Achieving a More Disciplined R and D Literature*

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One way to help control the growth of engineering and scientific literature and the associated problems of information retrieval is to start at the source—to seek simple but powerful ways of increasing the efficiency of papers during the writing. Some specific methods of structuring journal manuscripts are shown in which the original, important portions of the text and selected illustrations are deliberately expanded, while others are de-emphasized by devoting less space to them. The new methods involve using a three-sentence abstract of special structural style and high information content; illustrating the most significant technical contribution by means of a prominent figure; and scaling the size of text sections according to relative importance.

In today's world of proliferous publication, the journal literature of science and engineering, which traditionally has been characterized by logical and factual writing, needs a new writing discipline. The classical structure of a research or development manuscript still has a certain validity—an introductory portion showing background and purpose, a theoretical development, an experimental verification, and a summarizing discussion or conclusion. This general type of structural form has served well for several centuries, but the current problems of disseminating and retrieving journal information demand more efficient ways of shaping a manuscript from these structural elements.

The information problems have inspired a number of techniques[1-5] for handling the huge bulk of modern journal literature:

1. Index terms for clarifying and retrieving technical data.
2. Reader-interest profiles and selective dissemination of abstracts.
3. Use of a standard documentary unit with each paper to aid indexing, searching, and retrieving.
4. Private circulation of manuscripts and preprints.
5. Manuscript repositories and special distribution to certain classes of users.
6. Automation of typing, printing, storing, and retrieval of literature.

None of the above methods, of course, attempts to improve the communication efficiency of the manuscript itself. The approach discussed in this paper, on the other hand, is to tackle those information problems at the source—i.e., during the writing of a paper. The methods proposed here, however, are unconventional and are unlike the following typical criteria for sound writing which are widely cited in the literature:[6-10]

a) Use simple language for readability.
b) Develop a sound style of technical exposition.
c) Create a logical flow of technical information.
d) Consider the reader's interests and his technical level.

Although these standards for good writing are widely recommended in the literature of technical writing, they fall short of filling the modern need for a literary structure chosen for maximum information content. How can one construct a journal paper that has the most technical information for a given length? Word economies help writing efficiency, but more important is careful planning of the over-all structure of the manuscript.[11-15] The "reader-oriented" structuring technique fills a special need in modern technical literature.[16-18] This paper suggests some new structural forms for a full-length paper, in which significant concepts and data are emphasized while lesser portions are subordinated.

Such a manuscript will have the decided advantage of offering information in a useful, interesting form without the degradation of content brought on by using short words, short sentences, nontechnical language, and other stylistic panaceas for "clear" writing.

The special structural styling of technical information to be proposed here would seem to be an aid to the burdened readers of today's journals. Equally important, however, the new structures are intended to improve the intrinsic quality and value of research and development papers.

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THE AUTHOR-WRITTEN ABSTRACT

Since the abstract that precedes a paper in most professional journals of the engineering and scientific societies is the focal point of information, its structure deserves very careful consideration. As the bulk of technical literature grows, the quality and utility of abstracts become more and more important. When computers are used in certain information systems to search for technical content, information "noise" in a poor abstract is an unnecessary complication. Standards for the content of abstracts are surprisingly diffuse and the adequacy of an author's abstract is generally left to the judgment of the journal editor. Length varies anywhere from perhaps 50 to 500 words.

Regardless of the standards of a particular journal, one of the curious aspects of writing an abstract is the effect on the author. Constructing a brief description of the essential content is usually a challenge—a needed intellectual exercise—even a *discipline*. Here the author must divorce all his thinking from wordy or roundabout exposition and must come directly to the point. The shorter the abstract, the greater the disciplinary effect on the author! A *terse* abstract has another peculiar benefit—it gives the reader a quick insight into what the paper contains, filling a real need for those who scan the journal literature. The scanners are those who might benefit most from an author's abstract, and they far outnumber those who will read the entire paper. I would estimate the scanner/reader ratio for a typical journal paper to be from 5/1 to 10/1. The short abstract, packed efficiently with pertinent information, has much in its favor, particularly since abstracts longer than about 150 words tend to stray from the main point of the paper. A 500-word abstract frequently becomes diffuse.

