

WAITING FOR MR. KNOW-IT-ALL

OR

SCIENTIFIC INFORMATION TOOLS WE COULD HAVE NOW

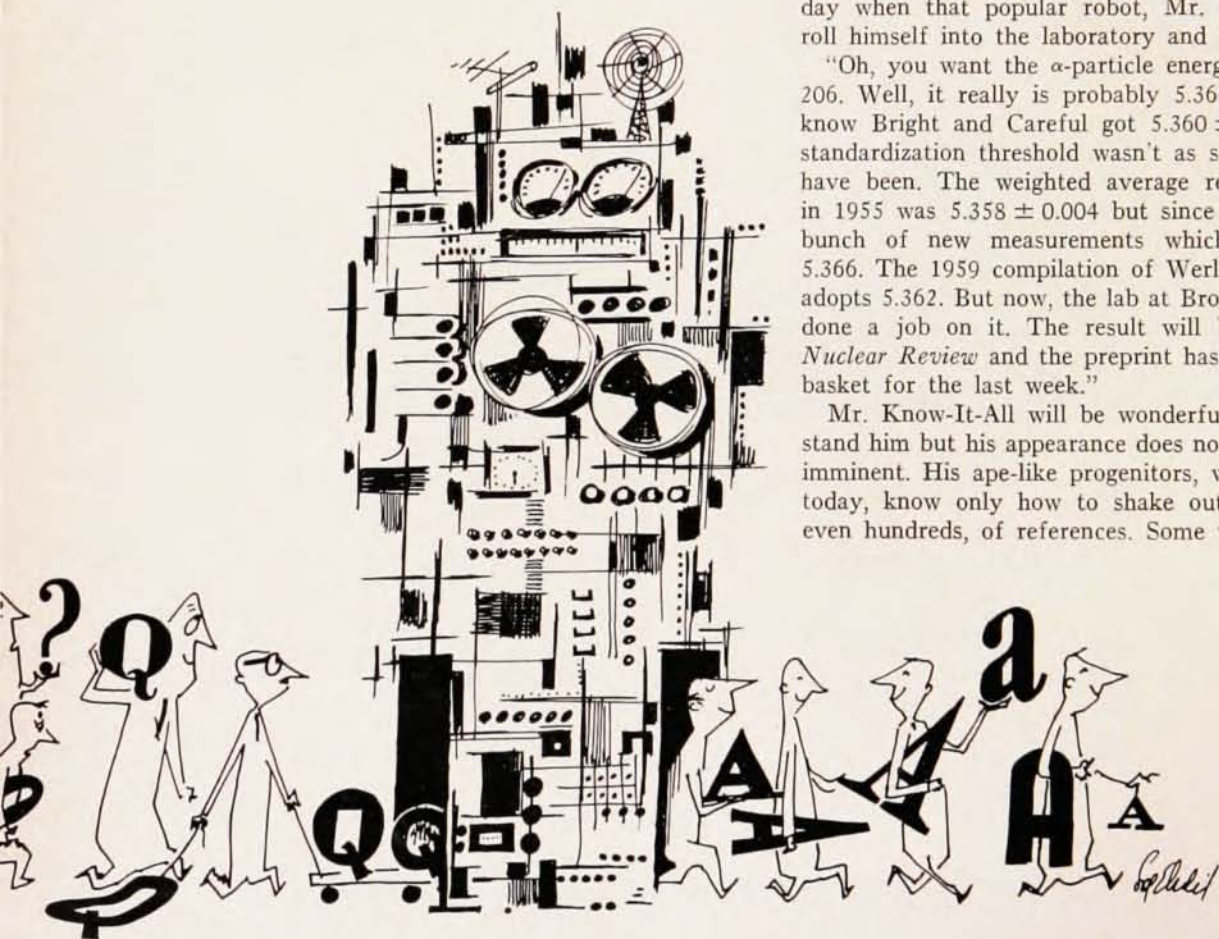
By K. Way, N. B. Gove, and R. van Lieshout

