TECHNICAL WRITING

PRINCIPLES AND FORMS

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Technical Writing: Principles and Forms

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To Bill, Joe, and Christopher

Preface

This book is a writing text for students in engineering, the physical and natural sciences, natural resources, home economics, agriculture, architecture, and business who have a background in their disciplines and who are seriously interested in preparing for the writing they will do every day as professionals. The text was born and grew up in our classrooms at Utah State University, The Ohio State University, Battelle-Columbus Laboratories, Bell Laboratories (Columbus), Goodyear Atomic Corporation, Oak Ridge National Laboratory, and Western Electric.

The chief weakness of most students in our technical writing classes has been a lack of language skills. Other teachers confirm our conclusions. In a survey we conducted of university teachers of technical writing, 80 out of 89 respondents listed weak language skills as their students' greatest obstacle to clear and persuasive expression of technical information.

The focus of this textbook is thus applied rhetoric: the skill and art of writing as they are formed by the specific demands of technical and scientific material and by the audiences who read it. The goal of a scientific or technical document is to transfer information. Results cannot be transferred until the writer knows *what*, *why*, and *to whom*, the central concerns of rhetoric. We have applied the principles of classical rhetoric, as modified by recent theory and practice, to the practical reports and articles written by scientists and engineers.

The book does not cover all aspects of professional writing. For example, it addresses individual writers and does not discuss in detail how to write collaborative reports, a common form in industry. Nor does it include such specialized technical documents as manuals and specifications. But we do discuss form in general, as well as methods for shaping material and language to fit the patterns of reports, proposals, letters, articles, and memos. Visual devices, significant elements in most reports, are also presented.

The advice we give is a guideline rather than a prescription. There is more than one way to make the language work. This book lays out options for expressing the matter of science and technology. The choice of which techniques to use under which conditions remains with the writer.

Scientific and technical literature at its best—in its leanness, calculated simplification, and inherent interest—represents some of the finest prose created in the language. Certainly scientists and engineers today produce far more written material than do novelists and poets, and may, in their way, be more influential. We supply examples, drawn from our classes, from industry, and from the technical and scientific literature. Some of the examples are models of good writing; others exemplify writing that calls for improvement.

Writing a book about writing is, as a scholar of the sociology of knowledge describes his discipline, like pushing the bus you are riding in. It is presumptuous, fearsome work. But many people have helped. Indeed, a concomitant of writing seems to be the process of getting into debt, of owing all the students and colleagues who criticized and praised and kept us going. The footnotes acknowledge our debt to individuals and organizations who provided examples.

Many students allowed us to use selections from their reports. We are also indebted to Roy M. Kottman, Dean of the College of Agriculture, Austin E. Ritchie, Assistant Dean of Agriculture and Home Economics, and Marion L. Smith, Associate Dean of the College of Engineering, all at Ohio State; to Stephen R. Jenne, Hanson Engineers, Inc.; to C. R. Pearsall, John Deere Service Publications; to Leon O. Talbert, Ohio Department of Transportation; and to Robert W. Teater, Ohio Department of Natural Resources, for providing examples used in this text.

Dolores Landreman, Battelle-Columbus Laboratories; Robert Kelton, Betty Brosch, and Martha Passe of the Department of English at Ohio State and Robert A. Rapp of the Department of Metallurgical Engineering; and Mary Hissong of Bowling Green State University read sections of the manuscript. All provided many helpful suggestions. Mary Jo V. Arnold, head of the Engineering Library at Ohio State, contributed the citations for Chapter 2 and helped shape the chapter.

Roger W. Staehle, of the Department of Metallurgical Engineering at Ohio State, supported both the authors and the book and kept us aware of the reality of what an engineer does when we tended too far toward theory. Our editor at Macmillan, Anthony English, cajoled us, entertained us, and cleaned up the text in many ways.

And, most important, our husbands, William D. Andrews and Joseph D. Blickle, read every word of every version of the text and offered precise corrections. They also put up with our obsession in writing this text. That was no mean feat, and we are grateful that they stuck it out.

Finally, this book represents the collaboration of two friends with different styles and different points of view who wanted to do something to codify what seemed to work in their classrooms and to assist students in thinking about and writing what they know. Our friends helped us. We made our choices according to what we thought was right. We alone are responsible if any of the choices were wrong.

D. C. A.
M. D. B.

CONTENTS

TECHNICAL WRITING

CHAPTER 1

INTRODUCTION

"A naturalist's life," Charles Darwin noted, "would be a happy one if he had only to observe and never to write." Scientists and engineers observe—that is, they collect facts. And they read about other researchers' observations. Then they think about the facts, interpret them, and express them so that the results can be useful. They make these results available on paper, in the form of letters, memos, proposals, reports, and articles.

