Scientific Editorial Problems

The 3rd annual Conference on Scientific Editorial Problems was held 29–30 Dec. 1954 at the Berkeley meeting of the AAAS. Marian Fineman, chief of the editorial branch, Dugway Proving Ground, Dugway, Utah, was chairman. The program was divided into four main topics: (i) preparation of technical manuals for complex instruments; (ii) effective technical writing; (iii) scientific journals; and (iv) military and industrial technical reports. We present seven articles in this section, each of which is based on a paper presented at one or another of the sessions.

The Care and Training of Authors

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James Thurber has drawn a number of cartoons centered in the theme of the permanent warfare between men and women. I might, for my purpose, have paraphrased this theme and entitled my article, "The permanent warfare between author and editor." I have myself been alternately on both sides in this battle, which I suppose classifies me as a mugwump. A mugwump has been defined as a bird that sits on a fence, with its mug on one side and its wump on the other.

I became assistant editor of a high school paper in Uniontown, Pa., in 1915, and have been serving almost continuously in some kind of editorial capacity ever since. I have also been an author for a slightly longer period, and have published a modest number of scientific and popular articles in my own and other people's journals. On the whole I should say that it is most satisfactory to an author to publish in a journal of which he is himself the editor. This not only insures appreciative acceptance and early publication, but affords a reasonable guarantee that one's manuscripts, when returned with galley proof, will not be annotated with snide remarks on spelling and punctuation, or have the best phrases deleted with a blue pencil.

I lately discussed the substance of these remarks with a graduate of a school of journalism, who expressed surprise and commented, "In journalism school we were taught to treat editors with great respect." If this be the case generally, I wish all scientific authors might take a course in journalism, for I know of nowhere else that such worthy ideals are inculcated. Most graduate students learn from their professors that editors are a necessary evil, to be borne with or if possible circumvented.

The essence of the matter is that editors are tough and that authors are touchy. Each of these attitudes is completely understandable.

An author puts his best efforts into a paper. It represents months or years of painstaking research, long hours of work in the library, and finally the throes of literary composition. He knows, or at least fondly imagines he knows, how to read, write, and spell. When he has finished his manuscript, he is proud of it. Naturally he thinks it is good, or he would not have taken the trouble to write it.

So he sends it off to a scientific journal. In due course, after having been read by one or more referees, it comes back with a few suggestions from the editor. The title should be changed, say from "Absence of extraneous elements in the flora of Turtle Mountain" to "Prevalence of indigenous elements in a selected Nearctic alpine flora." The introduction should be shortened to one paragraph, the review of literature omitted, the discussion limited to 500 words, reference made to Smith's 1951 bibliography and no literature cited except papers subsequent to that date, and a short summary written for *Biological Abstracts*.

The editor is of course merely trying to be helpful, but the gratitude of the author seldom finds expression in paeans of appreciation. The situation can be epitomized in the story of the two Boy Scouts who arrived late at their scout meeting, breathless and disheveled, just in time to answer the question, "Did you do your good deed today?"

"Yes," they replied, "we helped an old lady across the street."

The scoutmaster was inclined to regard this as a rather modest good deed, especially when it had to be bisected between the doers. "Why," he inquired, "did it take two of you to help one old lady across the street?"

With one accord they replied, "She didn't want to go."

The reluctance of authors to cooperate with editors who are trying to do good deeds on their behalf is little short of phenomenal. I once received two manuscripts from an author in the same mail. One I accepted and the other I returned with the suggestion that it could be more suitably published elsewhere. The author replied with considerable heat, "If you won't publish this one, send the other one back too." On another occasion I returned a manuscript with the unusual suggestion, not that it be abridged but that it be amplified to include additional material. I received no reply and did not pursue the matter further. Quite a long time afterward I wrote this author for some information that I personally needed in his special field. He replied, "If I give you this information—will you publish the paper I sent you five years ago?"

I have said that editors are tough, and they need to be so, because it is their business to maintain standards and to prevent the immense and increasingly complex business of scientific publication from falling beneath "the reign of Chaos and old Night." It is my present purpose to inquire just how tough they ought to be and how they can make it stick—in other words

(incidentally, when I am editing other people's copy, I always cross out the phrase *in other words* and everything that follows), what are the editor's prerogatives, by what sanctions can they be enforced, and conversely, where is the line to be drawn that will prevent the editor from becoming completely authoritarian? After all, authors have certain rights, however minor and inconsequential they may be.

The first thing to be said is that the editor must know his business. Speaking now in my capacity as an author, I will say that only once in my life have I won an argument with an editor. That was over the use of a possessive pronoun with a verbal noun, in such an expression as "I look forward to his coming." I won by stating with great finality, "The gerund always takes a possessive." He subsided because he had never heard of a gerund and wanted time out to look it up and see whether such a thing really existed or whether I had invented it on the spur of the moment.

Actually if he had been an editor worth his salt, he would have replied without turning a hair, "It may be true in general that the gerund takes a possessive, but it is not true in the case of this magazine."

Seriously, an editor has to have an immense and ready knowledge of grammar, spelling, punctuation, capitalization, permissible variant spellings, foreign words and phrases, the International Rules of Zoological and of Botanical Nomenclature and wherein they differ, and the special vocabularies of a dozen different sciences. He must know why it is often correct to capitalize the specific names of plants, but never the specific names of animals. He must know that new species of animals can be described in any language from English to Sanskrit, but that new plants must be described in Latin, and he should be able to read and edit the Latin description (we shall not insist that he be able to read and edit Sanskrit, although that would help). He should know that the direction that may briefly if inelegantly be described as from back to belly is dorsoventral in zoology and dorsiventral in botany; also that dorsi- is correct in certain anatomical terms, as dorsispinal. He must also keep abreast of the times, and be aware that language is a living thing and that correct usage changes from generation to generation. There is no use in trying to convince an author of the error of his ways by citing the 1910 edition of the *Century Dictionary,* or the battered copy of Woolleys' *Handbook of English Composition* the editor used in college. Recent editions of Woolley even cite cases in which the gerund does *not* take the possessive.

Most important of all, the editor must have a nose for mistakes, whether of expression or of fact, which corresponds to a good reporter's nose for news. His mechanism for spotting errors or possible errors must be as sensitive as a Geiger counter.

Now that I have described in glowing detail this superman, let us consider just how far he is entitled to go in exercising his extraordinary talents. The general procedure is something like this:

If the editor has any major changes to suggest, he returns the manuscript to the author, offering his suggestions for revision. These suggestions the author may accept or reject, although it must be acknowledged that he is under a fair amount of pressure to make the changes if he wants to get his paper published. His alternative, of course, is to withdraw the paper and submit it elsewhere. If the changes are of a minor nature, the editor will probably make them on his own responsibility, and the author first discovers them when he gets the galley proof. He is quite likely in a moment of pique to change everything back to the way he wrote it in the first place. He returns the proof to the editor, who erases the author's changes, and sends the galleys to be paged up. In due course the author receives a page proof, and by this time being madder than a wet hen, he reverses all the editorial changes, and does it in ink. However, the corrections in ink do not have the finality he thinks, because the editor has kept a duplicate page proof, which is the one he will, after due deliberation, send to the printer.

It is this final page proof that involves the editor in deep searching of soul. How far shall he compromise with the author, and how far shall he insist on the alterations which he thinks are desirable for the improvement of the paper or necessary for the maintenance of standards of scientific publication? I do not know the answer to this problem; I can only tell you the formula I have arrived at and how I reached it.

When I was a young editor, slightly past the high school phase but still not quite dry behind the ears, I was a great stickler for consistency. Every paper had to be set up in the same way; citations of literature had to be made in parentheses, by author, year, and page, referring to a terminal bibliography, which also had to be set up in a standard manner.

I was unhappily but usefully shaken out of this fool's paradise by a two-year stint in China as editor of the *Lingnan Science Journal.* In those two years I got out 2600 pages of scientific publications, written in French, German, and English and interlarded with Chinese. My principal German contributor corrected his proofs in German script, which is one of the best ways I know to get even with an editor. My Chinese compositor did not read English, but set type by picking out of the font the letters that looked like the copy that was given him; actually he did phenomenally well, but inevitably he mixed up letters like lowercase *b* and *d*; and for the first time I learned the literal meaning of minding one's *p*'s and *q*'s.

