Part I

An Introduction to Technical Writing

"Begin at the beginning," the King said, very gravely, "and go on till you come to the end: then stop."

—LEWIS CARROLL

It would be very easy to show how technical or report writing differed from other writing. My purpose, however, is to stress the similarities. Writing is for communication. This is no less true of technical writing than of writing for newspapers, magazines, or books of fiction. Except perhaps for a few novelists or poets, we do not write solely to express ourselves; we write to say what we have to say, so that our audience can understand it.

Many technical writers, unfortunately, seem to forget that their intention is to communicate, and they write as if for themselves. Their papers are insufficiently explanatory, and they are written with little or no regard for style or clarity. Occasionally, I hear of an important paper that has been ignored because no one could understand it, until the work was rediscovered independently by someone else. The original paper had no function except to establish priority.

Even relatively good technical writing is frequently characterized by long, complicated sentences and difficult prose. The writing is very formal, rarely uses proper names, and almost never uses the pronouns, *I*, *you*, or *we*. Such writing has to be very good if it is to avoid being very tedious.

One of the reasons for this kind of formality is the prohibition against using *I* or *we*. I do not know where this prohibition came from; it originated in this century and often exists only in the mind of the writer. The American Institute of Physics *Style Manual*, which prescribes the style for more than a dozen technical journals, specifically advises contributors to AIP journals to use the first person. Even so, most of the authors of papers submitted to these journals strenuously avoid writing *we*.

When I sit down to write a paper, I ask myself how a writer like Hemingway would write it. Hemingway. Not Faulkner, not Joyce. Hemingway, who wrote short, crisp, punchy sentences that never left any doubt what he meant.

A Farewell to Arms begins

> In the late summer of that year we lived in a house in a village that looked across the river and the plain to the mountains. In the bed of the river there were pebbles and boulders, ...

The modern technical writer might begin it

> At that point in time, a house in a village was lived in that looked across the river and the plain to the mountains, in the bed of which one could see pebbles and boulders, ...

A parody? Of course! But the style is only a slight exaggeration of the style of many technical papers. How much better they would be if they were written in the style of the original quotation!

I know many scientists who can speak perfectly clearly and expressively. Put a pencil into their hands, and they clam up. Why? I suspect that it has to do with their belief that scientific writing has to be written in that formal and unnatural style, replete with passive verbs and misplaced modifiers, shown in the Hemingway parody. When I see a manuscript written in this style, but poorly, I always advise

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Rule #1
Write the way you talk; then polish.

Jacques Barzun, the linguist, points out that language is not divided into poetry and prose; there is also speech, and speech is not prose. Speech is characterized by vocal inflections, as well as

by pauses, backtracking, false starts, hems, haws, and, sometimes an interminable succession of *y'knows*—not to mention misplaced modifiers and unattributed pronouns. Prose, according to Barzun, is not so characterized.

English prose is only a few hundred years old, and Barzun thinks we are still developing it. The earliest prose was complicated and flowery. Jefferson's most famous sentence, *We hold these truths to be self-evident* . . . , is 111 words long. In modern times, when most of us are in a hurry (and some may be speed readers), we cannot put up with too many 111-word sentences that begin with principles and end up overthrowing governments.

Some prose is still complicated and flowery; some is complicated and clumsy. But, in this century, many writers have discovered that good prose can be direct and simple. Their writing closely approximates speech, except that it omits the hems, haws, and *y'knows*—and it is more precise than speech. It has to be: writing lacks vocal inflections, tone of voice, and gestures. Perhaps more important, the writer can't tell when the reader does not understand.

Prose has to be written more precisely than speech, but not in a stilted or unnatural manner. You have to be careful of word order, making sure that a modifier is properly located with respect to the word or phrase it modifies, but you can still write short sentences that sound like highly polished speech. In short, good prose should read like polished speech, but not stilted speech.

That is why I always advise beginners, *Write the way you talk; then polish.* Polishing includes eliminating the obvious flaws, like slang and contractions, and you do some polishing automatically as you write. Afterward, you will want to go over the manuscript carefully, looking for sentences that are hard to understand, modifiers that are out of place, sentences that are too long, or ideas that do not follow one another and need additional clarification.

Many writers write long, complicated sentences. Sports writers are among the worst offenders, but even popular science writers are sometimes guilty of:

> Though this individual (called 0H62 because she's the sixty-second Olduvai hominid to be discovered)

> probably had, like other *H. Habilis* specimens, a rather modern head—with a large forehead, indicating greater brain power, and a rather delicate face—her arms dangled to her knees.