For these reasons, an abstract should be constructed from the elements which all readers look for, and peripheral explanations should be omitted. The basic elements, considering all types of technical literature (theoretical, experimental, analytical, reviews, surveys, etc.), are the nature of the problem studied, the approach being described, and the results obtained. From these common denominators, we can construct a three-sentence abstract that will apply to practically the whole realm of technical literature. An abstract of this kind will answer in some way each of the following questions:

1. What is the problem being discussed in this paper, and what is the scope of the treatment (theoretical, experimental, or both, or an application of the concepts described)?
2. What is the author's unique approach or his important contribution, and is it primary information, a review, or tutorial material?
3. What is a principal result or a typical application? (This statement should be *quantitative*.)

This type of abstract has maximum utility and minimum length. We offer this structure as a basic guide which will force an author to indicate the actual content of his paper.

At the same time, such a structured abstract is the test of a good paper. If a research or development manuscript, for example, is so disordered and nondescript that these questions cannot be answered, the chances are that the paper is not worth publishing. The questions, of course, need not be slavishly answered in any given order (an interesting approach to a "reader-oriented" order, however, is suggested by Weil *et al.*[19]), and the sentences may well be full of qualifying phrases and clauses. The well-written, well-thought-out trio of sentences will give a clear view of the manuscript, however difficult the abstract may be to write. The abstract for the present paper is an example of the proposed structure.

RELATIVE LENGTH OF MANUSCRIPT SECTIONS

We have suggested how an efficiently constructed abstract can immediately show the nature of an author's contribution to the literature; similarly, the character and quality of the paper itself are revealed by its structural form. A diffuse or weak organization gives an impression of uncertain results, while a well-balanced literary construction will inevitably display the author's work to best advantage.

However, even with careful refereeing and editing, journal papers will frequently have sections whose lengths are all out of proportion to their significance, thus weakening the manuscript. The longer sections, for example, might well be the parts of an author's work that he finds easiest to describe and, instead of offering proper support for the rest of the paper, these portions can be merely long-winded and tedious. An example of an overly long section might be the one describing an author's experimental method. Some portions can often be shortened by using literature references to well-known laboratory techniques. Sometimes an author, under the delusion that he is making his experimental results reproducible by describing the detailed technique, is merely regurgitating widely published laboratory methods and is actually weakening his manuscript with misplaced emphasis.

On the other hand, the shortest section of a paper (and the least developed) is sometimes intended to be its most significant contribution. Such a section can suffer—and frequently does—from insufficient discussion and interpretation, to the disappointment of the reader who has waded through routine descriptive material to find the author's main result! Referees and editors are the traditional guardians of proper balance among the various sections of an engineering or scientific manuscript. Standards and judgment on the relative proportions of a manuscript, however, do vary considerably among various journals.

Most editors will agree, nevertheless, that the common symptom of a weak manuscript is poor over-all structure in which the exposition is out of balance and the wrong aspects are emphasized. But do we always equate length with relative importance? Perhaps not in nontechnical writing, where a short sentence or short paragraph is sometimes used for emphasis. In scientific literature these literary devices are not so effective because the technical reader demands more textual substance for the important points. Since he looks for support and evaluation of technical ideas the rhetorical tricks of emphasis will not impress him—they are inherently artificial.

In fact, a technical manuscript in any discipline of science or engineering can be improved by scaling the length of its various sections according to relative

importance. If the main derivations, results, examples, and discussion are expanded and the less significant textual material is carefully compressed in length, the paper tends to improve in readability and to be more convincing in its presentation.