After two years of this I found that I had not entirely lost my editorial ideals, but I had modified them. The immovable object had yielded to the irresistible force. I arrived at the conclusion that consistency is an unattainable ideal. I do not mean that it should not be striven for; I mean only that it cannot be attained.

I still like the method of citation of literature I have described, a method that I learned at the University of California more than 30 years ago. I still

follow it in my own publications. I follow it as far as possible in my editorial work. But when I was editor of the University of Washington *Publications in Biology,* an entomologist turned in a paper that did not conform to this formula. I called this to his attention and suggested that he be guided by precedent. This was the wrong thing to say, because he immediately produced innumerable examples to prove that entomologists cite their literature immediately at the beginning of each discussion of a species, and that they may or may not include a terminal bibliography.

I was convinced, and agreed that the entomologists could follow their professional idiosyncrasies. This practice was allowed, and we follow it also in the *Proceedings* of the California Academy of Sciences. I think any journal that publishes papers in more than one field has to allow this kind of latitude, however deeply it may grieve the editorial spirit.

In matters which, in the final proof, still remain moot between editor and author, I proceed as follows: I correct positive and provable errors. I will not permit words to be hyphenated in the wrong place, or a singular noun to be followed by a plural verb, or a plural noun like *data* to be used with a singular verb. I still hold out for the correct cases for pronouns, although I am weakening, and may in another 10 years yield to such an expression as "It was him." But I have given up worrying about *shall* and *will,* split infinitives, and terminal prepositions. I make my suggestions, and the author can take them or leave them. After all, it is his grammar and not mine that the reader will judge, if indeed the reader pays any attention.

To those editors who feel that I am abandoning the real line of defense and retiring to an inner citadel that must ultimately fall, I shall offer this suggestion: a great deal of the difficulty between author and editor could be resolved, and the work of each made easier, if the editor would tell the author what he wants.

Shifting gears now from the third to the second person—if you are going to maintain specific standards, tell the author what your standards are. State under your masthead that manuscripts must be typewritten, double-spaced, on one side of the page, and should conform to the University of Chicago *Manual of Style* or some other—your own, if you care to write one. As a matter of fact, most things that most editors insist on can be spelled out on one mimeographed page, which can be supplied to a prospective author on request, or sent to him with the return of an unsatisfactory manuscript, with the suggestion that he comply. This avoids a great deal of argument, debate and needless correspondence, and puts the editor in a position that can be defended by logic instead of *force majeure.*

In conclusion, I should like to return to the terminal preposition. What should be the last word on this has been said by Winston Churchill. When an editor recast a sentence of his that ended with a preposition, Churchill changed it back to the original form and wrote in the margin, "This is the kind of nonsense up with which I will not put."

Most of the problems that arise between editor and author can be alleviated by a sense of humor and resolved to their mutual satisfaction by the use of plain common sense.

Security and the Editor

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Security, as it affects editors, is more than a conscientious locking of classified material in safes after the working day is through, or keeping a closed mouth on classified work. Both research people and those who enforce security seek, in addition to the safeguarding of data from unauthorized persons, the widespread transmission of scientific information as rapidly as possible. One of the big problems of security is that of proper balance between rapid and widespread transmission of information and iron-clad security. It is in this area that the industrial technical editor working on classified projects can contribute. Because research publications pass through his hands, the editor is in a position to maintain as a goal the classification of reports at a minimum consistent with safety.

To be more specific about the editor's contribution to security let us consider a typical research organization doing work under contract to the Atomic Energy Commission. Every research report which the research department issues goes to the publications unit for final preparation. Each report is assigned to a particular technical editor. He is responsible for editing, necessary rewriting, and some of what might be called report production, that is, the detailed work necessary for preparation of correct reproducible copy for a print shop. In addition to his editing duties, the editor may be called upon from time to time to write special material for various purposes.

From the day a technical editor is hired he is submerged in security. For example, let us take a hypothetical case, that of technical editor L. Drake. Like many editors in research organizations, Drake had a degree in a physical science with some laboratory experience, as well as training and experience in a writing and editorial capacity. He was trained to understand technical material; he had a strong interest in editorial problems.

Immediately after he was hired Drake's name was submitted to a preliminary security clearance. Within a few days he was given a security lecture. He was allowed to work only in a nonrestricted area while he was undergoing a complete security investigation. During the time of the complete investigation he was not allowed to work on classified material or to enter the restricted area. Drake was certain that his loy-

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alty, character, habits, and associations were above reproach, and he hoped that his investigation was being expedited so he would soon be able to enter the security area. He heard from neighbors, friends, and previous employers that a government investigator had interviewed them. Then for a time he heard nothing. One day the senior editor came in. He told Drake that he had been given a clearance and that he could enter the restricted area.

Now Drake's contact with security was even more constant. He was stopped at a guard station and the guard entered his name on a roll and studied his face. From now on Drake would be admitted to the area on recognition by a guard. Later that day Drake was given a copy of the department security guide. So far he had been immersed in elements of security that affected every other individual in the department, whether or not they were editors. It was when he went to work that Drake's problems became unique.

Drake's first assignment was a report on chemical research written by a member of the chemistry group. This was the type of work Drake could do best. Read the text, understand the chemistry, delete commas, correct misspelled words, rewrite the few sections that seemed to need revision. This was easy. Then to the art work. Check the spelling of words, indicate directions for the illustrator, order necessary photographs, then prepare a dummy layout of the finished report. Nothing to it. Nothing to it, that is, until senior editor Jones stopped by to see how Drake was doing.

Jones checked through the deleted commas, corrected words, and rewritten sentences. He suggested that Drake check these out with the author of the paper. "And be tactful," Jones said. "You know authors." Drake smiled. He had met a few.

Then Jones checked through the art work. Several of the photographs had security classifications marked on them. Several of the photographs did not. Jones picked up the photographs without security classification marks. "What are the classifications of these?" he asked. Drake shook his head. He did not know. Then Jones picked up the photographs with security classification marks on them and scrutinized them. Two of them were photographs that had been in their files for some time. The subjects photographed were no longer classified.

"How do I know these things?" Drake asked.

Question everything, he was told. Check your security guide. Check also appropriate laws, regulations, and directives. The security guide is a summary, not a substitute. Then ask the author questions. He is responsible for assigning a classification to newly prepared material. If he does not know, check with the department classification officer. He is the final authority within the department. For old material that may have had its classification downgraded, check with the declassification officer. This declassification is a continuing process. Over a period of time you will become familiar with the projects, the art work, the photographs. You will have a better over-all grasp of the work of the department through handling its research reports than almost anyone. You will get to know what is and what is not classified. By checking you can save time and trouble later.

Being conscientious, Drake heeded Jones' words. He looked through some of the report material that had to be drawn by an illustrator. None of the drawings had classification markings on them. They, too, would have to be checked. He gathered the material that had been rewritten and the material on which there was some question of security classification and went to the author.

Drake discussed the rewrite suggestions with the author. The author, like most authors, liked his way better, but he was agreeable. Yes. There were certain changes which were improvements. There were others he would prefer his own way. Drake then asked about security classifications for the illustrations. "I'm not sure," the author said. "It's a secret report. Make them all secret. That should certainly give them adequate protection." Drake jotted down *secret* on a notebook pad. Then he went back to work. He did not want to use too much of the scientist's valuable time.

The report was processed and the copy prepared for reproduction. The material was passed around for final approval. No one questioned the wording, the punctuation, or the classification of illustrations. They relied on Drake's judgment. The report went to the print shop, then two weeks later it was returned. There it was, in black and white, for everybody to see.

The report was mailed according to official distribution lists for classified materials. Many of the illustrations indicated as secret were overclassified. That is, some of them that had at one time been classified secret were no longer secret. Some of the newly drawn ones were not secret. Several research people needed copies of the photographs and drawings for a special unclassified booklet to be issued. Since the illustrations were marked secret, they could not go into an unclassified report.

