

WRITING
for
ENGINEERING
and
SCIENCE



BY TYLER G. HICKS

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Engineering and Science

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WRITING FOR ENGINEERING AND SCIENCE

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Writing for

BOOKS BY TYLER G. HICKS

PLANT ENGINEER'S EASY PROBLEM SOLVER

PUMP SELECTION AND APPLICATION

PUMP OPERATION AND MAINTENANCE

SUCCESSFUL TECHNICAL WRITING

WRITING FOR ENGINEERING AND SCIENCE

1961

NEW YORK

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LONDON

PREFACE

This book gives a basic and comprehensive coverage of the field of modern technical writing. It was written to answer the daily needs of all technical writers, be they practicing engineers or scientists, professional technical writers, or writing students in all branches of science and technology. The book provides a vigorous approach to all major forms of technical writing used today—reports, articles, papers, manuals, and specifications. Also covered are a number of miscellaneous writing tasks—news items, equipment releases, and advertising.

Two major divisions of content are used. The first five chapters present a broad coverage of the methods of technical writing—outlines, grammar, usage, illustrations, and tables. These methods are applicable to any technical-writing task. Other information given in these chapters will help the beginning or advanced writer better understand his position in the writing field and assist him in his dealings with printers, publishers, and editors. Several valuable checklists in these chapters make the book more useful during actual writing tasks in engineering and science.

The next ten chapters comprise the second major division of the text. These chapters discuss important writing tasks, such as engineering and scientific reports, technical and scientific articles, instruction manuals and bulletins, military manuals, specifications, sales and news writing. Each writing task is comprehensively analyzed on the basis of (1) the nature of the written piece, (2) the variations commonly met in the form of writing being discussed, (3) typical recently published examples of this form of writing, (4) good writing techniques, and (5) helpful exercises to develop writing skill, ingenuity, and independent thinking.

For example, the section on technical articles (1) defines and discusses the important characteristics of modern articles, (2) classifies articles into easily understood categories, (3) analyzes a number of well-written articles recently published in business and trade papers, (4) gives valuable procedures and hints for writing any kind of technical article, and (5) helps the beginning and advanced writer develop his skill by assigning him instructive exercises. These exercises present realistic writing situations.

This five-step approach to training technical writers is valuable for several reasons. The beginning writer's first introduction to a major writing task is presented in well-defined terms. Many beginning writers and students, and even some experienced authors, have little understanding of the elements of an article, report, manual, or specification. Once the student writer grasps the real characteristics of the writing task he is studying, he then easily understands the various ways in

which a given form is used today by management, government, the industrial press, and other groups.

With a basic understanding of the writing form and its varieties, the beginning writer is ready to study typical published examples. These modern, carefully chosen examples grouped at the end of the book illustrate hundreds of valuable techniques—from the choice of a title and lead paragraph to the last sentence in the selection. Other items studied are illustrations, captions, tables, subheadings, paragraphs, and conclusions.

During his study of examples of good technical writing the beginning writer also learns many useful writing procedures. These procedures are the actual steps taken by every technical writer when preparing a written piece. Topics covered include choice of a subject, preparation of an outline, writing the first draft, and revisions. Most of the chapters contain useful checklists available nowhere else. These will assist all technical writers throughout their careers.

Much experience with technical writers shows they learn most from studies of published works. A major part of this book is therefore devoted to outstanding examples of various forms of writing. Because of this, the book is ideally suited for a comprehensive readings volume in one- and two-semester, or longer, technical writing or communications courses. It is also a useful source book for instructors. In short writing courses this book can serve as the sole text. The introductory and explanatory material is sufficient to give the student a good grasp of every writing form considered. Also, the exercises enable him to check his progress and understanding.

Practicing engineers, scientists, and technical writers in technology and science will find this book a handy desk reference. It gives specific steps to follow in every major writing task. The hints given for professional technical writers are equally useful to and usable by engineers and scientists. Almost every engineer and scientist finds during his career that he must, for one reason or another, temporarily assume the duties of a professional technical writer. For example, the engineer might be directed to prepare a technical paper for his supervisor's by-line. Knowing the techniques used by the professional technical writer will help the engineer write a better paper in less time. All engineers and scientists will find this book equally helpful as a reference for the other major writing tasks they meet. Professional technical writers will also get much help from the book because it covers all the usual writing tasks they face.