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THE *New York Times*¹ and Senator Humphrey² have been talking about the plight of the poor scientists who find it easier to measure a quantity than to locate the results of earlier experimental work in the library. But instead of making a straightforward attack on the problems of handling the data explosion, everyone seems to be standing by for the day when that popular robot, Mr. Know-It-All, will roll himself into the laboratory and speak as follows:

"Oh, you want the α -particle energy of coloradium-206. Well, it really is probably 5.364 ± 0.002 . Yes, I know Bright and Careful got 5.360 ± 0.001 but their standardization threshold wasn't as sharp as it should have been. The weighted average reported by Riggs in 1955 was 5.358 ± 0.004 but since then there are a bunch of new measurements which cluster around 5.366. The 1959 compilation of Werlman and Leeberg adopts 5.362. But now, the lab at Brookridge has really done a job on it. The result will be in the March *Nuclear Review* and the preprint has been in your 'in' basket for the last week."

Mr. Know-It-All will be wonderful if our egos can stand him but his appearance does not seem to be very imminent. His ape-like progenitors, which are with us today, know only how to shake out dozens, perhaps even hundreds, of references. Some will even produce



dozens or hundreds of photostats or microfilms of the papers themselves. A researcher generally by-passes these monsters and pesters his friends till he finds someone who can say, "Oh, there was a critical review of that topic in 1959 and there have been only two papers since. All you really need are these three things."

ANNOYANCE with the pithecanthropes and hope for the early emergence of Mr. Know-It-All has kept many scientists from thinking about tools for obtaining scientific information that can be forged right now. The Nuclear Data Group members,³ however, being partly physicists, partly information purveyors, have naturally tended for some time to think of means of simplifying the work of all data users and collectors. We have come up with suggestions for five tools. None of them is very new or startling, but taken all together they could bring about a change of an order of magnitude in the ease with which a scientist can keep himself informed today and even tomorrow.

The suggestions are based on the concept of the organization of scientific information diagrammed in Fig. 1, which shows in a very rough way the steps by which information gets reported, collected, fitted by theories, analyzed, digested, and finally incorporated into the framework of physical thought.

The first and fundamental step consists of accounts of original experimental and theoretical work set forth in progress reports, talks, and journal articles; the second, of compilations of experimental data and tables of the calculated values of various functions, such as angular distribution coefficients, suggested by the theorists and needed for the interpretation of observations. Work in the second stage has a strong feedback with that in the first, often stimulating new experiments and theories which must be incorporated into new tables and compilations before a meaningful trend is visible.

In the third stage, review articles appear. These put together data and theories and often come up with a working model, a handy description, sometimes a genuinely new insight. In the fourth stage, the experimental data and the theories tend to get separated again. The book or treatise which presents the physical ideas in an integrated framework often does not have space for all the numerical results. These, in the meantime, have been criticized, checked, reviewed, and finally frozen into a "critical" table.

Except in fields which are just opening up, all stages of information organization are present at all times. Each stage really interacts directly with all the others. Not enough arrows could be drawn on the diagram to show this. For example, good review articles stimulate new theories and experiments; a treatise often shows for the first time the limitations of current theories and inspires new ideas; a critical table sometimes reveals fundamental inconsistencies in a set of

related values which starts immediately a whole new round of measurements.

A scientific worker usually knows what degree of information organization he needs for a given purpose. The man concerned with the success of various models in accounting for nuclear magnetic moments wants a review article on nuclear models. The theorist with a bright, new idea wants a critical table of moments with which to compare his calculations. The designer of a new experimental technique may need to know all the recent results for the magnetic moment of Br^{79} and so desires a compilation of experimental results.