One might argue that a good paper can have a short theoretical treatment and a long detailed section on experimental results. I would agree that this is a sound structure but only if the paper does not masquerade under a title claiming it to be a theoretical paper. Moreover, the author's abstract should not imply that his theory is the more significant part of his manuscript. On the other hand, in a theoretical paper an author should explain his concept, set it in the framework of previous theories, develop it fully, explore its limitations, discuss the implications, and show the true nature of his contribution in the context of what had already been known and understood. A shorter section devoted to experimental confirmation (if any) would then emphasize the magnitude of his theoretical contribution.

From these considerations, we can see that the character of an author's work tends to be colored by the relative proportions of his manuscript, and I propose that editors and referees add one more criterion of merit to those ordinarily used. The proposed criterion would be an assessment of the length of sections according to their relative importance.

ILLUSTRATING THE PRIMARY CONTRIBUTION

The same argument for size *vs.* relative significance can apply to the figures and tables in a journal paper. We usually think of the size of the illustrations as being properly guided by the optical resolution of the material in a chart, graph, diagram or photograph—i.e., the more material to be shown in detail, the larger must be the figure on the printed page. This way of choosing the size of a figure is generally followed by authors, draftsmen and layout men in the natural course of events. The conventional procedure, however, frequently ignores the powerful emphasis that can be achieved by choice of relative size. The eye is generally attracted to the largest graphical illustration or table of data on any printed page format. For the most effective emphasis of technical concepts an author will do well to build his paper around a central illustration in the form of table, chart, etc. Before he writes his manuscript, he should identify his main result or finding and, wherever possible, illustrate this graphically or in a table of data. This figure or table should be deliberately designed to be larger than most of the others in the paper. (Of course, more than one figure might be needed to illustrate the main concept.) Where lesser figures would ordinarily seem to deserve a large format, effort should be made to delete nonessential information, for the very reason that these figures are less important. The design of illustrations, then, should be used as a means of emphasizing the author's important concepts and of actually subordinating his supporting data. This technique, of course, is a far cry from the common practice of loading certain types of manuscripts with large numbers of charts to provide data that seem pertinent. Indiscriminate use of illustrations defeats their purpose by actually obscuring the main content in a paper, both

