appropriate—breaking off from a large journal a subject category that in itself is large enough to become a viable journal, while leaving the parent journal still prestigious and viable.

The difficulties of judging how to divide and into how many segments are obvious. The literature is replete with the debris of past errors in judgment, both in unsplit publications and in oversplit publications. However, it is also replete with successful exercises of these judgments.

Facing the need to divide is difficult. It is not surprising that alternative avenues, or delaying tactics, have been explored—and some found. The page charge is such an avenue. So is advertising, when available. But both have limits, since they are voluntarily made available by those who have the funds. Our projections show, though, that the ACS will not approach these limits in the next five or ten years—that is, that page charges, advertising, and subscription prices could hold our system in economic equilibrium without serious difficulty for the next decade.

In the past ten years, we have added 12 journals, only two of which, ES&T and Macromolecules, can be said to represent new areas of chemical coverage. The others are in essence or in reality separation of fields of chemistry from journals covering broader fields of chemistry.

By doing this, we seem to have stabilized our proportional service to members—that is, we continue to see 35–40% of them subscribing to journals. We seem to have found a way to cause our circle of purchasers to grow—not as rapidly as our costs grow, to be sure, but at least the trend is in the right direction.

But this factor alone does not explain our financial stability, as shown in Table V. Here, after repeating some numbers from Table IV, I have added a few facts about nonmember subscriptions. In 20 years, these have increased from 24,000 to 116,000. Even though the number of institutions where chemistry is practiced has increased, it certainly cannot possibly be greater than 30,000 in the world. The likelihood of each of these establishments needing research information is probably less than 50%.

Table V. Member vs. Nonmember Subscriptions

	1933	1948	1958	1968
Journals	3	3	7	19
% Members subscribing	100	60	35	37
Total member subscriptions	N.A.	61061	47622	86445
Total nonmember subscriptions	N.A.	23885	40193	116293
Subscriptions per member subscriber	3.0	1.7	1.5	2.1
Ratio member subscriptions to nonmember subscriptions	N.A.	2.6	1.2	0.75
Average nonmember subscriptions per journal	N.A.	8000	5700	6100

So, by breaking up our general journals into rather more specialized ones, we have not only caused those individuals who buy journals to buy slightly more (2.1 *vs.* 1.5 or 1.7 ten or 20 years ago), but we have greatly increased the relative significance to us of institutions, where price sensitivity is not so great as with individuals. This trend has strengthened the stability of our publishing programs and means that, so long as we publish journals of considerable scientific merit, we have a mechanism to "have our cake and eat it too"—that is, we can pay for our primary literature and yet can offer it in pieces to individuals at prices they can afford.

In conclusion, the problem of the primary literature can be stated very simply as learning when to start the next journal. That is, how to determine which segment of the chemical population is now large enough, active enough, productive enough, and funded enough to support it, and how to define its scope so that it will meet the general criteria for success that can be articulated from experience, while at the same time controlling the size of the parent journal.

Relationships between Primary Publications and Secondary Information Services*

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The information distribution and accessing system which operates in the scientific and technical community is based on three distinct, but interdependent, segments: the primary publications which record the information in discrete, printed packages; the libraries which collect, organize, store, and make available the accumulated primary publications; and the secondary services, each of which provides, for a specified range of primary publications, subject-oriented access to newly available information and/or organized subject-oriented access to the accumulated information store.

For the purposes of this discussion, the information processor is defined as the organization which provides primary and/or secondary publications and services. The information user is an intermediary which collects the output of information processors. The user often generates and uses specialized systems for handling proprietary

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Information processors are developing methods for more efficient information dissemination. The application of computer-based processes to information services has made possible more meaningful cooperation between the primary and secondary handlers of information. A number of cooperative experiments are underway between Chemical Abstracts Service (CAS) and the American Chemical Society primary publications, and between CAS and a Consortium of British information processors represented by The Chemical Society (London). Coordination between these groups can significantly reduce user costs, increase timeliness, improve reliability, and extend the usefulness of recorded information. As these experiments prove successful, they will be extended to wider-scale cooperative activities in order to provide better information service to all segments of the scientific community.

information. A library, if not the core element, is an essential part of a user organization. The information consumer is the individual or group which utilizes the information. The consumer may gather the information directly from primary and secondary sources or obtain it from a user. The consumer, in turn, generates new information to be stored in the system.