Time was spent checking and rechecking the proper classifications of these drawings. Then, to be on the safe side, the illustrations were submitted for declassification. This involved filling out, in quadruplicate, a declassification form. One copy of the form, together with one copy of the material to be declassified, was sent to a responsible reviewer, a technical man in the field who passed judgment relative to the declassification. Another copy of the form and a copy of the material were sent to the Chief, Patent Branch, AEC, Washington, D.C. One copy of the form and eight copies of the material were sent to the Chief, Declassification Branch, AEC, Oak Ridge, Tenn. The responsible reviewer and the patent reviewer made appropriate comments and then forwarded the material to the Declassification Branch. The Declassification Branch passed on the declassification and sent back one officially declassified copy. All recipients of the material were then notified. This time and effort could have been saved by the editor or author. How was the release of the unclassified report affected? The report came out much later than desired. In this particular

case it did not matter. In another case it might have been detrimental to some important program. You can be certain that Drake handled his next assignment correctly. He checked with the author, the classification and declassification officers, and he used better judgment.

An editor's job is not always concerned with classified technical reports. Because of his literary training and/or interests, he is often called upon for assistance on special writing jobs. For example, a department security guide was recently prepared for distribution to all persons dealing with classified material. Pertinent information was extracted from official laws, regulations, and directives. A technical editor did much of the writing work. After finishing the job, the editor sought the help of an artist to prepare small posters for a program of security consciousness. The guide and the posters were submitted to the appropriate AEC offices for approval before distribution.

Thus it is clear that security, as it affects editors, is more than a conscientious locking of classified material in safes after the working day is through, more than keeping a closed mouth on classified work. It involves a growing awareness of the work undergone in the research organization. It requires recognition of what is or is not classifiable. It requires decision and judgment. It requires the necessary tact and thoughtfulness in dealing with others, especially when you believe the author does not have the correct security information. Above all it requires a constant awareness of a goal: the classification of reports at a minimum consistent with safety so that data can be properly safeguarded and yet rapidly distributed to those who need it—for only under such conditions can American science maintain its technological superiority.

Is There Accepted Scientific Jargon?

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In the lobby of the Michelson Laboratory at the Naval Ordnance Test Station, China Lake, there is a full-size dummy of the Tiny Tim, a large aircraft rocket used in World War II. The Tiny Tim is now definitely in the public domain—if I may extend the use of publishers' jargon to the field of military security. Any casual visitor could look through the cutaway wall of the rocket motor and examine the propulsion system.

If you looked carefully you could see that the propellant charge consists of four cruciform grains of double-base powder with the peripheral surfaces of the arms partially inhibited in a helical pattern. Of course some, not knowing what to look for, might not see all that I have just described, although I would be willing to bet that even then you would have a much better idea of what makes the rocket go than you now have from the language of my description.

Some of you are no doubt puzzled and a little frustrated, but you are no more frustrated than I was when I first started editing reports on rocket development. At that time such a description would have bothered me a great deal. It probably sounds to you, as it once sounded to me, very much like standard English at the college level, with a liberal sprinkling of polysyllabic words, all of them to be found in a good desk-size dictionary. And yet somehow it fails to communicate clear information to a literate person who is not at least something of an expert in rocketry. Is it, perhaps, a simple example of *scientific jargon*? An example that does not contain a single coined word?

It is special language of some sort. Yet it is definitely not jargon in the sense of "chatter or twitter, as of beast or bird"—a meaning now rated obsolete, but a meaning still recognizable as a logical one for a word probably derived from the same source as *gargle*. Nor is it jargon in the current meaning of man-made "gibberish" or even "confused and unintelligible language" in the sense of a "barbarous or outlandish dialect."

Indeed, even after close examination most of the words appear to be burdened with little more than their usual meanings: for example, *charge, cruciform, peripheral, arms, helical,* and *pattern.* The rest of them appear to be, in this context, conveyors of precise special meanings beyond your present power to interpret.

Do the words *propellant, grains, double-base, powder,* and *inhibited* then represent jargon in the sense of "the technical, esoteric, or secret vocabulary of a science, art, trade, sect, profession, or other group?" Or are they merely the verbal "circumlocutions and long, high-sounding words" of the final definition of *jargon* in *Webster's New International Dictionary*?

When I first met them 10 years ago, these words were already established elements of the local technical vocabulary, and everybody used them. In time I learned, by asking questions of our experts and reading the reports of others, that they were definitely esoteric in their special applications. Once initiated, I too could understand their inner meanings.

I had to learn that a solid *propellant* of the type used in the Tiny Tim is a plastic substance, usually dark gray in color; that it is indeed the "fuel plus oxidizing agent used by a rocket engine" (as explained in the recent printings of *Webster's New Collegiate Dictionary*), but at the same time is definitely not "a explosive for propelling projectiles." Most certainly it *deflagrates,* or *burns* "with sudden and sparkling combustion," although we at the Naval Ordnance Test Station usually do not encourage the sparkling. But it never detonates, or explodes "with sudden violence" —or at least it is not supposed to; for when it does, it causes trouble at the wrong end of the trajectory.

And I also had to learn that *grains* of solid propellant are often several inches in diameter and several feet long; that *double-base* means that the formula includes both nitrocellulose and nitroglycerin; that the *powder,* before it is processed into *grains,* bears no

physical resemblance to the powder you put on your toothbrush, the powder you dust on your face, or the gunpowder in your shotgun shells, but that it most closely resembles rolled-up strips of battleship linoleum; and finally, that although the term *inhibited* can claim as an ancestor the common transitive verb *to inhibit* in the sense of "to hold in check" or "to restrain," in my example it means "covered with a slow-burning substance so as to retard combustion locally."

Now that I have initiated you into the rocket fraternity, you will at once agree that my description of the source of motive power in the Tiny Tim is not, in fact, "language full of circumlocutions and long, high-sounding words." Rather, it illustrates, in an elementary sort of way, the legitimate use of specialized vocabulary by one expert in a narrow branch of science to communicate exact information to other experts in the same branch with genuine economy of expression. In other words, it is an example of acceptable scientific jargon.

To test the economy factor, just try rewriting the example in what you consider truly standard English, even at the college level—without loss of meaning, that is. You will find your task nearly as difficult as trying to express the full meaning of the apparently simple equation, $e = mc^2$, in nonmathematical language.

Thus we are forced to conclude (i) that there *is* accepted scientific jargon and (ii) that without such jargon specialists would find communication at least as awkward and time-consuming as doing multiplication with Roman numerals. But finding an affirmative answer to the question, "Is there accepted scientific jargon?" leads only naturally to several more troublesome questions. These further questions are strongly implied in the letter to the chairman of the Conference on Scientific Editorial Problems, in which this topic was first suggested.

"Much of the editing of scientific papers is done by people not expert in the field," says our correspondent. He then points out that editors find real difficulty in differentiating between "accepted" and "non-accepted" jargon. As one example, he mentions the frustrated editor of a medical textbook who, not yet having reached expert status, altered the expression "diabetes insipidus"—and thereby profoundly disturbed his author. The editor evidently failed to recognize "a diabetes insipidus preparation" as accepted scientific jargon for "a dog that had been artificially made into a diabetic."

As another example, the letter writer mentions the English scholar turned technical editor—in desperation, perhaps to keep himself housed, clothed, and fed these days. This sensitive soul, who in his previous incarnation learned to revere Joseph Addison, the master essayist, balks when he is faced in his present incarnation with the term *Addisonian* meaning "a person with Addison's disease."

You will now recognize the following three questions as those to which we must find answers. (i) Is there a simple touchstone for determining acceptability of scientific jargon? If not, how does the inexperienced editor—or any editor, for that matter—find out whether or not the jargon staring him in the face from the manuscript page has actually been accepted in the subject field, and hence may be presumed to convey real meaning to the specialist reader without further definition? (ii) When is scientific jargon appropriate and desirable, and when should it be avoided? (iii) How does an editor overcome his mulish tendency to balk at new words, and particularly at old words with new specialized meanings?

Let me suggest a few answers. But let me begin with the last question and work backward, for an editor's first problem is to break down his own prejudices.