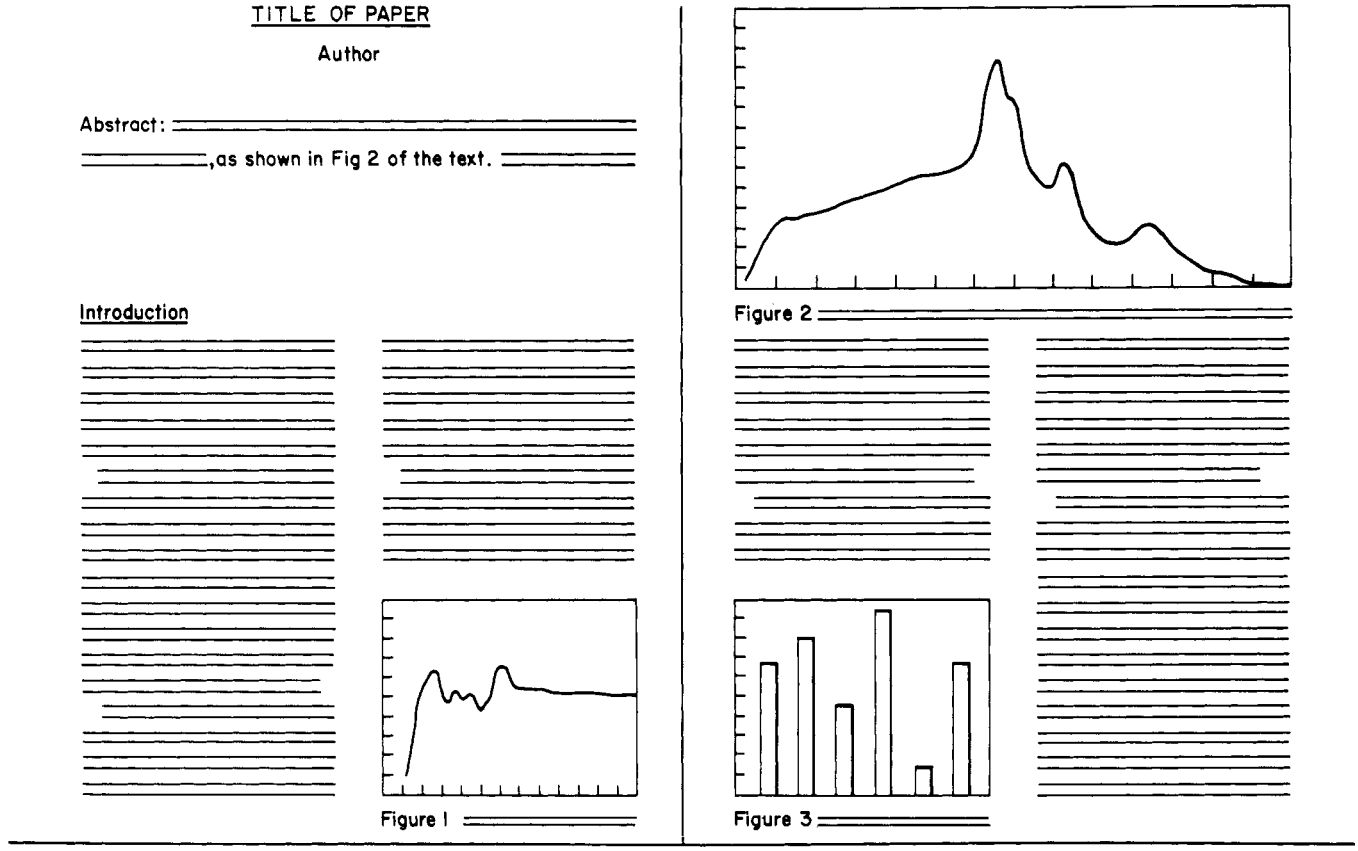

Figure 1. Specimen page layouts for emphasizing the significant figure

for those who read the text minutely and those who quickly scan it.

Since a rather high percentage of technical readers will only scan a given issue of a technical journal, a rather obvious advantage of this system of scaling the size of illustrations becomes evident. Readers of a journal styled in this proposed way would be able to scan the issue and immediately grasp the main content of each paper from its most prominent figure, as suggested here in Figure 1. In the hypothetical case shown here, "Figure 2" would represent an unusual or unique finding—i.e., the author's significant result that justified publishing his paper. An author's effort in designing such an illustration can have subtle but potent effects on the results he is reporting in the same way that careful writing actually affects his work.[20]

As an initial experiment I have tried one of these ideas in a special issue of the *IEEE Transactions on Engineering Writing and Speech*, August 1968. In this issue, each of 15 authors was encouraged to display his most important concept in a large illustration and to mention this figure specifically in the abstract. The papers deal with hardware, software, and systems aspects of computer-assisted engineering documentation, and in each paper the main contribution is emphasized by means of an illustration of large physical size.

CONCLUSIONS

I have pointed out that the needs of today's scientific and engineering readers are no longer met by the conventional structure of the journal paper, which was originally developed in a bygone era for leisurely reading. Accelerated technical progress and wide publication of results now demand new ways of providing information, however complex, in more readable form.

The structures suggested here for improving the R and D literature might be described in the "Instructions to Authors" issued by journal editors.[21] Authors can be requested (a) to provide their paper with a brief but highly informative abstract containing the three key elements of information; (b) to achieve the best emphasis for their main contribution by planning beforehand to adjust the size of the text sections according to their relative significance; and (c) to design illustrations in a way that actually contributes to the character of the paper by showing the chief results in a figure or table of large physical size.

Journals that adopt this policy will be offering technical information in a form that has special advantages for author, publisher, reader, and information retrieval services:

(1) Every author's paper will be constructed in a way that consistently emphasizes his more important results.

(2) The journal will thus become more useful and will provide more technical information per dollar expended on journal production.