These three scientists do not fare very well today if they turn to the indexes or abstract journals for help. A well-known review article entitled "Theories of Nuclear Moments" isn't listed in either *Physics Abstracts* or *Nuclear Science Abstracts*.^{*} *Physics Abstracts* gives no clues for locating a collection of values of nuclear moments. *Nuclear Science Abstracts* lists a book on nuclear moments but does not mention the fact that it contains a critical table of moment values. Neither journal (undoubtedly for the most justifiable reasons) contains any reference to the only existing recent compilation of magnetic-moment values in a review article in the *Handbuch der Physik* entitled "Nuclear Magnetic High-Frequency Spectroscopy". Our suggestion for Tool 1 would rectify this unhappy situation.

Tool 1: An abstract journal or index which covers material in all stages of information organization and identifies the stage, according to Fig. 1, to which each work belongs. The *Handbuch* article just mentioned would appear with the labels "Compilation" and "Review" while the book would be designated "Critical

^{*} Note added in proof: It has been pointed out to us that the review paper "Theories of Nuclear Moments" was abstracted in *Nuclear Science Abstracts*. However, the author's name is missing from the cumulative author index, which accounts for the fact that this paper was not found in our search.

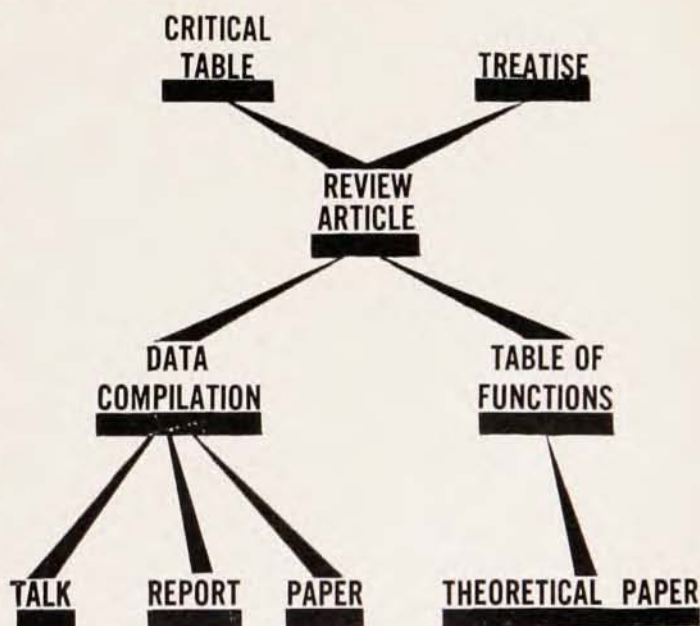


Fig. 1

Table" and "Treatise" to show that it contained both experimental and theoretical material in the highest stages of organization. Of course, suitable abbreviations would have to be found for these terms.

In some fields, directories to compilations exist.^{4, 5} If compilations were labeled as such in abstract journals and indexes, the preparation of such directories would be a far easier task; in fact, they could probably be made entirely by machine.

At present, compilations are often extremely difficult to locate. They seem to have a tendency to get published in peculiar or obscure places. In the literature of science, they are the stepchildren. Note the following:

1. Compilation of Thermal-Neutron Capture Gamma Rays, CRGP-784, 146 pages (1958)
2. Energy Loss and Range of Charged Particles in Organic Solids and Aluminum, E. I. Du Pont de Nemours and Co. Research Report, 33 pages (1957)
3. Tabulation of Radial Coulomb Integrals, AEC Report LA-2106, 120 pages (1957)

How long would it take your librarian to produce these? The obvious suggestion is the following:

Tool 2: More journals devoted to compilations and numerical collections. At least one such journal already exists, namely the *Journal of Chemical and Engineering Data*, which is issued quarterly. It seems that in nuclear physics alone there would be room for a quarterly. A library search showed that in the years 1957, 1958, and 1959 there were published, respectively, 49, 36, and 34 short* compilations and tabulations in this field. The page numbers for the same three years were 2214, 2421, and 1219.

The goal of the next suggestion is to make life easier for compilers and for those who want to find out what has been published in certain fields since the appearance of a compilation.