Tyler G. Hicks

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CONTENTS

Preface	vii
Acknowledgments	ix
1. Technical Writing and You	1
2. Communicating with Words	9
3. Grammar and Usage	20
4. The Language of Publishers and Printers	73
5. Illustrations and Tables	89
6. Engineering and Scientific Reports	123
7. Technical and Scientific Articles	144
8. How to Use Published Articles	168
9. Technical and Scientific Papers	178
10. Effective Presentation of Technical Papers	199
11. Instruction Bulletins and Manuals	207
12. Military Manuals	220
13. Writing Engineering and Industrial Specifications	238
14. Technical Sales and News Writing	253
15. Manuscript Preparation	260
Bibliography	277
Exercises	283
Index	293
Examples <i>following page</i>	299

Chapter I

TECHNICAL WRITING AND YOU

How Technical Writing Began. Engineers and scientists from the earliest days of recorded history have written reports, proposals, and other documents about their work. Much of the world's best-known technical writing has been done by outstanding engineers and scientists, such as Vitruvius, Agricola, Smeaton, Rankine, Parsons, Taylor, Hoover, Perry, Marks, Kent, and Rutherford. Studies show that, in general, the greater a man's engineering or scientific achievements, the larger the number of his published works of all kinds.

Until the start of World War II most engineers and scientists did all the technical writing related to their projects. Thus, engineers prepared instruction manuals, maintenance brochures, specifications, parts lists, and similar material. Scientists wrote reports covering their research findings, results of investigations, etc. There were few qualified technical writers in any field. The only major area in which engineers and scientists did not write extensively was industrial advertising. But even in this field engineers and scientists were often asked to check copy and verify technical facts.

With the start of World War II millions of young men were assigned duties covering the operation or maintenance of complex aircraft, naval vessels, tanks, and a variety of weapons. Adequate written instructions were needed. The Air Force was one of the first of the services to prepare training and instruction manuals for their flying and maintenance personnel. Other services followed. Soon equipment manufacturers began preparing comprehensive operating, maintenance, and instruction manuals as part of their contracts. Within a few years a huge volume of training and instruction literature was developed. Much of this was in the area of electronics, aircraft, submarines, and automatic weapons.

Most of the wartime technical writing was done by nonengineers and nonscientists—people with little engineering or scientific training. Some wartime writers were journalism majors who drifted from their normal work to the higher paying technical-writing field. Others were trained technicians with writing ability who wanted to upgrade their earnings. Another group was composed of former creative writers, such as novelists and poets, who turned to technical writing for greater security and other benefits. Few engineers and scientists were employed as full-time technical writers because industry and government felt that the talents of these men were more useful when devoted to design, development, and research.

With the ending of World War II private industry expanded its civilian output. Since many new products were complex, comprehensive instruction in their use was required. Industry turned to its wartime experience and began producing civilian technical literature that resembled, in many respects, the wartime literature. Introduction of nuclear energy, missiles, satellites, space probes, transistors, computers, and a variety of other new devices tremendously increased the need for well-prepared technical literature.

The Field Today. Technical writing is becoming more important with every scientific and engineering advance made by man. Today there is hardly a scientific project undertaken without using lengthy reports, feasibility studies, progress analyses, and status summaries. Engineering activities often require a full range of technical reports, society papers, technical-magazine articles, and even books. In selling and marketing, the technical writer prepares catalogs, news items, equipment releases, and sales brochures.

The booming missile and space industry employs thousands of technical writers. These men and women prepare millions of written pieces for all kinds of readers—from men operating ditch diggers to advanced scientists studying space-flight techniques. The output of these writers varies from a single-page maintenance instruction to a volume of five hundred or more pages covering an important scientific or engineering subject. Operating and maintenance instruction manuals for some advanced missile systems run to several thousand pages, weigh 100 or more pounds, stand 5 feet high, and cost almost \$1 million to prepare. And the burden on technical writers is increasing. For as our equipment becomes more complex so do the instructions for operation, maintenance, testing, and design.

Your Future. Beginners in technical writing have a bright and promising future if they develop their skills well because technical writing needs more highly qualified people than ever before. During World War II, when the need for technical writers suddenly skyrocketed out of all proportion to the supply, extensive training was bypassed. While people with little or no training were able to write and produce the needed material, some time and effort were wasted, and the written materials were not always as good as they might have been.

