only 16 miles from Baron’s home town of Gloucester. When Jenner died in 1823 all the well preserved biographical material was made available to Baron.

The Dictionary of national biography says of the resulting book that it ‘is not only a serviceable history of the vaccination movement throughout the world, but is full of human interest of the more homely kind . . . ’.

Modern opinion of Baron’s work is somewhat different, as a recent biographer of Jenner refers to the fulsome adulation expressed in the book.

A short quotation from the index to Volume II might be of interest:—
‘. . . Linnaeus, pious expression of, 316.
Lisle, Mr., 332.

‘Love to God’ appears to refer to a quotation from Jenner’s notebooks on p. 447 when Jenner is speaking of ‘our love of the Divine Being’.

The letter, as can be seen, is addressed to an unnamed dear friend, there is no mention of the indexer in the book, so, therefore, our harried predecessor must remain, as do his successors all too frequently, anonymous.

The MS letter is in the Royal Veterinary College Library. I am grateful to Mr. R. Catton, Librarian, for permission to publish it.

CITATION INDEXING*

John Martyn

American law, like English law, is to a large extent based on precedent. Since 1873 the American legal profession has enjoyed the use of a publication called Shepard’s Citations, which has to a very great extent facilitated the location of legal precedents relevant to a particular case in law. It consists of a listing of individual American court cases accompanied by a note of all subsequent cases which have cited it as authority and whether subsequent cases have reversed or overruled or in any way modified the authority of the decision in the original case.

* A paper read at a Discussion Meeting on January 20th, 1966.

In 1949 a note in the Journal of the Patent Office Society by Arthur H. Seidal referred to Shepard’s Citations and suggested that something of the same system might be applied in the American Patent Office. ‘Thus every patent could be given a separate index card and a notation made upon this index card whenever it was cited by the Patent Office as a reference against a later issued patent. Through the use of this card one could readily ascertain later correlated patents . . . By the use of this method a searcher, who had found a patent closely paralleling the disclosure which he was searching, could rapidly determine the state of the art both before and after the patent, and thereby accelerate his search.’
In 1955 a short article by W. C. Adair, a former executive vice-president of the publishers of Shepard's Citations, appeared in *American Documentation*. Adair suggested that the principle of Shepard's Citations might be applied to other fields, notably to scientific literature. This paper was written at the suggestion of Eugene Garfield who was at the time an associate editor of *American Documentation*.

A little later in the same year Garfield published a paper called 'Citation Indexes for Science' in which he proposed an index which would have the following characteristics: First there would be a complete alphabetical listing of all periodicals covered . . . similar to the *World list* but without the library holdings information. The main portion of the Citation Index would list all the articles in these periodicals which were covered by the index and with the details of each article would appear a note of other articles that had referred to the article in question, together with an indication of whether the citing source was an original article, review, abstract, patent and so on. In effect, the system would provide a complete listing, for the publications covered, of all the original articles which had referred to the article in question. Several other papers by Garfield and others followed in various journals, and in 1961, with support from the National Science Foundation, the National Institute for Health and the Institute for Scientific Information in Philadelphia, an organisation directed by Dr. Garfield, began the work which led to the publication in 1963 of the first issue of the *Science Citation Index*.

Now, as to what a Citation Index actually is. This can perhaps be best explained by showing you how the *Science Citation Index*, to take the biggest and best-known example, is compiled. A large number of journal titles (more than eleven hundred in 1965) is taken by the Institute for Scientific Information and an entry prepared for every paper, editorial letter, communication, review, report and so on—in fact everything except advertisements and announcements appearing in these journals. These entries are ordered alphabetically by the author, with 'See' entries for co-authors, and form the Source Index part of the Citation Index. The characteristic entry will look like this:

SNAPE F
PROC PICK C 93 129 64 6R 21246
FURTHER STUDIES OF THE ECOLOGY OF THE HAMPSTEAD PONDS

Snape F. was the author, we will imagine, of a paper called 'Further studies of the ecology of the Hampstead Ponds' which appeared in 1964 in the Proceedings of the Pickwick Club, volume 93, page 129. It carried six references in its bibliography. 21246 is the accession number assigned by the Institute for Scientific Information to this issue of this particular journal.

The six references cited in this paper by Snape, together with all the references in all of the other papers listed in the Source Index, are taken, and sorted, and listed by cited author and cited reference to produce the Citation Index proper. Let us suppose one of Snape's six references was to an earlier paper in *Transactions of the Pickwick Club*, vol. 1, page 14, by Pickwick, S., in 1827. In the Citation Index we will therefore find this entry:

PICKWICK S...27. TRANS PICK C...1...14
SNAPE F PROC PICK C...64...93...129

Should other authors have cited Pickwick's paper, then they will be listed alphabetically in the same way as Snape under the entry for this paper by Pickwick.