Most information consumers must utilize two or more secondary services and several libraries. Despite such dependence upon a variety of information sources, there is very little coordination among primary publications, secondary services, and libraries. In the traditional publication system, each processor has independently established editorial practices, organization of data, timeliness of coverage, and publication formats, and each library has assembled its own unique collection of primary publications and secondary services. Cooperation among information processors has been severely limited in the traditional system by the manual transcription processes which are required to transfer information from one operation to another and which prohibit the economic feasibility of wide-spread coordination. The resulting variations in practice and the imprecision of the recording processes associated with printed publications have, however, caused the information user and the consumer few problems with the traditional system, for the human intellect easily coordinates the use of different manual information tools.

In the developing computer-based information-handling system, however, coordination between component parts of the over-all system must be increasingly automated. Such automation requires fully defined self-consistency within each processor's operations and highly precise recording of the information handled within each component of the over-all information-handling system. Self-consistency within each processor's operations does not imply the same practices for all processors. To exchange machine-language records between two or more processors requires only that each processor operate at the same level of detail and that each operation follow its own defined practices consistently. To illustrate, one processor may depend fully upon ASTM CODEN,[1] consisting of unique five-letter codes for journal titles assigned by the American Society for Testing and Materials; this processor carefully validates his records routinely. Another processor may utilize the CODEN except for 100 titles; this processor has carefully defined the alternatives which he uses, and he also validates his records routinely. These two processors can easily and reliably exchange bibliographic data by use of a machine-stored dictionary for interconversion between those titles for which they use different abbreviations. On the other hand, two processors who do not validate their records to the same level of precision cannot easily or reliably exchange bibliographic data, even though they follow exactly the same abbreviation standards.

New information-handling technology offers many possibilities for improvements in providing the consumer with useful information. Close cooperation among information processors, users, and consumers can lead to the following advancements:

1. Substantial reductions in the duplication of efforts in both processing and utilization of information.
2. Easier processability of the information.
3. Increased reliability of the recorded information.
4. Better access to informational details.
5. More timely awareness of useful information.
6. Improved responsiveness to the consumer's needs.
7. More effective usability of a combination of information tools.
8. Reduced cost of development for a system which covers the full range of science and technology.
9. Better economic performance from the over-all system.

At present, the American Chemical Society (ACS) and other organizations are jointly developing a number of processing interlinkages which are expected to help in achieving such end results. A number of these joint efforts are discussed below. Any of these projects which are successful will be used as models for other interlinks between Chemical Abstracts Service (CAS) and primary publishers, additional secondary services, and libraries.

INTERLINKAGE THROUGH THE MANUSCRIPT PROCESSING SYSTEM

For several years, a number of publishers have been sending to CAS by air mail the corrected page proofs or first issues of those primary publications which are the most productive contributors to *Chemical Abstracts* (*CA*). Such cooperation, in combination with improved author abstracts in many primary publications and adjustments in CAS processing, has greatly improved the timeliness of *CA*.

The next step in the cooperation of primary and secondary processors is to coordinate editorial practices and to directly interlink the processing operations at the manuscript-editing stage of primary publication. An example of the latter interlinkage has been in trial operation for two years. In March 1967, through agreement with Frederick Greene, Editor of the *Journal of Organic Chem-*

istry (JOC), CAS started indexing the primary manuscripts simultaneously with their editing by the ACS production editorial staff for publication in *JOC*. Using copies of the accepted manuscripts, CAS identifies those chemical compounds which will later be recorded in *CA* volume indexes when, following their appearance in *JOC*, these papers are abstracted in *CA*. The CAS Registry Numbers corresponding to these compounds are forwarded to the ACS production editorial staff for inclusion with the original papers in the *JOC* issues.

