~2460[4]~~
2478[3] – FISCHER & PICHLER
2478[3] – GER. 716, 836
2478[4] – BRIT. 551, 312
2478[5] – GER. 717, 693

2810[7] – GER. 735, 276
3111[6] – PIGNOT
3114[5] – GER. 736, 844
3114[6] – GER. 736, 701
3443[7] – KIMPFLIN
3786[9] – U.S. RE. 22, 415
3801[7] – U.S. 2, 338, 805
3801[8] – U.S. 2, 338, 475
3802[1] – GER. 736, 922
3864[6] – SPIRK
4106[4] – GER. 738, 368
~~4106[4]~~
4122[3] – U.S. 2, 339, 927
4122[4] – GER. 738, 091
4122[5] – GER. 735, 662
4778[7] – U.S. 2, 345, 957
~~4790[9]~~
5065[4] – CAN. 421, 168
5385[2] – U.S. 2, 351, 248
5647[3] – HOFER
5648[7] – EIDUS & ELAGINA
5718[6] – MILBAUER
6078[4] – U.S. 2, 353, 600
6178[9] – CHAKRAVARTY & SARKER
6513[6] – THOMSON
6514[8] – LOPMANN

Figure 2. Notation Sheet Supplied Copy Girl to Fill Out Standard Abstract Forms

such an arrangement is made at the conclusion of the search. Also, the references are checked for pertinence and completeness, and each abstract is given a reference number. If the search form of presentation is to be followed, the typist can immediately begin stenciling from the abstract books while the technical man begins preparation of a subject index to the search.

The use of the loose-leaf abstract forms is of particular value in the continuous collection of data for supplements to existing searches or surveys. As two of its services, the information section issues a "Weekly Literature Notification Bulletin," which calls attention to articles of interest in the current literature, and the *Chemical Abstracts* bulletin already mentioned. During the preparation of each, abstract forms are filled out for all articles on subjects for which supplements will eventually be required. In the case of the literature notification bulletin, only bibliographic data are recorded on the forms, but in the case of the *Chemical Abstracts* bulletin, the abstracts are also included. When the supplement is to be prepared, all that is required is to add available material, if any, from sources other than *Chemical Abstracts* and begin typing. Figure 3 shows how selections for supplements requiring search and surveys are made, simultaneously, with selections for the "Weekly Literature Notification Bulletin" and the addition of articles to the section's files. The only time technical skill is required is when the selections are made.

JOURNAL Petroleum Refiner 8-46

Page No.	Weekly Bulletin Subject	Abstract Forms	File
87	Petroleum Substitutes	Synthine	Clip to 98
99	Synthesis, General	Hydrogenation Synthine	Clip to 108
109	Cracking and Reforming	———	———
111	Sweetening and Desulfurization	———	———
115	Cracking and Reforming	Catalytic Cracking	Clip to 118
119	Lubricants, Additives, Lubrication	———	Clip to 129
130	Unit Operations, Misc.	———	———
136	Fuels and Their Additives	Polymerization Alkylation Isomerization	Clip to 142
143	Refining, General	———	———
154	Economics, General	———	Clip to 158
196	Refining, General	———	Clip to 198
200	Cracking and Reforming	———	Clip
200	Isomerization	———	Clip
202	Alkylation	———	Clip
204	Polymerization	———	Clip
206	Refining, General	———	Clip to 212

Inf. Section Form 4

Figure 3. Combining Preparation of Weekly Bulletin with File Expansion Operations

After they are recorded on the form shown in Figure 3, a stenographer fills out the forms, makes additions to the files, and prepares the bulletin. During the page by page check of *Chemical Abstracts* for the abstract bulletin, notations are made of all abstracts to be added to the supplement books on the standardized forms, and this is done by the same stenographer who prepares the bulletin. Figure 4 shows a typical notation sheet for this operation.

Advantages of System

In all the methods mentioned for facilitating the preparation of searches and surveys, the work has been reduced to the stenographic level wherever possible. This is important both to keep the over-all cost down and to conserve the time of the technical personnel for other duties. Technical time has been further conserved by combining functions—

for example, making selections for the supplement abstract books at the same time that the literature notification and *Chemical Abstracts* bulletins are being prepared.