A truly competent editor, in my judgment, does his thinking in terms of the author and the readers of the book—not in terms of himself. His primary interest in the job, aside from his pay check, is to make sure that the author's intended meaning is conveyed accurately, efficiently, and effectively to all the readers for whom the book is being written.

He must learn not to edit into his author's manuscript the idiosyncrasies of his own personal style. He must, indeed, become a sort of Jack-of-all-trades in matters of style. Perhaps that is why an outstanding writer rarely makes an outstanding editor.

Similarly, he must train himself to think about words the way a lexicographer does. He must accept the fact that most words have several meanings, or exact shades of meaning, and that these are constantly changing. He must learn to identify these meanings with precision, and then to sort them into well-defined compartments by subject specialties. In the process, he will come to recognize his own preferences for what they are: the meanings that belong in the subject compartments where he has spent most of his time to date. Thus, he will learn to become objective in evaluating terminology, as well as successful in keeping his blood pressure down when he stumbles against a new meaning that at first repels him.

A recent experience of my own with the word *feedback* may help clarify the point. As one of a group of supervisors, I attended a seminar on management. Very early in the course, we began to discuss group dynamics. I was startled, and even a little offended, to hear my old friend *feedback* being tossed around rather carelessly.

I had first met *feedback* when I was a radio ham in the early 1920's. The regenerative circuit was new then. *Feedback* meant just what *Webster's* still says it means, "the return of a fraction of the output of an electric oscillation to the input to which the fraction is added at the proper phase," with the understood purpose of increasing the amplification or sustaining the oscillation.

But here were the management experts using the same word with some such meaning as "distorted information returned to the originator and used by him to check the effectiveness of his attempt to communicate undistorted information in the first place." Ever since, I have watched for different uses of the term.

The following are samplings of what I have found. The *Electronics Dictionary* (*1*) issued in 1945 and the *Dictionary of Guided Missile Terms* (*2*) issued in 1949 both recognize an expansion of the earlier meaning to include acoustic as well as electric output, but without any indication of a "control" or "checking" function. Stuart Chase in his recent book, *Power of Words* (*3*), comes out flatly and says, "A short, handy definition of a feedback is that it answers the question: 'How am I doing?'"; also, "Feedback is the control of a system by reinserting into the system the results of its performance." And even more interesting is this sentence from the October 1954 issue of *Audio* (*4*), which occurs in a discussion of a new system of tone generation for electronic organs: "This 'feedback' tends to reduce stability since it does not give complete control of the high-frequency master oscillator." But in the last instance, please notice, *feedback* is in quotation marks.

As a consequence, I can now distinguish between the precise use of the word by the electronics engineers and the more colorful special application to which it is put by industrial psychologists. And I have become a better editor in the process.

Now the second question should be an easy one for an editor on the staff of a technical journal. He would answer, I suppose, that scientific jargon is appropriate when it has become accepted in the subject field, and is desirable whenever its use saves space. Or is it really that simple?

But for those of us who edit for a mixed audience of specialists and administrators, the answer is not so easy. Some say, "Ignore the administrator; he won't understand anyway." And I ask, "Dare we ignore the holder of the purse strings?" Others, lacking experience, suggest avoiding scientific jargon altogether or defining each special term on first occurrence. Such an approach is just not feasible, however. Remember the propulsion system of the Tiny Tim.

The only answer is to make sure that the information of interest to each audience is presented in the terminology that each will understand most readily. On the one hand, this means liberal use of accepted scientific jargon in statements of technical problems, findings, conclusions, and recommendations for the specialist. On the other hand, it means furnishing the administrator with the general information *he* needs in *his* own terminology, together with a brief interpretation of at least the over-all problems, conclusions, and recommendations—but without the use of scientific jargon unless it is explained in standard English or is essentially self-explanatory.

Sometimes the end product takes the form of separate publications for specialist and administrator. More often, the best solution seems to be a special summary, written with the administrator or general reader in mind and bound into the basic technical publication. Usually, however, we do the best we can by simply trying to word the introductory and terminal sections of a single publication so that they are intelligible to both audiences.

The remaining, and probably most difficult, of the three questions I shall leave mostly to you. I have found no one touchstone for scientific jargon. We collect dictionaries by the dozen at the Naval Ordnance Test Station, for our subject matter threatens to include the entire range of the physical sciences. But no competent editor of ours would dare conclude that a technical expression had not yet been accepted just because he could not find it in a dictionary. Our fields of interest are changing too rapidly for even the special glossaries to keep pace with the changes in thinking.

The result is that we still do as I did in my early days of editing. We turn to a recognized authority in each field, when we can find one easily. We also consult the literature when we have time—especially the latest textbooks and the reputable journals. What we find there, we assume is, or will soon become, generally accepted terminology. Do their editors not have a much better clearinghouse than we? Do they not steep in their individual subjects, whereas we merely steam momentarily in one subject after another?

Otherwise, I must confess, we usually go along with even our junior authors, trying to insist that they define on first occurrence those terms that are noticeably new even in our local vocabulary.

I believe that there is indeed such a thing as accepted scientific jargon; that acceptance is determined mostly by usage; that such jargon is appropriate and desirable whenever it serves as a vehicle for accurate and efficient communication between experts, but not otherwise, and that it behooves an editor to learn to work skillfully and at ease among these words of special meaning.

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Use of the Technical Report in Military Planning

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In discussing the use of the technical report in military planning* I propose to interpret the term *military planning* as planning for tactical or strategic operations. Planning for military organization, equipment, logistics, and training is certainly a real part of all planning for tactical and strategic operations. The scientist and engineer record their experiences and to a degree their opinions in the technical report.

* Cleared for publication by the Office of Public Information of the Department of Defense on 2 Dec. 1954.

The military man plans changes in organization, equipment, logistics, and training in order to take advantage of new developments. After this is done he changes the military doctrine in order to take full advantage of the new organization and equipment. In times of emergency the strictly military planning often follows very closely after the development work has been completed and the technical report has been written.

Vannevar Bush has stated in *Modern Arms and Free Men* that by 1918 the principal devices of modern war—automatic guns, self-propelled vehicles, tanks, aircraft, submarines, radio, poison gas—had been tried out in practice. In addition, mass production had appeared, and the petroleum, automobile, chemical, and communications industries had approached maturity. Bush also states that the world made almost no studies of these devices and methods in the period between the two wars.

If we grant that Bush's analysis of the situation is essentially correct, and I think we must, then we must decide that something was wrong in our country and that we could have been much better prepared in December 1941 than we were. In these troubled times it is not likely that we will again be allowed the time to plan the application of advances in science and engineering that have been made in a period between wars after the fighting has broken out.

One might say, somewhat dogmatically, that the failure of the country to plan to take military advantage of technologic advances during the period between World War I and World War II was the result of the failure of the technical men to sell their ideas to the military, to the Congress, and to the American people generally. Actually, as we all know, this is a much-too-simplified generalization. During most of this period the American people were not interested in such things, and a regiment of Daniel Websters could not have roused them from their apathy. Today the situation is quite different. But even after December 1941 we still had considerable difficulty in utilizing the products of the laboratory and civilian engineering in our war effort. All sorts of reasons were given for our difficulties. The civilian technical worker was inclined to say that the military men had so little technical training and so little knowledge of technical matters that it was almost impossible to get them to accept any new idea. The military man, on the other hand, was inclined to view all civilian technicians as impractical dreamers and applied the term *long hairs* to the lot. I am happy to report that these days one almost never hears this term of derision used by military men. It appears that we do make progress.

Actually the military man's position, when he is required to decide upon the adoption of a new device, a new technique, or a new weapons system, is a very difficult one. Almost always he must decide to abandon a system that has worked successfully in the past. His decision to adopt a new item or a new system almost always means that much costly material must be junked before it is worn out or used up. His decision may well have real impact upon the production of the country and this is a serious problem in the middle of a war; further, and most serious of all, when the military man makes the decision to adopt new materiel or procedures, he is to a point gambling with the lives of many young men. He must be absolutely certain that the adoption of the new device will not, at the very least, cause the nation to expend more lives in winning the war at hand or the war that may be fought later.