In theory, it might seem that the addition of approximately 250 *JOC* registrations a week to the very large CAS workflow is a simple matter. CAS staff had, in fact, predicted that *JOC* manuscripts could be processed through the Registry System at such a rate that there would be no delays in the *JOC* publication schedule, and hence little additional composition expense resulting from additions of CAS Registry Numbers to *JOC* page proofs. In practice, however, maintaining control of 250 *JOC* transactions buried in a routine CAS workflow of 8000 to 12,000 transactions a week required several basic changes in the CAS processing system and the addition of some manual steps not initially anticipated. Moreover, printing costs of *JOC* were at first increased significantly by galley-proof changes to incorporate the CAS Registry Numbers. The system has now been adjusted so that CAS supplies the Registry Numbers before the galleys are set up.

An obvious benefit of this experiment derives from the complementary nature of the two editorial processes. The CAS compound registration process is largely dependent upon computer-conducted editing, which provides considerably greater emphasis on consistency of structural and molecular formula data than is possible in a traditional manual publication process. In addition, the CAS indexing operation includes a careful analytical review of the technical content of each paper handled in manuscript form. The following table shows the editorial value of CAS processing of *JOC* papers in 1968.

Papers Handled	1,260
Compounds Registered	13,392
Compound Name Errors Detected	84
Molecular Structure Errors Detected	34
Molecular Formula Errors Detected	224

The number of compounds registered is the total number of compound entries handled. If a compound appeared in two different papers it was counted twice.

Approximately 21% of the compounds were already in the CAS Registry files. There were 790,000 different compounds in these files on 1 January 1968, and 1,021,568 different compounds on 31 December 1968.

The experience gained by this pilot operation will enable CAS to design and build an efficient, economical system to interlink primary publication processing with CAS operations. A new system is to be installed late in 1969, and processing of *JOC* manuscripts should become simple routine in 1970. This kind of processing of original manuscripts will then be extended to other primary publications.

It is important to note, however, that each primary publication which is converted to manuscript handling causes an immediate increase in the CAS processing load, since processing of manuscripts must begin while published primary papers which have already appeared in print are still being processed. Although the increased indexing load is temporary for each primary publication, it is substantial for those journals which publish a large number of papers with many compounds to be indexed. Thus, primary publications must be added to this manuscript system gradually, or the immediate effect will be to slow the production of either the primary journals, the *CA* issues and indexes, or both.

INTERLINKAGE THROUGH THE CAS REGISTRY

The *JOC* experiment illustrates the interlinkage provided to the information consumer as a result of the establishment of the CAS Registry System.[2] The printing of Registry Numbers within an original paper makes possible, through the CAS Registry, the identification of other papers dealing with the same chemical compounds.

Once a Registry Number is assigned to a compound, all of the papers processed into *CA* since 1 January 1965—the date of initiation of the CAS Registry—which record significant detail about that compound are automatically and reliably interlinked in the CAS Registry. Moreover, the CAS file record for the compound includes its *CA* Index Name plus all available corresponding nonindexing nomenclature, as well as its two-dimensional structural diagram, with a full record of its three-dimensional configuration.

When CAS Registry Numbers become more readily available through published Registry Number indexes, these numbers can be expected to appear in a wide range of primary and secondary publications. It is then reasonable to expect that because of the resulting wide availability of Registry Numbers, the high responsiveness of the Registry System, and the machine-checkability of the numbers, Registry Number identification of substances will, in time, be required in manuscripts submitted for computer-produced primary publications.

A fully computer-based processing and composing system (the *CA* Volume Formula Index has been produced by this system since Vol. 66) will provide the basis for the expected publication of Registry Number indexes as part of the *CA* Eighth Collective Index (1966–71), and the likelihood of publication on a volume-by-volume basis of Registry Number indexes starting with the Ninth Collective Period (1972–76). Thus, the value of Registry Numbers in primary publications is greatly enhanced, for the Registry Number can be used in the *CA* indexes to identify directly all papers dealing with that compound.