Now let us look at a real entry:
FIG. 2.
Figure 1 is part of a page from the Source Index for the first quarter of 1964 and here you will see we have a paper which has two authors: A. C. R. Dean and Sir Cyril Hinshelwood. You will see that the second author has had his name truncated. They published a paper called 'Some basic aspects to cell regulation' in Nature, volume 201, page 232, in 1964 which had 96 references. The issue number of Nature was 4916 and the ISI accession number was 49833. Now these 96 references have been taken and distributed to form the Citation Index, and this is the relevant extract from the Citation Index.

One of the references (See Figure 2) was to a paper by Midgley in Biochim. Biophys. Acta in 1962, volume 61, page 513. Here you see beneath the reference of this paper a reference to the paper by Dean and Hinshelwood in Nature. You will also observe that Midgley's paper has been cited in the same period by Brown, in the Proceedings of the National Academy of Science in the United States, by Doi in the Journal of Bacteriology and by Moyer in Archives of Biochemistry. You can see that the citations given in the papers by these authors have been sorted alphabetically by the cited author, thus bringing these four references to Midgley's paper together. If you like to think of all the citations used in writing a scientific paper as being to some extent the ancestors of that paper, then we may think of the Citation Index as being a list of ancestors with their associated descendants.

The Science Citation Index, from which I have drawn this illustration, is a multidisciplinary service, including all scientific disciplines in its journal coverage. Other citation indexes have been confined to one subject area, such as the Genetics Citation Index, also produced by the Institute for Scientific Information, in 1963, and the index to statistics which is being produced by Dr. John W. Tukey. Some have been produced as indexes to the material appearing in one journal, the outstanding example being the index to volumes 1-31 of the Annals of Mathematical Statistics. This has a citation index to papers appearing in the Annals, arranged by author, which gives the reference to the paper, a reference to the abstract or abstracts of the paper (eight abstracting journals were searched to provide this), references to papers in the Annals citing the original, and references to papers in other journals citing the original, these last being produced by searching 37 journals in the statistical field, the proceedings of three Symposia, and three presentation volumes. In addition a subject index in great depth to papers and often to the content of specific pages is given, and, a most interesting feature, a 'forwards' citation index, collecting and listing the citations to other journals by authors of papers appearing in the Annals. This index was produced without the aid of a computer. The index to the Journal of the American Statistical Association, vols. 35-50, also includes in its author index a note of subsequent citing papers in the Journal, but in no other journal, and so is on rather a small scale. It also was hand-prepared. Tukey reports two other citation indexes, one a Bibliography of non-parametric statistics, by I. R. Savage, Harvard University Press, containing 'for each item indications of the other items in the bibliography which were known to refer to or, in the compiler's judgment, should have referred to the item in question'; the other is the annual index to IRE Trans. of the Professional Group on Information Theory, 1958 to date, which contains, as an 'Index to Footnote References', an author-ordered list of footnote citations from that volume to all items. A citation index
appears in the *Bibliography of aquatic sciences*, compiled by the Food and Agriculture Organisation. A citation index to the published proceedings of the two UN International Conferences in Peaceful Uses of Atomic Energy was compiled by Itek Laboratories for experimental purposes, and work involved has been reported by Ben-Ami Lipetz. The index is not publicly available. Another index was also prepared by Lipetz in a limited part of the field of physics, in connection with an experimental evaluation of the impact of a citation index.

Finally, the Short Papers contributed to the Theme Sessions of the 26th annual meeting of the American Documentation Institute, in December 1963, published in two volumes under the title *Automation and scientific communication* contains a citation index to all the references cited in the papers arranged by author and giving the full bibliographic details, including titles, of all citations, and additionally a KWIC index to these references. This was prepared on an IBM 1401.

We have seen that citation indexes can be prepared covering a large part of the field of science and technology, or specific areas, or to one journal-series, or indeed to any body of literature. They can be annual, cumulative or ‘once-for-all’ jobs, depending on the nature of the subject and the material. They can be arranged by author, by journal, or even, if specific to a particular journal, by initial page of the cited item, as has been suggested. They are flexible devices and can be arranged in whatever form is most suited to the needs and convenience of the user. They can be prepared by hand, but if they are to be of any size or cover more than a very small body of literature, or if speed of production is important then computer processing is essential.

To demonstrate this last point, we may note that the 1964 *Science Citation Index* has 151,639 source journal articles from 700 journals, carrying a total of 1,789,753 citations, which when sorted and arranged give references to 1,092,384 unique authored items by 323,889 authors.