All this tends to make the military man cautious and conservative, as who among us would not be if he were forced to make decisions of such magnitude in such a climate. To express it in the language of the salesman, the military man is a tough prospect. And yet the technical man must often, if he is to be true to his country and to himself, use every means at his disposal to sell a new idea to the military man. All of us who have any part in military research and engineering have a responsibility to keep senior military men fully informed of the progress of our work and constantly to point out the possible applications to military operations. We do this through the medium of the technical report. The report may be written or oral, and it may be delivered formally in the briefing room or informally in a club car, over dinner, or even at a cocktail party. We are fortunate today because the technical men of the country are fully aware that the responsibility for planning for the use of the latest technologic advances is no longer to be borne by the military alone. The scientist and engineer are ready to assume a large share of responsibility.

The scientist or engineer who really believes in himself and his ideas and in his work must use every avenue to sell the product of his work. If you are inclined to scoff at the informal and indirect approach, I call your attention to the Shepley-Blair report and to the manner in which the possible use of atomic power for military purposes was brought to the attention of the President when the last war broke out.

The technical report is always important and if the material reported upon has a bearing upon our national defense it is doubly important. The report must certainly follow some format or other. Many are used and as long as the material is presented in some logical manner I do not think that the format is very important; but the language used is of the utmost importance. The reporter is not writing entirely for the reader who is skilled in some technical field and who understands the language of the field. The governmental research and development structure has become so complex that reports will often be read by men who are not experts in any technical field. Yet these nontechnical readers must often make far-reaching decisions on the basis of knowledge they glean from the report. We must make every attempt to minimize the use of any vernacular that is peculiar to us or our group and to the workers in our field. I find the young doctor of philosophy particularly clumsy at writing his report in good English, English in which the use of simple words and phrases predominates.

Possibly the young man feels that he will be a disgrace to his university and to his teachers if he fails to demonstrate clearly that he is capable of using the technical terms that are peculiar to his craft.

The report must arrive at some conclusion. Administrators of scientific work and other planners must constantly make decisions concerning technical work that they cannot follow closely if for no other reason than that they do not have the time. These people are most interested in what the man in the laboratory thinks of his work, and the technical worker should sum up his ideas in his conclusions and sometimes in his recommendations. Yet many technical men seem absolutely incapable of coming to any conclusion concerning their work. Perhaps they write indefinite conclusions and fail to make recommendations on the grounds that this sort of action will relieve them of criticism in the future. But the conclusion is the meat of the report for many readers and it is particularly important for the busy administrator and for the reader who is not an expert in the field reported upon.

Without expending much effort I found the following conclusion in a report prepared in one of the Department of Defense installations. This report incidentally was one that certainly will be read by military officers who must plan for operations. The conclusion read: "The closed houses and slit trenches afforded some protection from the effects of the cloud."

Perhaps the technical man who is skilled in the particular field reported upon here can read this report and make up his mind whether the protection afforded is small or considerable. But what of the nontechnical reader? He is probably lost. It would have been much better if the writer had stated quantitatively what degree of protection was provided. He might be excused for hedging a bit and qualifying his statement by saying that his results were for some reason not too good and that his estimate might well be in error by such and such a percentage. But even so, he would be giving the nontechnical reader a much more precise idea of what he actually observed and believed than is given by the indefinite statement as written.

That the technical report is often used as the basis for military planning can hardly be questioned. The technical report is also often used by the administrator, who, unfortunately, is almost never highly skilled in the field reported upon, as a basis for decisions concerning the continuing effort to be placed upon that work. Two examples of how the technical report may be used directly by military men might be interesting.

In World War I the German chemists led by Haber conceived the idea that the stalemate on the Western Front might be broken by the introduction of gas warfare. They reported this to the German General Staff and convinced the chief that gas should be used. The technical problems involved were solved brilliantly by Haber, but it is clear that the military men were inadequately informed of the potentialities present. Hindsight tells us that if proper preparations had been made to take advantage of the gas attack, the impact on the Allies might well have been overwhelming. We must admit that the failure involved must be charged to the technical people. They had failed in their reporting.

However, the scientist does not always, by any means, fail to convince the military man. During World War II our troops ran into difficulties in the Pacific theater where the terrain was such that the Japanese could fortify caves. A team of military-civilian scientists was set up to study the problem. Their report indicated that flamethrowers of various types would be of real assistance, provided that special small troop organizations were set up to handle the weapons and that special types of training were given. Within a short period of time specially organized, equipped, and trained troop units made their appearance in the Pacific. It is commonly known today that these organizations were of real help in many fights. This was a case in which the technical men did an excellent job of reporting their work and made a real contribution to the war effort.

I wish to cite one other example of the difficulties experienced by readers when language is used in a clumsy fashion. This example also comes from a report written in one of the Department of Defense laboratories, a report that discusses some of the problems associated with the clean-up of areas and materiel after an atomic explosion. The report was written primarily for military staff officers who must use it to write military doctrine and training manuals for the use of troop commanders. It contains this sentence: "Dosage varies directly with the amount of contamination and with the length of exposure during decontamination." This sentence does not convey a precise idea; and the ideas conveyed do not seem to be technically correct. I have no thought of going into a technical discussion of the mechanisms by which penetrating radiation damages the human body, but I believe that the writer was trying to say that the radiation dose to which the worker might be exposed would depend upon the amount *and the type* of radioactive material in the vicinity and also upon the length of time during which he exposed his body to the radiation. I am quite certain that the reader of this report would gain incorrect concepts unless he had considerable knowledge of the physical and biological laws involved. The nontechnical reader might draw incorrect conclusions from such a statement and set dangerous procedures in action.

There is nothing to be gained by presenting more examples and further belaboring the point that clumsy use of the language can make a report useless or even dangerous. The technical editor must always fight against the poor use of the language. This may well be his most weighty cross, and he must bear it until he succeeds in training and convincing the writers of the reports that he edits. I am not convinced that writers and editors generally remember that the men who must study and analyze reports and make decisions based upon reports are not in general experts in the field of work being reported.

Clarity in Geological Writing*

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The natural scientist—the biologist, the geologist, and the physiologist—is faced with a considerably more difficult problem in communicating his ideas than is the physical scientist. The mathematician and the physicist, and to some extent the chemist, can legitimately use shorthand—formulas—to express their meaning; but the natural scientist is thrown back on his powers of description to express *his* ideas. And, paradoxical as it may seem, I think that much of the involved writing and unnecessary jargon that deface manuscripts in the natural sciences owes its origin to the subconscious quest for a formula, for a shorthand in which to relate one's observations and deductions simply.

But the English language is not susceptible of such treatment. Such attempts are bound to fail; and the failure is bound to induce in the reader a sense of frustration that militates against critical examination and eventual acceptance of the material presented. There is a branch of geology—I am not going to be specific, for I do not wish to hurt anyone's feelings—in which the English-speaking world for long lagged behind the Continent, mostly, I am convinced, because the only textbook in English was so appallingly difficult to read that the inquiring mind was discouraged.

Be that as it may, we can agree that the essence of good scientific writing is clarity. Although the content of a paper may be difficult to absorb, it is intolerable if an author's ignorance of the tools of his trade—and English is as much his trade as science—should further befog the unfortunate reader.

I have attempted in this article (*1*) to classify the main causes that combine to defeat the aim of clarity in geological writing. It may be that an orderly presentation of possible faults will strike a chord with those to whom a textbook of grammar or English usage is distasteful.

As far as possible I have illustrated each subhead of my classifications. I have used, for all except two examples, excerpts from manuscripts that have passed through my hands as editor in the Bureau of Mineral Resources; and my colleagues have forgiven me (*2*). Two examples, which were too good to miss, were taken from outside sources. I hope that if their authors recognize their offspring they will not hold it against me; I know very well that anybody going through my own writings could glean examples of a good many of the faults listed; and there are few of whom the same could not be said.

Ambiguity

Punctuation. (i) A common error is to omit the comma before a nondefining relative clause; although I call this an error, the normal result for the reader is ambiguity. Thus: "*Cycloclypeus* is very common in some of the limestones where it is represented by *C. indopacificus.*"

The author did not mean the clause to be defining, but the omission of a comma after *limestones* leaves the reader in doubt.