Tool 3: Content-labeling of research papers according to topics selected by scientists in different fields. This would be a categorization according to subject matter (angular correlation, reaction energy, half-life, etc.) rather than according to degree of organization. The idea is to have the *active scientists* in each field select the topics which are of live interest and to print these as "key words" just after the author's abstract. Determination of key words by active scientists would result in great "depth of indexing" in some areas, great shallowness in others. This is just what is needed in the different scientific fields. Control of the system by the people who are developing the fields will make sure that depth of indexing increases as each field develops and in directions in which there is real demand. The desirable thing is, not to have a classification system which is especially neat or elegant in an abstract way, but to have one which everybody will use.

The key words, requiring one or two lines of fine

* Less than 300 pages.

type per article, would bring a new freedom to all the physicists who have learned that they cannot trust the title of the author's abstract for complete information and who, therefore, today scan hundreds of papers in dozens of journals for new results on the topic they are studying (the decay of Ce^{139} or the quadrupole moments of rare earth nuclei).

The selectors of the key words, the "keepers of the keys", would have to be a most approachable and broadminded group of fellows, responsive to new ideas and new interests. Probably their lists should change annually. Once these have been prepared the problem of assigning the proper key words to a given article would not be an onerous one. It would have to be done by physicists but there is always one physicist who knows what is in a particular paper without even reading it, and that is the author. He not only knows exactly what it contains but has a real interest in seeing that it is labeled so that it will come to the attention of interested colleagues and compilers. The labor would be slight. The list of key words in the proper field could be sent by editors to the author who would merely check off those appropriate for his manuscript.

Why not just see that this information gets into the abstract or the title of the paper? The answer here is that this would be at least an order of magnitude harder than the execution of the above suggestion. Moreover, having the key words easy to find at the end of the abstract may have definite advantages. Examples of key words or symbols for low-energy experimental nuclear-physics papers might be:

$Hf^{176}(p,p') \gamma$, $B(E2)$; $Eu^{145}T_{\frac{1}{2}}$, γ ; $Ca^{40}(d,p) Q\beta$.

Content labeling should, of course, be applied to theoretical as well as to experimental papers. Besides helping those who search the current journals for new information on special topics, the key words would form the basis of useful tools which could be produced by today's machines.

Tool 4: New indexes made from the key words. These could be prepared in many forms once the fundamental work of categorizing had been done. Lists could be made, tapes could be punched, cards run off and sorted. Central bureaus could work out machine methods to prepare collections for subscribers or special requesters. Such indexes would take much of the drudgery out of compiling. New compilers would spring up to organize the data in areas not now touched; existing groups could speed ahead. The important thing would be always to have the list of key words up to date and even ahead of the times.

Retrieval of papers through use of the key words would be far more efficient in serving scientists than retrieval through permuted words in titles or words selected from abstracts since the topics covered by the key words would be chosen by active scientists and the papers would be categorized by other scientists (the authors) intimately aware of their contents. The

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documentalists would be *sure* that the topics chosen to be designated by key words are those in which the scientists of the day are keenly concerned. They would also *know* that any new information on one of these topics would be signalized by the appearance of a key word after the author's abstract. They could thus proceed without further work to use retrieval systems with confidence that they would be retrieving things on topics really wanted and that their coverage would be complete.

What about topics whose importance is not realized at first? The only answer here is that we ought to be somewhat better off than in the past. Since experienced scientists would be designating the topics, they could be expected to see ahead scientifically a little farther than the documentalists. "Polarization of reaction particles" might be designated by them as a separate topic when only one or two papers on the subject had appeared. In the case of a real blind spot, searches under some general topic would, of course, be necessary but such cases ought to be fewer than in the past.

Our final suggestion is to apply the new technique of card photography to the composition of abstract journals. If the editors of the world could agree on a common format for authors' abstracts (plus key words, plus stage of information-organization label), abstract journals could be composed photographically even before the primary journals appear.