Machine processing, however, does not solve all the problems, one such problem being that of inaccurate citation by authors. Different journals have different policies regarding references, and where one journal may encourage authors to give full references, showing the cited author’s name and initials, journal, volume, page-numbers, date and full title of cited work, others may drop the initials, title of cited work and journal page-numbers, and of course may very often produce their own version of abbreviated journal title. A surprising number of authors think it adequate to refer to ‘Berichte’, without stating whether *Chemische Berichte* or *Physikalische Berichte*, is meant, or to Ann., meaning Annalen or Annals, without specifying which of the seventy-odd journals, to which the abbreviation could be applied, is meant. Something can often be done by skilful programming to offset the source author’s varied citation habits; if one has three references, one to a paper by SNAPE, tout court, one to SNAPE F and one to SNAPE F H, then if the page, journal and year are the same for the three references, all three will be brought together under the longest entry. But, of course, if an author has used an incorrect citation, citing, for example, a non-existent journal, then this error cannot always be corrected.

Citation indexes have had a mixed reception. My own opinion, based largely on personal contacts, is that scientists are on the whole rather in favour of them, while librarians are much more cautious.
As an illustration of the scientist's view—perhaps an extreme view—Dr. J. M. Hammersley, reviewing the index to the Annals of Mathematical Statistics in Nature, said, 'Librarianship in the future will become a task less for the bibliophile and more for the electronic engineer. With the publication of these indexes . . . the writing is already on the library wall'. Examples of the librarian's view are harder to come by, but a representative view is expressed by E. M. Keen, who wondered '.. whether the citation index would look so attractive if similar effort were being expended on conventional indexes'.

We know that following up references cited in relevant papers is the scientist's most favoured method of obtaining information; it is not therefore very surprising that a device which allows them to follow references in time as well as backwards is greeted with enthusiasm. I suspect that there is another attraction for the scientist. We know too that using a library card index to gain information is second in unpopularity among scientists only to asking a librarian for assistance. (We do not know why this antipathy exists, we only know at present that it does—and deploiring the fact does not change it.) A citation index allows them to attack the literature directly, in a way to which they are accustomed, without benefit of intermediaries, and I believe that this is a factor which possibly influences many scientists' initial acceptance of the Citation Index.

Before we discuss specific methods of using it we must be clear on one point. The Source Index is in effect an author index to all items published in the titles covered by the Science Citation Index in the particular year for which the index is issued, but the Citation Index itself is not an author index, and should not be used as such. It is an index to specific documents which are cited by those other documents which form the Source Index, and is arranged by first author purely for the convenience of the user. It should not be used for compiling author bibliographies, firstly because it lists first authors only, and secondly because a first author's paper will only form an entry if it has been cited by one of the items in the Source Index.

The basic assumption upon which citation indexing rests is that there is some connection between a scientific paper and those other papers which it cites. That is to say, we assume a cited paper and the paper which cites it are roughly dealing with the same subject. This is a considerable over-statement which I shall now qualify.

The author may cite because his paper is a continuation of previous work by himself or by another, or to substantiate or refute previous work, or to compare or contrast the previous work with his own or because he is questioning previous work or applying previous work. He may in the introduction to his own paper be summarising or referring to a large body of previous work—in a sense performing the ritual obeisances to the father figures of his particular sub-discipline. Very often he will be citing previous work as a sort of shorthand to save himself the necessity of adducing proof of a particular point at length. He may, indeed, if not over-scrupulous in these matters, be merely interested in dazzling the bystanders with a display of his own erudition or adding corroborative detail, intended to give artistic verisimilitude to an otherwise bald and unconvincing narrative—but in general a citation implies a relationship between a part or the whole of the cited paper and a part or the whole of the
citing paper. By following the subsequent citations of a paper one is tracing the history of an idea, discovering where and how it has been used or applied and whether it is sustained or refuted or absorbed into later work.

How then is a Citation Index used? The normal approach would be to take a paper which you know to be relevant to your needs and interests and to turn to the Citation Index to discover in what subsequent publications this paper has been cited. If you find it has been cited in later papers you may then turn to the Source Index and look at the titles of these later papers and decide from the titles which of these papers you wish to see. Then you may ‘cycle’. You collect those papers whose references you have discovered, select those which are relevant and look at their bibliographies to find further relevant references. You would look at these further references and select the most appropriate as further entry points to the Citation Index. Thus you will speedily collect a body of literature, which is relevant to your immediate need, by moving from Citation Index to Source Index and back again as many times as need be, at each stage sifting the discovered material for relevance either by scanning titles or the discovered papers themselves.