This writer has tried to give you too much information in a single sentence. Some scientists do the same thing:

> The square of the autocorrelation function of an edge-enhanced image of a manufactured object was obtained by generating a Fourier-transform hologram in a converging-beam optical correlator using a liquid-crystal display video monitor addressed by a charge-coupled device video camera, which has good rectilinearity.

This author is trying to impart information in parallel instead of in series. In a single sentence, he tries to tell us about the experiment, the object used, the type of correlator, the type of display, the type of video camera, and the reason for using it. Several short sentences would have been better, even though a bit longer:

> The purpose of the experiment was to recognize a manufactured object optically. For video input, we used a charge-coupled device, because it has good rectilinearity. We displayed an edge-enhanced image on a liquid-crystal TV monitor and placed it in the object plane of a converging-beam optical correlator. We generated a Fourier-transform hologram of the display on the monitor and used it to obtain the autocorrelation function.

The second example obeys

Rule #2
Write one thought per sentence.

You don't have to adhere strictly to this rule. The main point is not to pack too much information into too short a space. Make your writing flow, one connected thought after another, so that the reader sees where you begin, where you are going, and where you end up. Tell your story logically and completely, conveying each important fact in a single, tightly constructed sentence (or, at least, a single independent clause).

A corollary to Rule #2 is

Rule #2a
Be explicit.

Don't make the reader infer something, and don't bury an important fact where it might be overlooked. For example, if you want to tell certain details of your experimental system, don't let us infer what is important by hiding these details inside a cluster of modifiers. *The single-mode, water-cooled, HCN laser beam was directed into the blazed, evacuated, ruled-grating, infrared spectrometer.* If it is important, for example, that the laser beam was a single-mode beam or that the spectrometer was evacuated, tell us in a separate sentence, so that we don't overlook the important fact.

Other writers seem to forget that their readers do not yet know what these writers are about to tell them. They remind me of a colleague I once had; he started a seminar with the words, "Most of you have heard me ramble about these things before, so I'll just go on." (Unfortunately, I had not.) These writers start their stories in the middle and work their way toward the end or, if we are lucky, toward the beginning and the end simultaneously. They do not realize that they have to give uninformed readers enough background to educate them to the point where they can understand the new material. These writers just present their material with no explanation or background.

The better approach is

Rule #3
Write for the uninformed reader.

When I am enlisting people to give a seminar or a colloquium to a group, I always ask them to choose a level of presentation that will enable a typical college senior in physics or electrical engineering (or whatever) to understand it. I ask them to take great pains to avoid speaking only to the two or three specialists in the room and, instead, to speak to the rest of us. In other words, speak to an intelligent and sophisticated, but relatively uninformed audience. Explain. Simplify. Use analogies. Rationalize when necessary. But do not go so fast that you leave most of us behind.

Similarly, do not write your paper for the two people at your institution and the three others elsewhere who will understand it instantly. Write it for a wider audience. How wide will depend on the publication. Obviously, a very short paper written for a highly specialized conference needs less explanatory material than a longer paper written for a journal with tens of thousands of subscribers. Even so, try to write each paper so that you address as wide an audience as possible, within the constraints laid down by the publication. The result will often be an elegant paper that will be appreciated for its insight by specialists and nonspecialists alike.

A paper addressed to a wide audience will probably be read and cited more than one addressed to a narrow audience. More important, though, you will have a greater chance of being understood if you write simply and include ample background. I think, therefore, that it is preferable to err on the side of simplicity and to try to explain as much and as clearly as possible.

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So far, I have addressed the similarities between technical and nontechnical writing. Everything I have said could be applied

equally well to magazine writing or news broadcasting. How does technical writing differ from more general writing, and why do many technical writers have so much trouble expressing themselves?

First, the material is often extremely complex. Sometimes, alas, authors do not thoroughly understand their subject; then, writing a clear paper is almost impossible. More often, though, authors understand their area very well, but are unable to express themselves simply and clearly. Theorists, for example, may see the equations before them as in a book, but not know how to put the words in between.