ADDITIONAL INTERLINKAGES PROVIDED BY SECONDARY SERVICES

The *JOC*/CAS joint development project is addressed mainly to the handling of compounds. A more general primary/secondary subject-indexing interlinkage is being developed through a similar process for manuscript indexing. The ACS primary publications staff and the CAS staff are exploring the possibility of creating volume indexes for primary publications by an automatic extraction of the appropriate index entries from the computer tapes used to prepare *CA* issue indexes. This system could

be based completely on manuscript processing, as is the *JOC* project. Alternatively, the regular printed form could be processed by CAS for the early issues of a given volume of the primary journal. The latter issues could be handled by CAS through manuscript, so that the indexing of all papers in the volume could be completed in time to include a volume index within the last issue of the publication. This project should be in the experimental stage by the end of 1969.

An even more direct linkage to secondary indexes is a possibility for the more productive primary publications. Approximately 250 publications contribute 50% of the journal papers covered in *CA*.[3] For these, *CA* index references could lead directly to the primary publications instead of to *CA* abstracts. This, in turn, suggests either the elimination from *CA* issues of abstracts corresponding to such primary publications or, more likely, the reduction of corresponding *CA* abstracts to only the titles and bibliographic citations of the papers.

As the primary publications are converted to computer-based systems,[4] and as the continuing CAS development of computer systems leads to more timely *CA* volume indexes, *CA* volume index entries will be available in machine-manipulatable form at the same time that issues of primary publications are printed. Therefore, if the expense were justified, the required data could be extracted automatically from the CAS processing stream, organized into an index of chemical compounds, and composed for inclusion in each primary journal issue, or in the last issue of each primary volume as a volume index. On the other hand, there might be little need for a compound index in primary issues if such an index were to appear in *CA* issues almost simultaneously. Thus, *CA* issue and volume indexes would provide effective, timely access to the compounds reported in those primary publications handled through the manuscript system.

Although material will be processed earlier in this manuscript processing system, *CA* indexing timeliness will not improve until the number of papers processed as manuscripts constitutes a significant part of the total *CA* workload. For example, although *JOC* index terms are available early in the *CA* indexing process, they are such a small percentage of the total workload that they can only be stockpiled until other phases of the indexing have "caught up."

Since manuscript processing would not be economically feasible for a large portion of the primary publications—e.g., foreign journals, and journals low in productivity of index entries—which must be processed through CAS operations, a parallel approach must be developed for printed publications in order to improve over-all *CA* timeliness and production efficiency. A computer-based system is gradually being developed for the production of publications and services such as *CBAC* and *POST*. In effect, these services are pilot plants through which CAS is gaining the experience necessary to convert *CA* itself to a single-analysis publication, computer-processed and computer-composed.

A major factor affecting the efficiency of current *CA* indexing is the need to derive *CA* systematic names for each compound indexed. This process will become more efficient as the Registry files continue to grow, because more and more of the required index names will already be in the system and available for use. The CAS Registry, by almost fully automatic processing, converts recorded structural diagrams and nonindex nomenclature to *CA* index names and established index cross-references by recovering such data from the computer files. Index names not yet in the files are generated by chemists. In time, the registration operation is expected to reduce the size of the name-generation task to proportions which can be managed without slowing down the primary publication process. In addition to the expected higher percentages of index name retrieval, the use of more fully systematic *CA* index names in the future offers the prospect, several years hence, of automatic generation of a fair portion of the new index names which must be added to the registry files.

INTERLINKAGES THROUGH THE EFFORTS OF THE PRIMARY PUBLISHERS

Thus far, the discussion has highlighted methods by which secondary processors help provide more thorough indexes to primary publications. There are also several steps that primary publishers can take to help identify indexing points in the papers they publish.

For example, when a fully computer-based primary composition system comes into existence, all of the structural diagrams in the primary publications will be routinely recorded in computer-readable form. At that time, compounds which are to be indexed in primary or secondary publications can be keyed for identification during the primary production processes. The corresponding structures then can be extracted easily and automatically from the full primary text and processed through the Registry System without further keyboarding. This adds the possibility of identifying in the secondary subject indexes the exact points in the corresponding primary papers where each indexed compound is discussed. Equally important, a practice of this kind would provide a compound-indexing depth several times as great as is economically feasible in the present system. Such added depth in indexing of compounds would not necessarily be useful unless computer-based search capability and concept indexing are greatly improved.