Human nature being what it is, at this point two questions usually spring to mind. The first question is: ‘Suppose I do not find that my original paper is cited at all. Does this mean that I will find nothing?’ And the second is: ‘If my first paper is cited and I am able to start cycling, does this mean that I am going to find too much?’ To answer the first question it is quite possible that your entry paper has not been cited, although if it were not cited in 1961, 1964 or 1965 (the three years for which the Science Citation Index has so far been published) then this suggests either that your paper is on such a specialised topic that no one else has done any subsequent work upon its theme—which is worth knowing anyway—or that it was not a particularly good paper in the first place. However, all is not lost. Your entry paper itself probably has some references appended to it and these themselves may be used as entry points to the Citation Index. You may find on looking at the Index that the particular paper you have in mind has not been cited but that some other papers by the same author have been, and you may be able to decide that one or more of these will serve as a suitable starting point. Generally though, if you are beginning a search on a specific subject it is unlikely that you have only been able to find one key reference as an entry to the index.

On the second point, that of finding too many references of varying degrees of relevance, we must not forget the ability to filter the returns according to our particular needs by using either the discovered titles or the discovered papers themselves. The fact that a fairly large number of references may be discovered is not in itself a bad thing. All we are doing when we are using a published index is to select from the enormous library gathered by the whole index, a sub-library of material of greater specificity to our needs than the whole, which in almost all cases must be subject to some evaluatory process carried out by the person whose information need is the subject of search. For example, if we enter the Citation Index with a paper dealing with a certain experimental technique, we would expect to find a number of papers concerned with the applications of that technique, some concerned perhaps with modifications of it, some with further
associated techniques, one or two perhaps refuting its validity. A manufacturer of apparatus might be more concerned with different applications, an experimentalist with allied techniques, other research workers and naturally the original worker himself with modifications of the technique, and presumably everybody in possible refutations. The point I am trying to make is that having gathered a body of literature, which is in a broad sense about the specific topic, then part of that body will be relevant to some enquirer, other parts to other enquirers, and however refined the type of indexing applied it seems to me over-idealistic to expect to be able to present a seeker after information not only with all the information he requires but also with only the information he requires. What is noise to some is very relevant to others.

I have reported elsewhere the results of some small-scale tests of the performance of the Science Citation Index, and I shall not this evening repeat the figures I obtained. Instead, I shall give you some opinions, based on studies made by myself and others. In terms of information retrieval on a specific subject, whether the subject is defined in words (as it must be to approach the subject index of an abstracting service) or in citations, the Science Citation Index performance is comparable to that of one of the larger abstracts journals; a real comparison is not strictly practicable, because citation indexing is more flexible than a formal subject index, and because the types of information produced by the two sorts of index are not the same—it is rather like trying to compare kippers with bananas, but to pursue this analogy, kippers and bananas are both foods, and it is possible to say to what extent one finds each satisfying. I think I have already demonstrated, in reporting on some tests of abstracts services carried out at Aslib, that no abstracts service is comprehensive, and that to approach even 90% coverage of a topic it is necessary to use a number of services, each of which adds a little more to the total. Similarly, some unique items would always be added to your search product by using the Science Citation Index, and taken on its own, one could expect to find a satisfactory proportion of the total sought.

Where the Citation Index scores over an abstracts service is in its interdisciplinary nature. Because its source journals cover the whole field of science, it is not bound as are most abstracts services to one discipline, and consequently may not only be expected to provide a reasonable coverage of many disciplines but also can indicate the links between disciplines, the 'cross-fertilisation' effect of an idea originating in one branch of science which is applicable or useful to another.

It must be remembered, though, that a Citation Index is essentially only a guide to the existence of information and not a container of information in itself, in the sense that an abstracting service is. Whereas a volume of abstracts may serve in some cases as a substitute for original documents, this is practically never true of a Citation Index. The Citation Index is a tool which can only be exploited to the full in a large library, or in a situation where the user has access to a large library. Ideal situations in which one might hope to find a Citation Index are the Patent Office Library and the Science Library—neither of which has one—or in a university library. However, as the existence of the National Lending Library makes an extremely large collection available to all, there is no reason why a Citation Index should not be useful in smaller libraries.
I am sure that I could not find a better audience to which to express the view that normal subject indexing is an intellectual process, and I hope I shall not be misunderstood when I say that to me one of the attractions of citation indexing is that it is not. What I mean by this is that citation indexing of documents does not require the same analytical effort as normal indexing. If citation practice and journal title abbreviations were standardised, citation indexing would be an essentially clerical process, and if, as Tukey and Waldhart suggest, a Permutated Title Index to the source citations were added, it would still remain a clerical job. Given the computer programmes, and some high grade clerical effort in the initial preparation of the input data, very large numbers of documents can be indexed by machine methods, very quickly. If this discourages you, remember that citation indexing is not a substitute or replacement for conventional indexing; it is a new form of indexing in its own right, and is an additional and parallel means of access to the literature. And as one can only apply it to material which carries citations, it will not be applicable to a large proportion of published books.