This book aims to assist students of science and engineering in thinking about their materials and shaping them into an appropriate form. The physicist John Rader Platt wrote:

> The failure to recognize a brilliant man is only partly due to the stupidity or stubbornness of the scientific community; it is also partly his own fault.
>
> For brilliance has an obligation not only to create but also to communicate. A scientist cannot really go "voyaging through strange seas of thought alone." The more penetrating eye will see him to be surrounded by a cloud of witnesses. He takes from others; he gives to others. He must address the problems of his time. He must translate his thoughts into the language of his contemporaries. He must scatter them abroad for interaction. A thought which has not penetrated to other minds will die unfruitful.[1]

Section I of this book, "Evidence," discusses the design of a research project. It centers on methods for gathering and using printed materials, a major source of evidence for both students and professionals.

Section II, "Expression," presents strategies for good writing. It discusses options in word choice, sentence structure, organization, and verbal and visual techniques of presentation. Its goal is to show students how to express what they know clearly and effectively.

Section III, "Forms," explains how to fit evidence and expression to the audience's expectations and to the forms of documents required by a company or other organization.

Writing As a Skill

Darwin's lament about writing expresses a feeling shared by many researchers. Lest all the difficulties of writing seem overwhelming, let us emphasize that writing is a skill. It is not a mysterious God-given talent, as many students think. Although those who practice it at the highest level can turn writing into an art, that is certainly not its sole function. Like operating an oscilloscope or programming a computer, writing can be learned. Those who write poorly can learn to write acceptably, and those who write acceptably can learn to write well.

How? Writing can be learned in three ways:

1. By writing
2. By reading
3. By learning and reviewing basic principles of exposition and the use of words in specific applications

The practice of writing is by itself a good teacher. Ask an engineer who has risen through a company's hierarchy because of his or her communications skills how he or she learned to write and you are apt to receive a simple reply: "By writing." Nothing can take the place of extensive practice, especially if the results of that practice are seriously evaluated by the writer as well as by outside "critics"—the writer's teacher, supervisor, or colleagues.

Another sure way to improve writing skills is to read widely and critically. In this way a student enlarges his vocabulary, develops a sense of the rhythms of language, and sharpens his awareness of the range of forms of sentences and paragraphs. A student serious about improving his writing would do well to read scientific papers and reports, of course, but he will also benefit from reading poetry, novels, histories, magazines, and newspapers. Reading increases one's consciousness of language, its patterns and possibilities.

The third way to improve writing is the one emphasized in this text: the review of basic principles of exposition (Chapters 4 to 7), with special attention to the forms of writing most used by scientists and engineers and the special problems that occur in those forms (Chapters 8 to 14).

The purpose of discussing writing is not to turn scientists and engineers into grammarians. Knowledge of the basics and a vocabulary expressing that knowledge are critical diagnostic tools. If one can label an error—can recognize, for example, what exactly is wrong when he is told that his sentence lacks parallel structure—he can more readily correct the error and write a good sentence than if he merely has a vague sense that something is wrong. The suggestions given in this text are based on the assumption that the writer needs to recognize the best way to do things, the terms that describe errors, and the methods for avoiding such errors.

Good Writing

In working toward good writing, the student must of course know what good writing *is*. Good writing is:

1. Accurate
2. Clear
3. Concise
4. Conventional
5. Appropriate

1. Good writing is *accurate*. It presents facts as they are, without distortion. It presents all the relevant information, and the writer makes certain that the information is true. Accuracy is commonly understood to apply at the level of research, but the writer must not abandon his commitment to be accurate when he turns from discovery to the job of communicating what he has discovered.

2. Good writing is *clear*. We say that writing is clear when its meaning is easily understandable; when it contains no obscurities, no misdirection, no ambiguity, no wandering; *when it cannot be misunderstood*.

3. Good writing is *concise*, which means that it carries its message quickly. The writer uses only those words necessary to convey his point; he writes to the point and eschews the irrelevant, both in issues and in words. Good writing uses as many words, sentences, and paragraphs as are necessary—but no more.

4. Good writing is *conventional*, in two senses. It adheres to the conventions of standard English usage: proper words, properly spelled, properly grouped and punctuated in sentences (the Handbook offers guides to particulars). Good writing also adheres to the conventions of the institution or professional society that employs the writer or to whom he is writing (see Appendix B). These are

conventions of style and form. For example, the Army writes a date this way: "22 June 1945." Most civilians write "June 22, 1945." If the writer is preparing a report for the Army, he adopts its form. A good business letter follows a number of conventions in heading, form of address, introductory paragraph, and complimentary close (Chapter 14). The good technical writer learns and applies these conventions.