Today every project manager and engineering supervisor recognizes the need for *trained* technical writers. Gone is the time when *any* kind of writing background was acceptable. The beginning technical writer today must know much about the use of English, outlines, illustrations, specifications, parts lists, etc. But of all his qualifications the most important is the ability to write clear, concise English. For this is the essence of technical writing. Unless you learn how to properly organize and clearly present written material your chances of succeeding in technical writing are extremely small. So this book concentrates on developing your writing skills. While doing this you will also learn much about the other phases of technical writing.

Understanding the Field. Today there are two main categories of people doing technical writing: (1) engineers and scientists, and (2) professional technical writers. It is important that you understand how each performs his task in the production of written material.

Engineers and scientists generally prepare reports, articles, papers, or books as

an adjunct to their normal duties. The normal duties for which the engineer or scientist is employed *are not* writing. For example, an aeronautical engineer is hired to design a specific airplane—let's say the jet DC-8. But during its design he may write ten reports to his supervisors on various phases of the work. Some of these reports may be extremely short—so that they are in memo form. Others may be hundreds of pages in length, requiring months of preparation. Much the same is true of the scientist.

During or after the design of this jet aircraft or any other product, the engineer might decide, or might be asked, to write an article about the product for one of the technical magazines (often called business papers) in the field. One such paper is *Aviation Week*. Were he writing an article about one feature of the product, say the shock absorbers in the landing gear, the engineer might submit his article to *Product Engineering* or *Machine Design*. He might, of course, have submitted such an article to *Aviation Week* instead. A scientist doing work on this or another project might submit his work to the same papers. But it is more likely that he would send it to the *Aeronautical Engineering Review* or some similar publication.

While working on this design project the engineer might also decide to prepare an engineering paper for presentation before and publication by the American Society of Mechanical Engineers, the Institute of Radio Engineers, or American Institute of Electrical Engineers. The engineering paper would probably differ from the article in a number of ways. The paper might be more mathematical; it might be longer; it might be far more specialized than the article. While most engineering and scientific papers are prepared on request, the engineer could decide to prepare the paper and then seek someone in an engineering or scientific society who would encourage submission of the paper.

After long or unusual experience in a field an engineer or scientist might decide to write a technical book covering some phase of his work. Or his employer might delegate him to write the book. Lastly, the engineer or scientist could be encouraged by a book publisher to write a book.

In all these examples our engineer or scientist is doing his routine work first; *then* he writes about it. His primary job is seldom writing. Instead it is design, operation, maintenance, research, or some other task. But the writing is an important adjunct to the man's main effort. Technical writing is the means by which the engineer or scientist communicates his knowledge and findings to others in his field; it is one of the most respected ways of reporting engineering and scientific developments. In a speech to scientists, Dr. Milton S. Eisenhower, president of Johns Hopkins University, stated that in a recent year reports in the physical and life sciences alone ". . . filled 55,000 professional journals containing 1,200,000 significant articles, plus 60,000 scientific books and another 100,000 research monographs."

Since the engineer or scientist is closer to his work than anyone else, he usually is best qualified by reason of knowledge to write about his activities. But, unfortunately, highly developed engineering or scientific abilities are not always accompanied by well-developed writing skills. So we find that *some* engineering and scientific writing has, in the past, been poor. For this reason, and because

more and more engineers and scientists are required to write as part of their job, courses in technical communication are becoming popular. Today the engineer or scientist *must* be able to write well if he wishes to have an outstanding career; otherwise he may find his advancement is limited. In a survey of 3,800 engineering graduates of Purdue University, about 90 per cent of the engineers ranked writing and speech as "must" or "very important" subjects in their professional careers. Many industrial firms now have publication-incentive awards for technical material published by their engineers and scientists. Cash awards are common. Other firms give salary and professional experience credit for the material their men publish.

While engineers and scientists are writing more material with a greater degree of skill, they still cannot meet the tremendous needs of industry and government. Also, in recent years there has been a tendency to limit the writing of engineers and scientists to their immediate work. This leaves an enormous demand unfilled; for example, operating and maintenance instructions. To meet this demand and to help overworked engineers and scientists, the professional technical writer was developed.

Professional Technical Writers. Engineers and scientists who write are, as we saw, usually part-time writers. Their main task is not writing—it is something else. And until recently few engineers and scientists were trained writers; they picked up their writing skills as they needed them.

Professional technical writers are, as distinguished from engineers and scientists, employed primarily to write. Any other tasks are secondary. And more and more today the professional technical writer is a trained individual. He is a specialist in technical communication. His engineering and scientific training is usually broad instead of specific. This broad background enables him to rapidly assimilate the engineering and scientific facts he uses in his writing.