With the conversion to a computer-based production system, a primary publication could, as part of its processing operation, identify those data elements which are of use to appropriate secondary services. This would reduce duplication of effort, since most scientific and technical primary papers are covered by two or more secondary services. The data could be extracted automatically by the primary publisher and packaged for delivery to the secondary services at a cost reasonable for both.

INTERFACE BETWEEN CAS AND CS

A major developmental program now being carried on between The Chemical Society (CS) of London and CAS illustrates the potential for cooperation between primary publications and secondary services. *Chemical and Engineering News* reported on this project in the article entitled "ACS, British Link Information System" in the issue of April 28, 1969. For the past 12 months, a full-time CS editorial staff member has been at CAS in Colum-

bus establishing a written set of guidelines for the identification of informational input for the CAS system within the routine editorial processing stream for CS journals. The guidelines are intended to focus on the identification of the items which will go into *CA* subject indexes rather than on their conversion into standard index entries. With the basic chemical journals, the indexing, which is carried out directly upon the original journals, requires the greatest part of the data analysis effort. By mid-1969, CS should be sending CAS marked copy for completion of the indexing in Columbus. Work will start with the *Journal of The Chemical Society, Section C (JCS-C)*, Organic Chemistry. Should this pilot project be successful, a revised set of workable guidelines will be established, and the range of CS input will be extended as rapidly as staff can be trained.

In 1968 the CS helped to found a United Kingdom Consortium on Chemical Information for the purpose of handling chemical information. This Consortium is at present basing its developmental program on established CS programs. As soon as the *JCS-C* is being completely and routinely processed, another journal of a Consortium member, as well as other *JCS* sections, will be entered into the input development project. It is intended that eventually all of the journals, patents, and reports from the UK which are to be input to the CAS system will come from the Consortium operation.

Once a routine input is flowing regularly from the Consortium to CAS, consideration will be given to the possibility of converting part or all of the input to machine language for direct input to the CAS computer system. As the system continues to develop, the Consortium will assume greater responsibility for standardizing the index input. The Consortium and CAS will thus share the responsibility and economic burden for UK input to the CAS system.

CURRENT TRENDS IN PRIMARY PUBLICATIONS

There are several ways in which primary publishers can simplify the handling of publications in computer-based systems and at the same time facilitate for the information user and consumer the concise and correct identification of a desired paper in a given source publication. Nonstandard practices of recording bibliographic citations are common in primary publications. These citations are usually readily interpreted by an experienced consumer or user, but they are often not easily handled by the keyboarder or other worker who must convert extracted references into a standard form for use in a secondary publication or service. Of course, the problem becomes much worse when a primary publisher does not follow a consistent practice in recording citations. Starting in 1967, a number of the ACS primary journals began to carry, on the upper half of the front cover, CODEN with the CAS check digit, the issue number, and the volume number. The appearance of this information in such a prominent place greatly simplifies the processing of journal issues through library, selection, assignment, and keyboarding operations. It also eliminates the possibility of a valid CODEN being copied onto the wrong journal.

CODEN greatly reduce the keyboarding necessary to record the bibliographic identification of each paper covered in *CA*. In addition, this form of citation greatly reduces the size of the stored bibliographic record. CAS has added a computer-calculated check digit to each CODEN. The check digit is recomputed each time a CODEN is keyboarded, so that invalid CODEN can be identified in the computer system. There is the possibility that a valid CODEN may be copied from library files onto the wrong journal. A computer comparison of the CODEN/volume number input against the established computer file of CODEN/volume numbers detects nearly all errors of this type. Coden with CAS check digits are to appear in the 1969 edition of the CAS publication, ACCESS, which identifies all primary publications which have had *CA* coverage from 1907 to date.