5. Good writing is *appropriate*, to the subject, purpose, and audience. The importance of appropriateness cannot be overemphasized. The writer always tailors his materials, form and manner of expression, and ordering of information to fit the audience he is writing for and the subject he is writing about.

A useful concept for understanding the complexities involved in achieving the goal of appropriateness is that of *rhetoric*. The word has bad connotations today: we often say *rhetoric* when we mean language that is empty, misleading, bombastic, or characteristic of people, such as politicians, whose sincerity we doubt. But this is a recent connotation. In its original sense *rhetoric* means simply the art of writing or speaking to achieve a particular effect such as to persuade, instruct, or describe. Rhetoric concerns the relationships among writer (or speaker), subject, purpose, and audience. Together these shape the document.

Rhetoric has unique value for the technical writer because it emphasizes *choice*: Words may be selected and arranged in an almost infinite number of ways (limited only by the conventions of the language itself) to fit the specific rhetorical situation. To gauge the rhetorical situation, the writer might first fill in the parts of this model:

Writer:
Subject:
Purpose:
Audience:

Here is an example. A mechanical engineer (writer) is assigned to write a ten-page report on domestic use of solar energy (subject). He is to show the advantages of solar energy to heat the water used in a house (purpose). The report is to be sent to the senior designer in a large construction firm (audience). These conditions dictate a highly technical report.

The working of rhetorical choice is illustrated if we change one of the components. We keep the writer, subject, and purpose the same but make the audience of the report not the designer but the potential homeowner. What changes are dictated by this? Obviously, the homeowner (unless he is an architect or mechanical engineer) has less technical background than the designer does. The writer therefore simplifies his discussion, eliminates technical terms, and explains complex issues. He might begin with a simplified (but accurate) description of how the sun's energy can be converted for home use—something that the senior designer probably would not need to be told about. Then he could go on to show the application of this information to a particular house. Probably he would stress the long-term savings possible through solar energy use. Because the initial cost for installing a solar device is higher than that for installing a conventional electric or gas heater, the writer would have to explain carefully the difference between initial and long-term costs—another fact the senior designer would already know.

Making wise choices—about vocabulary, sentence structure, amount and kind of evidence, and plans of organization—depends on the writer's understanding of the rhetorical situation. The *writer* must know himself and his abilities and interests and know his *subject*; the *purpose* toward which he is writing; and the needs, experiences, and assumptions of his *audience*. Meeting these needs makes writing appropriate.

Appropriateness—along with accuracy, clarity, conciseness, and conventionality—is the goal of good writing. And good writing is the goal of this book.

NOTE

1. Quoted in Steve Aaronson, "Style in Scientific Writing," *Current Contents*, January 10, 1977, p. 7.

SECTION 1

EVIDENCE

CHAPTER 2

Finding Something to Say

Before you write, you must have something to say. Reports are based on evidence. With a clear purpose in mind, the author gathers his material. This gathering is shaped by the type of research problem to be dealt with and the specific institutional purpose of the report—what it is to do for the reader and for the company or industry. In beginning a research project the researcher should think about the reports he must prepare along the way or at the end.

This chapter classifies the two major sources of evidence—primary and secondary—and then focuses on methods for searching the literature of science and technology. Printed materials are essential elements in most research. The student should know how to locate and use relevant ones. Chapter 3 analyzes ways to use printed materials. Chapter 11 gives specific advice on topics for formal reports and discusses major purposes for such reports.

Three Forms of Research

Research problems can be broadly classified into three types: problems of fact, problems of means, and problems of value.[1]

PROBLEMS OF FACT

The so-called basic, fundamental, or pure sciences are concerned mainly with problems of fact. Basic scientists examine what occurs and suggest explanations for how, and sometimes why, things occur. Physicists engaged in discovering elementary particles, naturalists examining the feeding habits of quail, chemists studying the kinetic theory of gases—all deal with problems of fact.

PROBLEMS OF MEANS

Problems of means are the technical problems that engineers, technicians, and other applied scientists focus on. These problems include the design of hardware and instruments to conduct basic research. The building of devices, machines, houses, and industrial plants—from ball point pens to nuclear reactors and solar-heated apartment houses—also presents problems of means. Another set of such problems centers on why engineered structures fail. From bicycle tires to starters on cars to blades on steam turbines, things fail. Someone has to assess the circumstances of the failure, determine possible causes, select a probable cause, and recommend what to do to get the thing back in action—and to prevent such failures in the future.