Tool 5: Quicker abstract journals. A special section of the *Physical Review Letters* now contains abstracts of *Physical Review* articles that are still in press. The same sort of thing could easily be done for all journals if a uniform international style (for abstracts only) were adopted. Actually, only the dimensions and the order of the material (title, author's name, journal name, etc.) need be standardized. At the time the journal is in the process of being printed, the standardized authors' abstracts could be run off on cards; batches of cards could then be sent from every journal to the appropriate abstract journals, where they could be sorted and arranged in any desired manner. One of the newly developed photographic techniques for composing pages from cards would do the rest. Libraries and individual scientists might even want to subscribe to collections of the abstract cards as well as to the journals.

Abstract journals which try to improve on authors' abstracts would still be free to do so. Such journals would appear later than the photographically composed "quickies" and would be more expensive, but often they would be worth it. It is readily granted that authors' abstracts are sometimes far from perfect. But real improvement of their content will be a far bigger job than standardization of their form. A major step forward will require specialists in abstract writing who will work in collaboration with authors. A few such specialists are already beginning to appear⁶ but many will be needed. Moreover, they will have to become accepted and even viewed with gratitude by scientists.

TO summarize, our five proposed new tools are:

- (1) Identification of the stage of information organization to which a scientific publication belongs, according to Fig. 1, and exhibition of the stage (or stages) in abstract journals and indexes;
- (2) More journals devoted to compilations and numerical collections;
- (3) Content-labeling of research papers according to topics or key words selected by scientists in different fields;
- (4) New indexes made from these key words on cards, tapes, or lists;
- (5) Abstract journals made photographically from authors' abstracts with the stage-of-organization labels and the key words attached.

The most novel feature of these suggestions is perhaps that they imply collaboration between scientists and information specialists. The cleavage between these two groups is wider than the division between scientists and humanists which has been so vividly described by C. P. Snow.⁷ Apparently the rift got started long ago when scientists shrugged off information problems as little matters which could be handled satisfactorily in any one of a number of ways and were, therefore, of no great interest. The information people then solved them as best they could, but, as things grew more complex; the solutions were not always to the scientists liking. However, they usually managed to get what they needed, often by adapting simple tools and bypassing the complicated systems which were evolving. Many documentalists pretend not to notice this, others make studies to discover the habits of scientists as though they were bright dolphins who could be watched but not questioned. But apparently little thought has been given to enlisting their collaboration on problems whose difficulty and interest have now become undeniable and whose successful solution is fundamental to future scientific progress. Instead scientists are dissociating themselves more and more from information problems and documentalists are spiritedly designing systems for the use of creatures with whom they have practically no contact.

Some brave souls are needed to step in and break this trend. The two groups need each other very much today, but a determined effort will be necessary to start patterns of real cooperation. The planning and creation of our five tools, or something like them, might provide a good beginning.

References

1. Science Overwhelms the Scientists, Leonard Engel, *New York Times Magazine*, Oct. 1, 1961.
2. Humphrey reported that information services "are often so weak, or are presumed so weak, that innumerable scientists and engineers state that it takes less time to perform research than it takes to try and find if the research has already been performed". *Washington Post*, Oct. 5, 1961.
3. The ideas presented here have evolved through many discussions, particularly with C. L. McGinnis, R. Nakasima, G. H. Fuller, and F. Everling.
4. *Directory to Nuclear Data Tabulations*, R. C. Gibbs and K. Way, 185 pp., 1958; Supplement, 1959 *Nuclear Data Tables*, pp. 1-38. Both US Government Printing Office.
5. *A Directory of Continuing Numerical Data Projects*, Office of Critical Tables, National Academy of Sciences-National Research Council, August 1960.
6. As is shown, for example, by abstracts in *Nuclear Engineering Abstracts*, a Silver End Documentary Publication, London.
7. *The Two Cultures and the Scientific Revolution*, C. P. Snow, The Rede Lecture 1959, Cambridge University Press.

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