The use of computer-calculated check digits is very helpful in the processing of standard citations into a computer system, for it greatly increases the reliability of the recorded data. Unique numbers for individual papers would simplify the processing of bibliographic citations and increase the reliability of the over-all system even more. These numbers could be a combination of volume number, issue number, and individual serial number of the paper, as well as a computer check digit. Patent and report numbers should also have computer check digits. Such practices would somewhat increase the size of the bibliographic record, for the page range would have to be retained in order to simplify the identification of individual copies. The bibliographic number would appear on the first page of each paper. For instance, using CODEN for the publication code, allowing two digits each for the volume number and the issue number, and four digits for the number of papers, the "document registry number" for the fifth paper which would appear in the current volume of the *Journal of the American Chemical Society* would be JACSA95010005h when using the CAS check digit routine.

Another way in which primary publishers could simplify secondary processing would be to routinely acquire and print the full first name, middle initial(s), and surname for all authors. This practice would greatly simplify the building of effective secondary author indexes. Careful coordination of abbreviations for technical terms also becomes essential when machine-language records are transferred among information processors and users.

Two additional trends in primary publication practices and their effects upon the secondary services should be mentioned. One noticeable trend is the increasing number of short papers or communications. Presumably, this trend should result in a decrease in the average number of index entries per paper, but no such trend is evident. On the contrary, the average number of *CA* subject index entries per paper continues to rise steadily. Thus, despite the trend toward short papers, there is no less information being recorded in the primary literature.

A trend which adversely affects access to the publicly available information store is the growing practice of primary publishers to store part of the author's data in a depository. For those who utilize such primary publications directly, the practice presents no impenetrable barrier, provided that the publication identifies the existence of the deposited information. For those who depend upon alerting services for lead-ins, the use of depositories which are identified in the primary publications generally does

not reduce the access to the full record. For those dependent upon indexing services, access to the "deposited" information is generally lost. This is due to the great increase in cost and interruption of workflow which result when indexing services try to routinely obtain copies of the deposited information. The tendency of each primary publisher to establish his own depository amounts to dividing each publication into a publication pair consisting of a formal journal for which routine subscriptions are easily available, and informal copies of deposited material for which subscriptions are unavailable. Control and coalescence of the many separate depositories would be of great value to indexing services.

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The Primary Journal: Past, Present, and Future*

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The historical role of the primary journal as a social institution of science, as well as a communication medium, is discussed, with particular reference to its function as the official public scientific record and the prime mechanism for rewarding the performance of research. The impact of various proposed changes in the role of the journal on these traditional functions is also considered, and predictions are made as to its possible future state in a more computerized world.

Since its inception in 1665, the modern scientific journal has evidenced a startling growth (Price,[1,2] Figure 1). It began with a precursor stage, which seems to be common to most social institutions,[1,2] went through a period of exponential growth, and finally shows signs of saturation,[3] itself the precursor of either stagnation as an institution or transformation into a new institution.[1,2] In order to understand the nature of this social institution called the scientific journal, let us look at its functions (Table I). There are three which are important: The journal is a means for recording information—the official public record; it is a means for disseminating information—a communications medium; however, it is also a means for conveying prestige and recognition—in short, a social institution.

RECORDING INFORMATION—OFFICIAL PUBLIC RECORD

These three functions are now, and have been from the beginning, completely intertwined. To see this, let us look into them in greater detail. The recording function has several parts: that of a formal means of control of quality through the editor-referee system[4] (the "gatekeepers," according to Price[1,2]), and its obverse—the formal means for validating the author's work to him. It supplies an archive, with all of its implications as an educational and historical resource. As a public archive, it is the resource for scientific scholarship out of which come such distillates as compilations and reviews. It is just this combination of the public archive, the formal validation procedure, and the consensus-forming mechanisms culminating in scientific scholarship which, as Ziman[5] has shown, transform mere opinion into what we call scientific knowledge. From the point of view of society, this recording function is of great importance. The last, but very important, aspect of this function is the use of the journal for establishing priority, which, as Merton[7] has shown, is an essential factor in the complex motivation procedures for science.

DISSEMINATING INFORMATION—COMMUNICATIONS MEDIUM

The second function is that of disseminating information. Here also there are several parts. It is a means for communicating scientific information, including tentative information—in order to solicit comment, initiate scientific dialogue; it is a means for disseminating information of interest to scientists: pedagogical, historical, news

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