PROBLEMS OF VALUE

Problems of value require judgments about how something should be rated, what is to be preferred, what ought to be done. A simple form, closely linked to a problem of fact, is whether something meets predetermined, objective standards. One can measure whether a part meets its specifications or whether a slice of bread meets minimum daily requirements for nutrition. Other problems of value involve setting up standards and criteria for a particular situation. An engineer might be asked to recommend a specific material for one application—the propeller of a supertanker or a shipboard incinerator. He must determine the conditions of operation, review candidate materials, set up standards for selection, choose one material that meets the criteria, and justify his choice. A child development major might need to design a day care center to meet federal standards.

Another form of the problem of value involves questions of policy. Scientists, economists, and others are developing tools to aid in policy decisions. Computers are being used to simulate real conditions, to test a wide range of optional patterns, and to make predictions. Econometrics, for example, models economic systems to forecast trends. Such predictions are often used by business and government leaders to help avert economic difficulties. Wildlife managers also use mathematical models to test many variables in animal populations and to adjust management practices accordingly.

Science policy, however, is not always subject to objective standards. Indeed, many problems of value cause the researcher to resort to subjective, personal standards in deciding what ought to be. Often such problems are controversial. Students should learn to recognize a value problem and to test whether the standards being used are objective or personal, in order both to weigh others' solutions for the problem and to avoid being too subjective in their own solutions.

Statement of Purpose

Each of these forms of research implies certain procedures for gathering evidence. The researcher first decides on a topic. He then limits it to something he is enthusiastic about, has adequate technical competence to handle, can obtain adequate data on, and can fit into the time available for research. He converts his topic into a statement of purpose, his objective. He should write out his statement: "The purpose of this project is. . .

"to analyze toxic compounds in drinking water." (fact)
"to select an acceptable diet for a child with phenylketonuria." (means)
"to examine barks of trees to discover compounds with medicinal properties." (fact)
"to design a pond to water 300 cattle." (means)
"to develop a management program for a 50-acre woodlot." (means)
"to determine the economic impact on the state of Florida of an increase in the price of electricity." (value)
"to develop a procedure for inserting metal replacement joints in rabbits and sheep." (means)
"to design a noninvasive (not beneath the surface of the skin) device that will measure cardiac output and heart rate." (means)
"to determine if effluents from a municipal sewage treatment plant conform to Environmental Protection Agency standards." (value)
"to design a semiportable sprinkler irrigation system for a 40-acre field." (means)

Preliminary Outline

With his purpose clearly in mind, the researcher draws up a preliminary plan or outline that indicates specific goals and the subjects to be covered in the research—the questions he wants to answer. The entries represent the components of his project. In planning, he inventories his own mind and sorts out what he knows and what he needs to learn.

In addition to the plan, the researcher should set up a schedule of discrete tasks in order to avoid sinking under the weight of the endeavor as a whole. He should establish his own deadlines for accomplishing the steps in advance of required deadlines and get an early start (for a sample chart of a research plan see Figure 9-1).

Sources of Material

To help a writer find the material appropriate to his needs, a distinction should be made between two sources of material:

primary material: The facts collected and inferences made by the researcher himself through observation and experiment.
secondary material: The facts collected and inferences made by others and conveyed to the writer through conversations, interviews, or published documents.

Both forms provide the researcher with

- Facts (sometimes expressed as statistics)
- Inferences (generalizations, often correlations, that researchers use to make sense of facts)
- Evaluations (someone's opinions of a fact or inference)

PRIMARY MATERIAL

We won't discuss in detail the collection of primary material here. The student may gather material from his experiences. For example, to write a report on management practices at an Acme supermarket he may think over his experiences while he was a cashier at one. To compile a report for dieticians at cooperative student houses, he might review what he learned while serving as a student dietician.

The student may use methods learned in technical classes to set up experiments or conduct field surveys. He may use highly sophisticated questionnaires as interviewing tools. He may rely on complex mechanical instruments to help him make observations. Whatever his procedure, he compiles data as systematically and accurately as he can, and then he sits back to derive some generalizations from them.

SECONDARY MATERIAL

At the beginning of any research project the investigator needs to find out what has already been done on the general topic. He does this by talking with colleagues, writing letters of inquiry, interviewing authorities, or, most frequently, reading the literature. Letters of inquiry are covered in Chapter 14. Here we focus on methods for conducting interviews and searching the literature.