(ii) "Mildly active vents in the crator were emitting white vapour and traces of sulphur were observed in the vicinity."

Such an ambiguity is resolved as the reader proceeds, but the immediate reaction is that the vents were emitting white vapor and traces of sulfur; and the reader must go back and re-evaluate the sentence. Anything that breaks the reader's train of thought in this way is harmful: the omission of the comma after *vapour* is inexcusable.

Phraseology. Ambiguities resulting from infelicity of phraseology abound. Here is a short specimen that covers a wide field of speculation: "The copper deposits have become unpayable below the zone of secondary enrichment."

Have beeome poses a lot of unanswerable questions.

Obscurity

Punctuation. (i) Here is an extract, encyphered by the indiscriminate use of commas, such as no author should ever produce for a reader's puzzlement (I have disguised the names involved, which might identify the author: I do not wish to alienate my friends): "Remarks on No. 1 Bore are based on reports by Blank, on No. 2 Bore, District of Somewhere, on drillers' log notes by Dash, in a report for ABC Ltd., on bores in the So-and-so area, Mt. Such-and-such, and District of Elsewhere, on personal investigations."

(ii) Perhaps also to be recorded under punctuation, even though syntax is also involved, is the habit of stringing together large numbers of descriptive adjectives before a single noun, usually with inadequate or incorrect punctuation. Thus: "The white sand-dunes are composed of semi-consolidated and loose, white, medium-grained to fine conglomerate sized, angular to sub-rounded, fragments of foraminiferal tests, mollusca, etc., and carbonate and quartz sand."

Prolixity and involved writing. Here I take two examples from outside sources; we have never risen to these splendid heights. One of the extracts is Australian and one is American. (i) "The sharp widening in the backwardation in the Metal Exchange quotations for zinc recently illustrates the tight prompt position which has developed." (ii) "A uniformitarianistic approach to the origin of the . . . Series seems consistent with most data, and, if this philosophy is followed, some interesting environments of origin are suggested."

Cliché. Clichés are an abominable feature in manuscripts. They indicate only that the author is either unable, or too lazy, to think out the subject matter for himself. But besides the general cliché there is another allied danger against which the author must arm himself: the coining of a cliché peculiar to his own work by overusing a descriptive phrase that he is particularly fond of. The effect on the reader is the same: boredom, and a suspicion that the author is using the phrase without consideration for its precise meaning, and hence is imprecise in his thinking—for the one is the corollary of the other.

Examples are of course not possible in a short article, but perhaps I may be allowed to quote a short sentence that illustrates a cognate point: ". . . it is present as shreds and patches from 1 mm. to 5 cm. across."

The concealed quotation from *The Mikado,* even though it may well have been subconscious on the author's part, distracts the reader from the—essentially serious—de-

scription of a rock. The concealed quotation is fortunately rare in scientific work, for it has no place there.

Imprecision of expression. Clarity is precision: the constant use of vague qualifying adjectives and adverbs shows clearly that the author is pretending to a precision that his thoughts have not reached. Such work is a nightmare to edit, because the editor no more than the reader knows what the author means by such phrases as *in limited quantities, relatively shallow water,* and the rest.

Error

Punctuation. Errors in punctuation are legion; the commonest seems to be the misuse of that difficult stop, the comma. An editor—one editor, anyway—seems to spend as much time in erasing and inserting commas as in all other corrections put together.

Grammar. (i) Only a few of the many errors in elementary grammar can be quoted as examples. The unattached participle is common, and brings joy to the sophisticated: "Driving to the east for about a mile, the seam broadens." "Deep-seated rumbling was noticed while encamped on the upper slopes."

(ii) The transferred epithet occasionally pops up: "Deepest information yet obtained is from a bore."

If the information is deep, it is only in a colloquial sense!

(iii) And "number attraction"—where the verb agrees in number not with its subject but with some intervening noun—is one of the editor's daily companions: "The surface of these flat areas are usually 'crab-holey.' "

Vocabulary. (i) Most of us are so proud of our vocabulary, unfortunately, that we do not use the dictionary as we should; and hence *comprise* is misused for *constitute* (almost invariably), *mitigate* for *militate, distinctive* for *distinct,* and even *effect* for *affect.*

(ii) It is hard to convince authors, too, that absolute words cannot be qualified: *unique* and *minimize* are common victims. A more subtle snare is exposed in " . . . an extremely poikiloblastic garnet." Textural terms like *poikiloblastic* are absolute: they, too, cannot be qualified.

Nonsense. The realm of sheer nonsense is most often entered, in my experience, by authors who wish to give a spurious air of precision to a vague statement by using mathematical terms that they understand imperfectly. Four examples show this common error:

(i) ". . . a semi-vertical fault." The author meant "quasi-vertical"—or, better, "nearly vertical"—not a fault hading at 45°.

(ii) "The field is semi-elliptical in shape." But, even with the radii known, there are eight possible semi-ellipses round any given point.

(iii) "The corallites are unidirectional, but not perfectly straight." In that case, what on earth does *unidirectional* mean?

(iv) "The ratio of men at work to men . . . sick (of silicosis) . . . rose at one time to one." It is to be hoped that the rise continued.

Two points stand out from this analysis. The first is that there are two main ways of distracting the reader's attention from the scientific content of the paper he is studying: first by making it unnecessarily difficult—and frequently impossible—for him to grasp the author's meaning without first untangling a jungle of jargon and grammatical obscurity; and secondly by introducing incongruities and errors that distract his attention (one must assume that he is himself sufficiently literate to notice them). The first is the more serious; but the second may be compared with, say, a wrong entry by the cymbals during a symphony.

The other point—which rather astonishes me when I reread what I have written—is the prominence assumed by punctuation. Incorrect or inadequate punctuation is the factor common to all the major divisions I have sketched. Everyone thinks he knows how to punctuate: that is the main trouble; for it is hard to persuade intending authors that it is an art, requiring—and repaying—special study. (This paper, by the way, is punctuated according to English usage; there are several points in which it is incorrect, or at least pedantic, by American usage.)

A third point—which may be specific to Australia, although I do not think so—is that young graduates on the whole cannot write English; have never been trained in the use of English (a result perhaps of too early and too great specialization at school and university), and have not even been made aware that fluency of composition is an essential part of their professional qualifications. But that opens up such a wide vista for discussion that it may well be left to a separate paper.

Most of the points I have catalogued so far are of general application, and it is only in the examples that a specifically geological application can be seen. But there are one or two other considerations that are of special importance to the geologist.

First, there is the general question of terms that have come to us from the miner, the naturalist, and other people not primarily concerned with precision. This may affect geological writing in two ways: in the use of inherited terms that cannot be precisely defined, and in the use of metaphor.

Geology is an earthy science in more ways than one; and one need only cite a single example of a term inherited from the "practical" miner to show the difficulty. The word *ore* is in everyday use in geology, and indeed is inseparable from it; but it cannot be defined. The long and indecisive discussion that followed a recent paper by W. R. Jones (*3*) showed, not only that every contributor had a different definition to offer, but that no agreed definition which would be of general use was in fact possible. Nor is it always possible when reading a paper to understand just what the author means by the word. Attempts to restrict the meaning of a mining term—as in *ore*—or to extend it—as in *mineral*—are a common source of confusion and inexactitude.

Also, the adopted language of the geologist is rich in metaphor, some taken from other professions and some from everyday life. We talk of *beds* of sediments, of *tongues* of intrusive rock, of *flanks* of folds, and so on. Such metaphor is normally dead, but it is only too easy to make it spring to life by an unfortunate choice of words. Here is an example of a dead metaphor brought to life by the incongruous juxtaposition of another dead metaphor: ". . . consequent streams flow down wrinkles on the flanks and noses of the anticlines."

Admittedly, this is error likely to occur in all writ-

ing; but among the sciences, geology, perhaps because of its plebeian origins, seems to be particularly susceptible to it.