(3) The reader (whether he is carefully reading or quickly scanning) will save time and effort in assessing the significant contributions.

(4) In information retrieval, either by computer, "normal text searching," or by manual methods, the abstract (and also text of the paper) can be more useful by virtue of its high information density and less "noise."

There is another important aspect—the two structural concepts (b) and (c) can be used as additional criteria for editors and referees of journal manuscripts. In addition to appraising a proposed paper by conventional standards, the referee can assign a new importance to structural proportions.

LITERATURE CITED

(1) Bernal, J. D., "Summary Papers and Summary Journals," *J. Document.* **21** (2), 122–27 (1965).

(2) Brown, L., "The Future of the Scientific Paper," *J. Document.* **18** (1), 1–5 (1962).

(3) Brown, W. S., J. R. Pierce, and J. F. Traub, "The Future of Scientific Journals," *Science* **158**, 1153–59 (1967).

(4) Salton, G., "The Use of Standardized Documentary Data in Automatic Information Dissemination," *IEEE Transactions on Engineering Writing and Speech* 11 (2), 101 (1968).

(5) Bean, J., "Effectiveness and Problems of New Data Presentation Techniques," *Proceedings of the 15th International Technical Communications Conference,* May 1968, Paper W-IV.

(6) Peterson, Martin S., "Scientific Thinking and Scientific Writing," Chapter 2, Reinhold, New York, 1961.

(7) Gray, D. E., "The Technical and Scientific Report," *Proceedings of the 1960 Institute in Technical and Industrial Communications*, Colorado State University, pp. 25–33, 1960.

(8) Ulman, J. N. and J. R. Gould, "Technical Reporting," Holt, New York, 1959.

(9) Kapp, R. O., "The Presentation of Technical Information," Constable & Co., Ltd., London, 1957.

(10) Mills, G. H. and John A. Walter, "Technical Writing," Holt, Rinehart, and Winston, New York, 1962.

(11) Tichy, H. J., "Effective Writing for Engineers, Managers and Scientists," Chapter 5, Wiley, New York, 1966.

(12) Weisman, Herman M., "Basic Technical Writing," Chapter 8, Charles E. Merrill Books, Inc., Columbus, Ohio, 1962.

(13) Michaelson, H. B., "Structure, Content and Meaning in Technical Manuscripts," *Technical Communications* **15** (2), 1968.

(14) Davis, R. M., "Experimental Research on the Effectiveness of Technical Writing," *IEEE Transactions on Engineering Writing and Speech* **EWS-10**, 33–38 (1967).

(15) Krescher, A. H., "Some Considerations on Format for Manuscripts in the Scientific Literature," *N. Y. State Society of Medicine* **62** (9), 1488–91 (1962).

(16) Weil, B. H. and J. C. Lane, "Psychological Barriers to Writing," *Chem. Eng. News* **34** (51), 6244–46, 48 (1956).

(17) Weil, B. H., Ed., "Technical Editing," Chapters 1 and 6, Reinhold, New York, 1958.

(18) Skolnik, H., "Hercules Technical Reports," 6th ed., pp. 6–8, Research Department, Hercules Inc., Wilmington, Del., 1964.

(19) Weil, B. H., I. Zarember, and H. Owen, "Technical Abstracting Fundamentals. I. Introduction," J. CHEM. DOC. **3**, 86 (1963); "Technical Abstracting Fundamentals. III. Publishing Abstracts in Primary Journals," J. CHEM. DOC. **3**, 132 (1963).

(20) Michaelson, Herbert B., "Creativity in Scientific Writing," *Proceedings, 7th Annual Institute in Technical and Industrial Communications*, Colorado State University, July 7, 1964; "Creative Aspects of Engineering Writing," *IRE Transactions on Engineering Writing and Speech* **4**, 77 (1961).

(21) "Handbook for Authors," American Chemical Society Publications, Washington, D. C., 1967. Also the various "Instructions to Authors" that appear in the ACS journals.