Today's professional technical writer handles a variety of tasks, from instructions for a housewife on how to operate her new washing machine to procedures for launching a rocket to the moon. In this book we avoid the smaller technical-writing tasks like operating washing machines, assembling model airplanes, or running a lawn mower. Instead we concentrate on the big jobs such as reports, instruction manuals, and books. Applying the skills learned for these big tasks, the writer can easily perform any of the smaller ones.

The modern professional technical writer is becoming more important every day. Originally assigned only operating and maintenance instruction jobs, his scope of activities has broadened. Now we find the professional technical writer preparing almost every instruction manual used by the Army, Air Force, Navy, Coast Guard, and Marines. Some of these manuals are outstanding contributions to the literature; some could never have been written without the help of the professional technical writer.

Projects employing the professional writer today cover such varied activities as nuclear energy, guided missiles, submarine warfare, distant early warning systems, and space exploration. In addition, the professional technical writer has actively entered a new field—one that will ensure his future. He has become a "ghost" writer for the engineer and scientist. This means that the professional technical

writer will now engage in all the engineering and scientific writing activities we discussed earlier. So the new writer must be adept at reports, articles, society papers, books, manuals, and a raft of miscellaneous writing forms.

The emergence of the new writer can be traced to several reasons. Shortages of engineers in key industries led to studies of how engineers spent their working time. Where the writing load was heavy, some of it was shifted to professional technical writers. This left more time for engineers and scientists to devote to primary tasks. And with the growing competence of technical writers, many firms found that the work done by a team of an engineer and a writer was better than either could do alone. The engineer supplied his detailed technical know-how while the writer expressed this knowledge in clear, concise prose. Lastly, the writer could bring important specialized knowledge to the job. This knowledge covered items such as illustrations, tabulations, the use of color, relations with the client for whom the engineering and writing were being done, production schedules, and printing information.

Job Description. The Center for Technical Publications Studies, Fordham University, held a seminar workshop to prepare a comprehensive job description for the technical writer. The job description developed by the University is reproduced below, with the permission of the Center.

Read this description carefully. It covers many of the topics you will study in this book. Once you can perform all the tasks listed in this job description you will be well on your way toward a higher level of proficiency as a technical writer.

JOB DESCRIPTION AND PERFORMANCE REQUIREMENTS *

Writes instructive or descriptive material on technical or scientific subjects, interpreting and creating an acceptable presentation of the facts or the ideas and theories of others for a given audience.

Work Performed

1. Performs research necessary to obtain complete understanding of the scope of the proposed publication and to gain a thorough technical knowledge of the subject.

Receives a verbal or written work order for the desired publication, together with instructions on its general purpose, and any available basic reference material, such as specifications, proposals, correspondence, engineering reports, drawings, photos, similar publications, and supervisory or sales memoranda and notes.

Studies the supplied reference material to acquire background information on the project and to ascertain policy governing content, presentation, and quality level. May consult with engineers, other technical personnel, the publications supervisor or sales personnel to clarify technical or other details of the writing project.

Analyzes information on hand to determine whether additional research is required or whether the supplied material is sufficient and can be adapted to the publication requirement.

* From "A Report of a Study to Determine the Duties and Responsibilities Called for under the Job Entitled 'Technical Writer,'" prepared by Joseph Child and Robert Johnson, under the direction of Harold N. Schleich, The Center for Technical Publications Studies, School of General Studies, Fordham University, New York, N.Y.

If additional research is required, determines the most logical sources and the best method for obtaining the required information. Performs the necessary research; may make field trips to libraries, government agencies, manufacturers, educational institutions, technical societies, etc. May confer with customer's technical staff through established lines of liaison and may observe, study, or operate the actual equipment, object, or process.

Makes suitable notes to ensure proper correlation and retention of the information obtained.

2. Organizes the proposed manuscript to provide an orderly plan for the preparation of the required text material.

Prepares a general outline; breaks the subject material into major topics, considering:

- a. The general purpose of the manuscript (catalog, magazine article, engineering report, equipment operation or maintenance manual, etc.).
- b. The specific application (formal training, guide for field operations, promotion, general information, etc.).
- c. The knowledge and skill level of the user.
- d. The complexity of the subject.

Arranges these major topics in logical order. Determines the logical sub-topics to be discussed or treated under each major topic and arranges these in proper sequence.

Classifies and indexes the reference material in accordance with the general outline.