The geologist works, unavoidably, with incomplete data. The surface rocks on which he makes his observations are interrupted by soil, by vegetation, by human habitation, and it is a fortunate field worker to whom more than 1 or 2 percent of the total surface that he is working on is available for direct observation. From this inadequate exposure he must interpret the whole of the surface plan of the rocks; not only that, he must also extend his interpretation into the third dimension of depth, on which he can obtain very little information at all. Consequently the map and the report of the field geologist can be classified, not too contemptuously, as intelligent guesswork informed with a knowledge of precendent.

He is often right, or nearly right: that is a tribute to his skill in deduction and his assimilation of the lessons of his predecessors. But it calls for a nice accuracy in writing to be able to steer a course between the Scylla of dogmatic assertion and the Charybdis of apologetic qualification. Knowing the other fellow's difficulties, one is more lenient toward the conditional than the absolute; nevertheless, too many *maybe*'s and *possibly*'s and their like impair one's opinion of a man's work.

A third problem inherent in geological writing—and probably common to writing in all the natural sciences—hinges on the amount of routine description that must be included. Although the data presented may be of vital importance, it is somewhat difficult to avoid what one author from the Bureau of Mineral Resources has called "a deadly monotony reminiscent of a railway timetable," when describing, say, the lithology of type-sections, or successive deposits of the same mineral (there is *mineral* intruding itself in its industrial sense). Matter such as systematic descriptions of fossils can legitimately be so written: it is not meant for continuous reading or immediate absorption, but for reference; but matter written so that "who runs may read" must be written very skillfully if the reader's interest is to be maintained.

It would be idle to pretend that all the difficulties I have outlined are normally surmounted, or even that they are in all cases surmountable, either by author or by editor. They are matters of style, not of grammar, and great stylists are rare even among professional writers; and even a Gibbon might falter at the task of making routine descriptions interesting. But we can aim at perfection even though we know we cannot attain it.

Much hard work remains to be done before the scientist is persuaded that it is to his own benefit to take greater pains with his writing: that he pays for bad writing by being faced with unreadable papers by others. Maybe some day we shall see a courageous author put a footnote to a paper: "Blank's paper may be ignored, for the knowledge to be gained from it is not commensurate with the appalling effort of reading it."

In the meantime, editors will have to resign themselves to being (professionally) unpopular and misunderstood.

References and Notes

* Presented by Graham Unikel, Department of Chemistry, Stanford University.

1. Presented with the permission of the director, Bureau of Mineral Resources, Geology and Geophysics, Melbourne, Australia.
2. My thanks are due to my colleagues in the Bureau of Mineral Resources who have unwittingly provided me with my material, and who accept resignedly the return of a manuscript endorsed "Not understood: please rewrite more simply."
3. W. R. Jones, "Ore: what is it?" *Bull. Inst. Mining Met.* No. 564, p. 75 (Nov. 1953); discussion, *ibid.* No. 569, p. 333 (Apr. 1954).

A System for Testing and Increasing the Intelligibility of Technical Reports

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The problem of making technical reports intelligible to the lay reader is of great importance. Research is increasing in volume, and more and more nontechnical persons are finding it necessary to understand the results of the expanding research effort. Project Big Ben of the University of Pennsylvania's Institute for Cooperative Research has been concerned with the problem of intelligibility during recent years. The project has evolved a system for testing and increasing the intelligibility of the many technical reports prepared for nontechnical readers.

The Big Ben system is only one of many possible systems, but it has had the advantages of trial for two years. Thanks to the various improvements that practice has suggested, I am able to report that our system actually works. Why is any system necessary for insuring intelligibility? Is it not a simple matter for the editor and the author merely to sit down quietly together and *make* a report intelligible? The answer is, I believe, *not always*. It should be, perhaps, but it is not. Why?

Let us consider the state of mind of an author who has just completed a report and is still in the heat of composition. He is the nucleus of our problem—not merely the author as author, but the author in this special, this interesting, condition.

I would not be blasphemous, but the author in this state is remarkably like God in the Book of Genesis: he has labored, he has created, now he would examine the result of his work, "And God saw everything that he had made, and, behold, it was very good" (1:31). Finally, even as God, the author is ready to rest.

The author in this particular state of mind is the heart of our problem. We must understand him, we must appreciate his condition, if we hope to solve that problem.

Let us look in upon the author who, in the sanctity of his office or laboratory, has just applied what he considers to be the finishing touches to his report. He

closes, perhaps even locks, his door, and submits to the exquisite pleasure of reading his own words. He grows a little pale and the line of his chin becomes firm under the impact of the ambitious purpose and generous scope he has bravely stated. When he reaches that section in which he sarcastically disposes of some poor scientist unfortunate enough to have engaged in a similar research effort for a different sponsor, an evil smile plays about his lips. At last, as he reads his most superb passage (the one in which he has pulled out all the literary stops at his command), he loses all control of himself and bursts into tears.

At this point the editor, who has been examining the carbon copy and has been affected somewhat differently, enters. He begins (I will not include here the vital cushions of tact and diplomacy that the wise editor would employ),

> "Look here, your report does not really fit its stated purpose and scope. You must either expand the body or make your purpose and scope less ambitious. And this sarcastic section, diabolically clever though it is, emphasizes a minor point and thus distorts your central message. By the way, this high-flying passage is ambiguous and confusing because you have used approximately five times the number of words you actually needed."

The author is now, understandably, unhappy. He is disappointed; he is hurt; perhaps he is angry. His splendid work, he believes, is threatened with emasculation. And who makes this threat? A person from that quaint never-never land, the humanities; a person whose only function on the project, the author had thought, was to provide comic relief.

Of course, *we* know that the editor is on the side of the angels. He has logic as his weapon if he is worth his salt as an editor. His warning to himself, if he is wise in his dealings with authors, has always been "Don't give them rules, give them reasons."

The author, however, in an emotional and biased state, cannot view the editor's reasons objectively. But what if a *number* of people were to tell him the same thing? What if these people were not editors, not "humanitarians," but fellow technical specialists, fellow authors? Then the author's report might be changed more easily. This is the essence of the system I have mentioned. It is, essentially, the closing of the gap between editor and author. It is the assigning to authors—for a time—the duties and responsibilities of editors. But, specifically, how does it work?

The editor must first convince management that the reporting and reviewing phases of any research effort are worth a substantial expenditure of time. The editor must be consulted on the establishment of deadlines; he must see that these are set at least one month after the date on which an author will submit what he considers his completed report.

During this month or more the editor supervises the review of the document through a number of stages. In the first—the editorial—stage, the editor or a member of his staff edits the work for mechanics of form and format. In the second—the technical review—stage, the editor designates a technical man (in the author's field and of at least the author's stature) to edit the work for technical accuracy. As stage three, the editor sets up a trial audience composed of technical specialists from fields similar to, as well as from fields divorced from, the field of the report. This group consists of 10 or 12 persons, and includes the director of the organization or his deputy. Each member of this audience receives a corrected copy of the report after it has passed stages one and two. The members of the trial audience are given at least one week to study the report and to write into it any corrections or changes that they feel are necessary. The trial audience then meets with the author to discuss the report.

The director, his deputy, or the editor acts as chairman of the meeting. First, a general question is considered: Does the report accomplish its stated purpose and stay within its stated scope? Then follows a page-by-page consideration of the intelligibility of each section, each paragraph, each sentence, and each word.

Let us suppose that the report is in the field of chemistry. If a statistician or political scientist does not understand any part of the work, he says so at that point. It may turn out that this gentleman merely did not read the particular section carefully. If this is the case, the other members of the trial audience will readily defend that section.

The instinct of the audience, we have found, is not to change any part of an author's work unless that part is actually ambiguous or misleading. If any part of the report is unsatisfactory, a good proportion of the audience will so indicate when that part is reached in the page-by-page review. The author, faced with numbers, is quick to see the error, and is quite willing to correct it.

Whenever possible, the faulty section is changed during the meeting of the audience—the new wording usually being a joint effort of the author, the editor, and the members of the audience who were most interested in the change. If the change is a complicated one, it is made later, in an informal discussion between the author, the editor, and the interested trial-audience member or members. Our experience shows that the tone of the audience is friendly. Honest effort is made toward cooperation. The author benefits from several different viewpoints and is frequently supplied useful information on content as well as on presentation.