The problem, in a way, is that the material has become so familiar that it is trivial. It is extremely difficult to explain trivial material to someone else. Try, for example, to tell a fifth grader why division by a fraction is the same as multiplying by the reciprocal of that fraction. You can't just say, "That's the way you do it"; that is not good enough. Rather, you have to work through the problem *as if you were seeing it for the first time*, even though that may well not be the way you first learned it.

The equation alone,

$$[1/(a/b)] \cdot [(b/a)/(b/a)] = b/a,$$

is also not good enough. You have to explain, step by step, what you did and why. For that purpose, you have to use words.

The same is true in technical writing. Start with something your audience already knows and go on from there. Give a reason for every step. For example, don't say *Linearizing the equation*, followed, with no further explanation, by the result; rather, write *Taking the logarithms of both sides, we derive a linear equation of the form ....*

Explain yourself every step of the way. Leave out nothing except algebra and arithmetic. Be very specific in describing a design or an apparatus. If you have to skip, say so, and outline the proof or give a very specific reference.

Technical writing is also characterized by very precise terms. This leads to complex modifiers and, frequently, clumsy constructions. For example, many digital watches and portable computers

use something known as a *liquid crystal display*. When you use such a display to make a video monitor, you end up with a *liquid crystal display video monitor*. Hyphenating (*liquid-crystal display video monitor* or *liquid-crystal-display video monitor*) helps only slightly; you are still left with a clumsy string of five nouns that are hard to break up. Such constructions are common in technical writing and help make it difficult to read.

Often, we solve the problem by making up an abbreviation, such as *LCD monitor* or *LC TV*. As long as the abbreviation is familiar, that is an acceptable solution; otherwise, it may make your writing even more inaccessible. The better solution is to use prepositional phrases or subordinate clauses, *a video monitor that uses a liquid crystal display*, for example. Afterward, just refer to the monitor as *the monitor*.

Technical writing also uses made-up words and precisely defined words that may not have the same meanings as they do in ordinary speech. For example, *repeatered*, in electrical engineering, may be inelegant, but it has a specific definition: a *repeatered cable* is *a cable in which one or more repeaters have been installed*. Similarly, words like *energy*, *force*, and *power* have different meanings to the physicist than to the layman. Power has yet other meanings to the political scientist and the psychologist.

Grappling with highly qualified (or modified) nouns is a real problem in technical writing and should not be dismissed lightly. It is one of the things that makes many technical papers hard to read. It is also no accident that one of the longest discussions in this book concerns *hyphenation*.

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Most technical papers are organized according to a formula. That formula is essentially the one we learned in junior high science class: Introduction, Theory, Experiment, Observations, and Conclusions (including Discussion or Recommendations). In addition, most papers have an Abstract and References, and some have one or more Appendixes. These sections may not be explicit in the paper, and one or more may be missing, but this is still a rough outline of much technical writing. It is usually a good

outline to follow, whether you are writing a one-page paper, a letter to the editor, a thesis, or a lengthy report.

The American National Standards Institute suggests a similar organization: Introduction, Materials (when appropriate), Method, Results, and Discussion. This form is widely used and, in effect, combines Theory and Experiment into Methods; and Observations and Conclusions into Discussion. As above, the sections need not be explicit in the paper; both formats are simply suggested outlines to follow. Neither, for example, precludes beginning a paper with its main conclusions or recommendations, and ANSI points out that the material should not be forced to conform to the ANSI format. In particular, short letters, papers with lengthy appendixes, mathematical or theoretical papers in which the methods and the argument are the same, and engineering specifications or instruction manuals need not follow either recommended format in detail.

The Title is also an important part of a paper. In fact, it is the part that will be read by the most people. Do not skimp on your Title; make it say something to the reader. No one will read your paper if the Title is uninteresting or unintelligible. Make the Title brief and to the point, but let it tell the reader that an interesting paper or a meaningful result follows. A poor Title or a Title that does not convey the real importance of your paper usually sells your work short.

The Abstract is equally important. Too many authors write a significant paper and then toss off an Abstract that conveys little or no information. Today, when there are Abstract journals and computer databases, many readers will see nothing but your Abstract. Give them enough information to make them want to go to the trouble of finding your paper and reading it. Conversely, give them enough information that they can avoid looking up your paper only to find that it is irrelevant to them. In short, make your Abstract an informative summary of your paper and include your results or recommendations whenever possible.