Prepares detailed outline: analyzes the reference material for each topic and develops and expands ideas into further sub-topics, grouping and arranging them to achieve continuity and best subject coverage. Repeats this procedure for each topic, developing the outline for smaller and smaller portions of the manuscript, to the logical ultimate.

3. Prepares a draft of the manuscript in accordance with the detailed outline.

Writes the text, drawing upon his developed knowledge of the subject and desired scope, and using his communications skills to create an acceptable presentation of the technical data for the given audience. May conduct additional research to validate or clarify portions of the technical data. Uses a style and format for the writing set forth in applicable specifications or may select or develop a style or format best suited to the presentation. Defines new and unusual terms.

Determines the illustrations required to supplement the written material and selects the most suitable type of illustration, such as a photograph, line drawing, rendering, etc. Prepares sketches or preliminary layouts of line drawings and renderings and specifies the requirements for photographs. May supervise the photography. Assigns nomenclature to photographs by marking on overlays or other method. Requests the preparation of preliminary or final art from the art department and provides additional oral or written instructions as required.

Maintains written control and record of changes in cross references, figure references, tables, and the like during the development of text and illustrations to ensure accuracy of these details in the final manuscript.

Routes the final manuscript through established channels to obtain technical editor or customer approval.

4. Revises and rewrites text to meet technical editor's and/or customer's review requirements.

Receives the draft of the proposed publication after technical editor or customer review. Studies the corrections, comments, criticisms, or suggestions made, to determine the specific revision requirements and their effect on other portions of the text. Rewrites affected portions of the text and requests new or revised illustrations as required. Checks very closely to assure that all references and notes in other portions of the text conform to the revised portion and makes any required changes or corrections. Reviews the new or revised illustrations to ensure accuracy and conformance with the required changes. Routes the revised text and illustrations for final approval. May obtain and present factual data as a basis for not accepting changes requested by the editor or customer.

Responsibility

Responsible for the development and presentation of text and illustrations for technical publications which may cost thousands of dollars. Responsible for completing his work within the budgeted hours under maximum general supervision, and also responsible for meeting acceptance standards and delivery schedules for the completed manuscript. Responsible for technical accuracy of work performed by illustrators, typists, and others engaged in producing the manuscript. Responsible for determining the necessity for liaison and research in connection with the manuscript. Responsible for conducting approved liaison and research.

Job Knowledge

Must be able to interpret technical and scientific data, such as blueprints, diagrams, charts, engineering reports, and specifications for material, equipment, publications, etc. Must know research methods and techniques. Must be able to plan and organize manuscript in accordance with the requirements of specified media. Must have a comprehensive knowledge of good grammar and punctuation and be able to write clear and concise descriptive and instructional material. Must know illustration techniques and publication production methods and practices. Must have a general knowledge of the basic sciences and specialized training or experience in the technical area in which he is writing, i.e., aeronautics, agriculture, electronics, chemistry, mechanics, etc.

Mental Application

Must be able to discriminate between essential and nonessential data from the reader's viewpoint and thereby determine sufficiency of content. Must keep abreast of current trends and techniques for written communication and their particular application to his specific work. Must be able to organize major publication projects and to determine suitable work assignments for assistant writers. Must readily adapt to different writing style and format requirements and be able to carry out several projects concurrently. Must be able to arrive at decisions and judge the relative merits of these decisions with respect to their effect on the time, cost, and acceptance standards for the end product.

Using this Book. The present book is designed to meet the educational and training needs of the two main categories of modern technical writers—engineers and scientists doing some writing and full-time professional technical writers. Careful study of the analyses and techniques presented will give you a surer understanding of the various forms of writing used today. With this better under-

standing will come improved writing—clearer communication with all who read your words.

Be sure to study carefully the introductory material and every example given in the sections in which you are interested. All the material and examples were chosen to give you valuable experience with important writing techniques. To acquire similar experience some famous writers of the past spent months—sometimes years—just copying, word for word, the works of authors they respected. After copying a complete essay or other work these beginning authors would tear up their handwritten copy and move on to another selection which they admired. While the true value of this procedure is debatable, the advantages of studying the outstanding works of others is admitted by every experienced author.

So study the examples. You will profit far more than you may realize. The techniques you acquire will serve you for a lifetime of active writing.

Do as many of the exercises at the end of the book as you can. They will strengthen your grasp of the subject. With a little practice you will find you are writing better material in less time. You will be communicating better with your readers. And since the ultimate purpose of all technical writing is better communication, you will be nearer your ultimate goal—a proficient technical writer.