In stage four the director or his deputy reviews the report for consistency with the overall policy of the organization. Since either the director or his deputy attends the trial-audience meeting, stage four is often combined with stage three.

The author then proofreads the masters and signs a form stating that they are accurate in every detail and have incorporated every change agreed upon during the various stages of review. An accurate, intelligible report is the result of this effort.

Of course, the success of this system depends upon

the success the editor has in convincing management of the importance of such editorial review. He has good ammunition with which to do this. It is easy to demonstrate that a research organization is not judged on the good looks or scholarly record of its investigators, but is judged on its product, information, and on the effectiveness with which that information is presented. The system that I have outlined requires control, and it costs time and effort. But the alternative can be chaos.

Sometime ago I heard of a case in which an editor had been completely bypassed: an author had sent his document directly to the contracting agency. Some months later the editor had the wicked satisfaction of learning that the report had been returned with the comment that, because of its illogical punctuation, faulty structure, and generally ambiguous presentation, it was not acceptable. As a reult of this embarrassing circumstance, I feel that that particular editor will have the full support of management in establishing such a system as I have discussed.

Technical Manuals: Their Increasing Importance to Industry and Defense

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"Graphic communications" might well be used as a second title for an article on the importance of technical manuals to industry and defense. Such a second title may appear to be very broad in scope, but I use it to help dramatize a new philosophy respecting technical manuals—a philosophy that we should embrace throughout the scientific, engineering, and technical world. Because of the extreme complexity of today's industrial machinery and weapons of defense, the instruction books we call technical manuals must be prepared according to new high standards of ready understandability. In short, our technical manuals must be engineered as carefully as the equipments they concern. That means we must expand sufficient time, thought, energy, and money on them to make them virtually faultless instruments of graphic communication. Surely this is a far cry from the concept widely entertained in the past, that technical manuals can be a kind of "cheap and dirty" afterthought in a program involving the design and production of costly and complex equipments.

Slowly and surely we are being forced by the tremendous advances we are making in our technological world to understand the need for better-written and better-illustrated instructional material. In fact, the mistakes we sometimes make because of deficient instruction manuals are reason enough for us to tackle this problem more earnestly.

In the commercial and industrial world a deficient manual program can be the direct cause of bad production, poor maintenance, customer dissatisfaction, loss of goodwill, and loss of business. It can even mean tragedy, such as took place not long ago when a commercial airliner crashed because of faulty instructions in a maintenance manual used in servicing the airplane. One paragraph of the Civil Aeronautics Board Accident Investigation Report covering this case said:

> Figure . . . illustrated the idler as a straight-designed component whereas the actual part is curved, and depicted the forward and rear push-pull rods incorrectly in their inboard and outboard relationship. Instructions . . . of the same publication referred to this figure for removal and installation purposes. From this figure, . . . , correct positioning of the idler could not be determined.

This seems to be a good example of the importance to industry, and to the lives of the public dependent upon that segment of industry, of the need for *good* and *foolproof* technical manuals. There must be countless other examples involving anything from the frustrations of a housewife when her newly purchased can opener is supplied with confusing instructions, to some major loss involving lives and costly property.

With respect to the military services, it should be obvious that mistakes can be extremely costly indeed. The mistakes may range all the way from the peacetime mishandling of small arms to performance failure, in a national emergency, of a complex guided missile system. Even during peacetime the costs of maintenance can sky-rocket when armed services personnel fail to "get the word" in clearly understandable fashion from well-written, well-illustrated maintenance and trouble-shooting manuals.

We can no longer afford to be penny wise and pound foolish in our technical manual programs. It is ridiculous to spend fabulous amounts of the public's money on defense equipments and systems, only to have a portion of those sums frittered away unneccessarily because good instructions for operation and maintenance are lacking. All too often have there been instances in which, after splendid thought had been applied to the conception, development, and production of intricate devices for defense—devices that often are referred to by the military as *hardware*—the instruction manual has been treated as a mere afterthought. We have said: "Oh, yes, perhaps we should have some kind of instructions on this," or "We've spent so much on the hardware that the instructions will have to be 'cheap and dirty.'"

We cannot afford that kind of short-sightedness any longer. It is far too costly. Today, if our intricate weapons of defense and our complex products of industry are to be well understood by those whose job it is to run and maintain them, we must apply to our instruction manuals a kind of "engineering" that, in its way, is comparable to the superb engineering on the hardware itself.

To do this we need to change our thinking about instruction manuals. We need to adopt a new philosophy concerning them. We need to realize that they are *the* vital link of communication between the engi-

neering talent that created the hardware and the technicians who operate and repair it. We must say to ourselves: "How well can this book be written? How clearly can it be illustrated? Let us make it as foolproof as we can." In the long run such a concept will pay off, although initially it may seem to be more costly.

Perhaps this simple illustration will help to emphasize the importance of good technical manuals in today's complex world. Bear in mind the second title of this article, *Graphic communications*. Bear in mind also that in any system of communication, particularly those involving electronics, such as radios and television, the slightest deficiency in a component may cause garbled transmission or reception, or may stop communication altogether. Deficiencies in such systems may be the intermittent change of value in a resistor, the burn-out of a transformer, or the breakdown of insulation in a capacitor. Similarly, in oral communication, poor organization of thoughts, deficient enunciation, and a weak voice may limit the transmission and reception of ideas.

Just so it is in graphic communication. The ambiguous wording and the illustrations that are too small or too crowded tend to reduce effectiveness. They tend to cut down on over-all clarity and they defeat or materially weaken the originally intended purpose of getting the message through.

Let us, instead, be more painstaking in our development of text, more generous in our treatment of illustrations, and let us print our material so that its effectiveness is not impaired.

From time to time I have heard that people in the scientific world are concerned about their inability to marshal support for their pet ideas and projects. Perhaps a reason for this lack of support lies in the inability of many a scientist and engineer to be understood. And why is he not understood? Because, in his oral and written and illustrated presentations he uses jargon and illustrative methods that are obscure to all except a few who possess virtually equal specialized learning.

What is the answer to this situation? In part, it would seem that in our schools, our colleges, and our universities there is need for far greater emphasis on the *how* of graphic communication. We must be taught at an early age that it is not enough to become highly capable as a scientist or engineer alone. But in addition, we must know better *how to communicate to others*—a larger, much larger field of others—those things we wish them to know about our work. We must know more about how to write lucidly; how to illustrate three-dimensionally, and how to speak so that our audience will listen and can understand.

In the preparation of technical manuals, particularly, we cannot afford to write and illustrate in a style calculated to impress others with our superior knowledge. Such treatments may be quite appropriate when our audience consists of engineers or scientists with general knowledge equal to our own. However, when our audience consists of operating personnel and maintenance technicians and, for that matter, many administrative people in the services or industry, then our problem to make things unmistakably clear is a tough one.

Until more of us learn the techniques of clear presentation, we may need to enlist the services of others whose experience and proved capability have qualified them for such work. Such specialists often provide the means for bridging the gulf between the scientific or engineering level and the technician level. These specialists have rendered great service to the armed forces and to industry. For the most part, what specialized talents there are in this field have migrated to such organizations, and the need for their services continues to grow. That is why we must now tackle the problem on a long-range basis by providing formal education along these specific lines on a scale far larger than ever before.

The leaders of the future world of science, engineering, and technology are more likely to be those men who not only are proficient in their specialized fields, but who are also proficient in their ability to set forth clearly their worthwhile ideas. If they have been unable to develop such a proficiency in themselves, they should recognize the shortcoming and seek the assistance of others who can help. In any event, they should recognize the importance to industry and defense—yes, even to civilization itself—of effective graphic communication, and particularly the importance of the technical manuals that form the link of communication between their plane of thought and that of the operating and maintenance technician who will use them?

It is only by such means that we can assure the communication of information needed to keep pace with the purely scientific and engineering strides that we now foresee.

Scientific journals are the circulatory system for the ideas of science. It is largely through them that science develops, for scientific growth is the result of cross-fertilization between laboratories and groups in different countries. One of the evil consequences of war is that it stops the flow of scientific ideas from one nation to another. And to the extent that this process is blocked the development of science is definitely retarded.—RAYMOND B. FOSDICK.