The Introduction is the place to give the background for your paper. You may want to explain why you pursued the line of research you did, or you may want to describe the work that led

to your own. Don't make the Introduction a series of references that tell who did earlier work but nothing about that earlier work. To the greatest extent possible, let your paper stand on its own feet, so that it can be read without recourse to the References. Only those who want to study the subject in greater detail should have to consult the References.

The Introduction can also include a summary of the paper. There is nothing wrong with telling what you are going to demonstrate in the body of the paper and, perhaps, how you are going to do it. Complex papers with relatively narrow interest can often be improved greatly if the Introduction is so complete that the nonspecialist can read it alone and profit from it.

ANSI recommends, further, that you make your assumptions explicit in this section and justify your method when there is an alternative. Even the specialist has not followed your line of reasoning before; that is why you are writing the paper.

Some papers contain both a Theory section and a section on Experiment or Apparatus, whereas others have only one of these sections. This is where you get down to business and, often, write solely for the specialist. Describe your experimental design or your theoretical approach in as much detail as you think necessary, but try not to leave out whole lines of thought (without saying so). Make your paper detailed enough that an expert can reproduce your experiment or your calculation without reinventing most of your development. If the description or the theory seems too tedious, consider putting some of the more detailed or mathematical material into an Appendix.

As a general rule, write a section on Discussion or Results separate from your detailed Theory or Experiment section. A reader might initially want to skip the more complicated parts of a paper and yet learn of your new results. Whenever possible, explain your results so that the reader can appreciate them without reading the entire paper in detail.

Include an explicit Conclusion section only if there is still something unsaid, or if you think that the conclusions should be grouped together and stressed. But do not feel that you must have a Conclusion, and then write a vague summary with no real point to it. Make every word count.

References are for a reader who wants greater detail or additional background. They are not a substitute for an Introduction, nor are they a list of credits, as at the end of a movie. Make your References as specific as possible. If the publisher allows it, include titles and first and last pages of papers you cite, and include page or chapter in book citations.

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Complex material and highly precise definitions are, I think, the major characteristics that distinguish technical writing from other writing. Other differences include the use of figures and tables, references, and equations. But these differences are not as fundamental, because they do not influence technical writing style directly.

This book is largely a plea for simplicity, for what Flesch calls *a word diet for those who are verbally overweight.* I recommend writing short sentences in the active voice, rather than long sentences in the passive voice. I argue in favor of a short word or phrase in place of a long or pompous one. I suggest using the pronouns *I* and *we* whenever possible.

In grammar, I demand precision, but I am not a purist or a prescriptivist. I avoid the dangling participle and insist on the correct use of adverbs. But I see nothing wrong with many split infinitives, and I begin sentences with *It is* when I think it is appropriate. I try to make my writing as close to colloquial as I can, without crossing the line into inelegance.

This book is for those who love writing or who want to improve their writing skills, but it is aimed most specifically at scientists and engineers, and most of the examples are drawn from scientific papers. Lawyers, administrators, and others who frequently write formal letters, reports, or briefs could also use it profitably by skimming over the entries that are specific to scientific writing. The book covers the gamut from letter writing to publications in archival journals. It is written in an alphabetical format, and it includes entries on grammar, usage, and definitions, as well as other entries specific to scientific and technical writing. (Because of the format, some concepts may be repeated and a few errors pointed out more than once.) The grammar entries themselves are

not exhaustive; rather, I have chosen only those that seem most germane to technical and report writing. I assume, in other words, that the reader knows the rudiments of grammar and punctuation, and I concentrate instead on those areas with which technical writers have the most difficulty.

I have included many examples both of writing that could stand to be improved and of my suggested improvements. Most of the examples have been gleaned from real papers and manuscripts, but I have shortened many or edited them so that they display only one error at a time. To those who think they recognize their own handiwork, I can only apologize and offer the hope that the author was someone else.

The examples appear in *italics*. Cross references are in **boldface**. Some of the entries contain commas, so cross references are separated by semicolons, not commas.

Despite its format, this book is intended to be read from cover to cover, casually, during lunch hours or short breaks, the way I have read several other similarly organized books. My purpose is to make the case for clarity and informality in technical writing.

Many of the entries are words or phrases that appear frequently in technical writing. I have chosen these entries with care, to highlight the problems in a way that listing them under a general heading would not. Therefore, the owner who does not read the book from cover to cover will ultimately overlook a lot. After a first reading, the book should prove useful as a reference handbook.

As poet and etymologist John Ciardi used to say, Good words to you!