The final test of any scheme, system, or process is—what does it offer? The continuous collection, classification, and filing of literature and patents as outlined in this paper have been found to afford advantages far in excess of the relatively small amounts of time and money spent in its accomplishment.

CHEMICAL ABSTRACTS, SEPT. 20, 1946

PAGE NO.	IDENTIFICATION	CLASSIFICATION
5393[4]	PALFRAY	HYDROGENATION
5442[2]	HOWES	NAPHTHA ISOMERIZATION
5442[5]	MYERS	NAPHTHA ISOMERIZATION
5548[4]	DAVIS	DIESEL FUELS
5552[5]	HILL	CATALYTIC CRACKING
5552[5]	VILAND	CATALYTIC CRACKING
5552[6]	CAULEY	CATALYTIC CRACKING
5552[7]	PETERSON	CATALYTIC CRACKING
5552[9]	FOSTER	CATALYTIC CRACKING SYNTHINE LUBRICANT ADDITIVES SYNTHETIC LUBRICANTS
5553[2]	BERG	NAPHTHA ISOMERIZATION
5554[2]	TAO-SEN KING	SYNTHETIC LUBRICANTS
5554[8]	KAUPPI	SYNTHETIC LUBRICANTS
5556[8]	LAY	CATALYTIC CRACKING
5556[9]	THAYER	CATALYTIC CRACKING
5556[9]	MOORE	NAPHTHA ISOMERIZATION
5557[6]	WARSLEY	SYNTHETIC LUBRICANTS
5558[7]	WARRICK	NAPHTHA ISOMERIZATION
5559[1]	LAY	NAPHTHA ISOMERIZATION
5559[2]	MATUSZAK	NAPHTHA ISOMERIZATION
5559[4]	MATUSZAK	NAPHTHA ISOMERIZATION

Figure 4. Notation Sheet for Making Additions to Supplement Books during Preparation of *Chemical Abstracts* Bulletin

First, and perhaps most important, the existence of up-to-date, comprehensive files, logically classified by an index system, makes possible the rapid preparation of literature and patent surveys directly from filed material without the necessity for searching the abstract journals. The collection of material, which is usually the most arduous step and the step most susceptible to errors of haste and omission, is obviated, with savings of time and money.

Almost equally important, if not fully so, the same files can be used in the preparation of technical papers and books by members of the organization. Here the advantages are manifold; subject classifications may be removed from the files one by one as needed and taken home or to the office for individual use. In many cases, the article file suffices for the work in question. However, the card file is available when more comprehensive coverage is needed. In essence, the card file is a portable condensation of *Chemical Abstracts* arranged by subject matter. Extraction of a subject classification from this file and removing it to the office for study is equivalent to transporting some 40 volumes (or roughly 130 separate bindings) of *Chemical Abstracts* to the same place and then searching them for one subject out of thousands.

How effective the use of the files has proved may be judged from the fact that "The Chemical Technology of Petroleum" was written almost exclusively from them. This book, by W. A. Gruse and D. R. Stevens of Gulf's Mellon Institute fellowship, is widely known and highly regarded throughout the petroleum industry. The work by Gruse and

Stevens is only one example of the way in which the files have rendered yeoman service. Other examples include numerous technical papers and at least one other book.

Finally, the fact that the card, literature, and patent files are up to date at all times makes the issuance of a supplement to existing information, whether survey, article, or book, only a matter of writing. The briefest possible answer to the question, "What does the scheme offer?" is simply time—time saved from laborious searching—technical time conserved for technical work.

Summary

The over-all scheme has been devised purely from the standpoint of the needs of Gulf Research & Development Co. Certain operations, such as the preparation of bulletins concurrently with making selections for the files, have been discussed only to make the Gulf picture complete and to illustrate how time may be conserved in the collection of material for the files by combining this step with other existing operations. The salient feature of the scheme is simply the continuous collection, classification, and filing of the literature and patents. It is this operation which has been found most helpful in the preparation of surveys and which is passed on to others for whatever use they may care to make of it.

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