What will be the future of Citation Indexing?

One recent development is that the Institute for Scientific Information is offering an Automatic Subject Citation Alert service, ASCA. Subscribers to the service submit a profile of bibliographic citations reflecting their subject interests—they pick, say, fifty papers in their own field which they consider to be very much on their principal subject interests—and they receive every week a computer printout describing every current item in the ISI coverage that cites any of the question-citations in their profile. (They may also use as profile items the name of an author, whether first author or no, the name of an organisation, the name of a patent assignee, or a US Patent Class.) This is considerably cheaper than a subscription to the Science Citation Index, and being a weekly service, more up-to-date. As the ASCA service and the Science Citation Index are produced from the same data, the one may be considered as an extract from the other, tailored to the individual user.

Another interesting use of citations has been their use as one of the means of access to the literature store of the Massachusetts Institute of Technology Technical Information Project, under the direction of Dr. M. M. Kessler. Very briefly, this is a computer-stored collection compiled largely from the periodic physics literature. For each of the articles in each of the twenty-one journals the location of the article (journal, volume, page) is recorded, the title, authors, the institutional affiliation of the authors, the citations (journal, volume, page), the location of the article in Physics Abstracts (when this information becomes available), and subject-index information if the latter is available from a published source. The above information is punched on cards, verified, edited, and transferred to magnetic tape for permanent storage. This tape is then edited by the computer to detect clerical errors and transferred to an assigned location on the computer disc memory where it is immediately available for manipulation or search.

'The computer facility at the project's disposal is an IBM 7094 operating in remote, time-sharing fashion. This facility is itself an experimental project (Project MAC). It consists of a central computer with 100 remote consoles having access to its facilities. The consoles are standard
teletype machines presently distributed at various locations around the MIT campus. Contact with the computer is by means of ordinary telephone connections. The 100 consoles are available to perhaps 400 people who can at any time try to use the computer on a time-sharing basis. As many as thirty people may use the computer at the same time.'

By making requests to the store via one of the consoles, access may be had to the literature, using authors' names, words in titles, journal volumes and so on, or by using a citation to demand all papers in the store which cite a specified document. The response to this last query will be a list of journal papers, so that the output from the console looks very much like an entry in the citation index. Further description of this system can be found in the various published papers of Dr. Kessler.

This evening I have told you what a Citation Index is and a little about its performance characteristics. I have not said much about how it will be used in practice, because citation indexes have not yet been available for long enough to enable us to assess their impact on literature-use habits of scientists and information workers. There is another aspect of citation data which I have not touched on at all; this is their use in historical and sociological studies of science itself. It will be obvious to you that citations provide a powerful tool in the study of networks of scientific papers, and consequently in the study of the development and ramifications of scientific thought and progress. I feel that its possibilities in this direction, discussed by Dr. Garfield in a recent report, 'The Use of Citation Data in writing the history of Science', and by Professor Derek de Solla Price in several papers notably 'Networks of Scientific Papers' in the journal Science last year, have still barely been explored, and many uses remain to be found for this fascinating and valuable source of data. But this is to touch on a hobby-horse of my own, and a hobby-horse which I shall not ride tonight.

A Short Reading List on Citation Indexing and its Uses

Garfield, E. 'Citation indexing: a natural science literature retrieval system for the social sciences.' American Behavioural Scientist. VIII, June 10th, 1964, 58-61.

Garfield, E. 'Science Citation Index—a new dimension in indexing.' Science, 144, 3619, May, 1964, 649-654.


Kessler, M. M., Heart, F. E. Concerning the probability that a given paper will be cited. Massachusetts Institute of Technology, November, 1962.


Pipetz, Ben-Ami. 'Evaluation of the impact of a citation index in physics.' American Institute of Physics, September, 1964.

Price, D. J. de S. 'Networks of scientific papers.' Science, 149, July 30th, 1965, 510-515.

Waldhart, T. J. A preliminary analysis of the Science Citation Index. Thesis on microfilm, University of Wisconsin, 1964.


Effective use of the Science Citation Index. A programmed text. Philadelphia, Institute for Scientific Information, 1964.