Interviewing

Interviews are useful in obtaining information—especially unpublished results—from a researcher whose work is pertinent to one's own project or from any person whose testimony on the subject will be authoritative. Conducting interviews is never easy; the first one is particularly hard. But one can only get better at it and learn from experiences. The interviewer has to develop his instincts to know when to relax, when to push, when to listen, when to talk—and when to call it quits. Following are a few suggestions for organizing an interview.

Before the interview

1. Select carefully whom you want to interview. Don't waste your time—and that of the person being interviewed—by approaching someone who cannot tell you what you want to know.
2. Do your homework. Know the basics about the subject and the person. You'll be resented if you inquire about facts you could easily have learned before.
3. Outline the form you want the interview to take; prepare a list of questions.
4. Request the interview well in advance. The request should be written if the interview will be formal (for example, between a student and a major researcher) or if there are security problems.

In the request for an interview

1. Give the person to be interviewed a choice of possible times for the interview.
2. Present your own credentials.
3. Show how the information to be gained in the interview will be used.
4. Indicate why you can't obtain the necessary information in already available sources; justify taking the person's time; interest him in the reasons for the interview.
5. Indicate the subject of the interview as specifically as possible, perhaps giving illustrative questions. With adequate warning, the person to be interviewed can brief himself on your needs.

In the interview itself

1. Arrive promptly with an adequate supply of pencils, pens, and paper. (Keep them out of sight until you are ready to use them.)
2. Take a few minutes to chat with the person to establish a cordial relationship and encourage his trust in you, as well as to let your own nerves settle.
3. Be ready to adapt questions to a new situation. Be flexible. Let the person being interviewed talk. Gently remind him if he gets off the topic, but don't indicate boredom or impatience; allow a little slack. Interrupt only if necessary for clarification.
4. Either take notes in a notebook or, *having obtained permission*, record the session on tape.
5. Verify key or controversial statements before you end the interview.

After the interview

1. Compile the notes or transcribe the recording while the interview is fresh.
2. Thank the person being interviewed in writing (if the request was in writing) or informally. You might send him a copy of the final product.
3. In the final report, refer to the interview by a citation that includes the name of the person interviewed; his title, if any; the place of the interview; and, invariably, the date. The date is necessary to establish a context; it will protect you and the interviewee should his opinions subsequently change.

Searching the Literature

Evidence of the growth of the literature of science and technology is staggering.[2] For example:

- Scientific and technical books published in the U.S. have risen from 3,379 titles in 1960 to 14,442 in 1974.
- The number of scholarly journals increased from 1,490 in 1960 to 1,945 in 1974 in the United States; worldwide, from 18,800 to 49,440.
- Total number of scholarly articles has increased from 106,000 in 1960 to 151,000 in 1974.
- The number of federal government-sponsored scientific and technical reports increased from 14,750 in 1960 to 63,060 in 1975.

Some historians propose that as the nineteenth century was the age of industry, ours is the age of information. Students must mine such information and use it to solve problems they have defined or been given. Technical information takes many forms. The following list suggests some printed forms. In addition, of course, there are films, microfilms, and tapes.

- Books: texts and monographs
- Manufacturer's publications (catalogs, advertising brochures)
- Handbooks and manuals
- Dictionaries
- Encyclopedias
- Standards and specifications
- Directories
- Annual reviews and yearbooks
- Statistical sources
- Patents
- Proceedings of conferences and symposia
- Technical reports from industry
- Dissertations and theses
- Professional society and industrial periodicals, journals, transactions
- Government documents: technical reports from government-sponsored research
- Newspapers

Careful study of the information on a given subject indicates not only what has been found and who the major researchers are, but also what remains to be done: those inviting possibilities for future investigations. The student shouldn't work in a vacuum; knowing the literature gives context to his research and prevents both errors and unnecessary duplication. On the other hand, the literature should not be allowed to warp the student's thinking, prejudice his results, drown his enthusiasm, or destroy the freshness of his perceptions. He must balance the use of authorities against his own experiments and thinking.

There are three steps to follow in searching the literature: (1) establish boundaries, (2) assemble a preliminary bibliography, and (3) procure the documents.

ESTABLISHING BOUNDARIES

The first step in searching the literature is to establish boundaries for the search. Boundaries may be defined by

- Time period to be covered (last 5 years? 10 years? 1965-1978?)
- Geographical limits
- Age groups
- General or particular information

An article in a scientific encyclopedia (like the *McGraw-Hill Encyclopedia of Science and Technology* or *Van Nostrand's Scientific Encyclopedia*) or dictionary will provide general information about the topic, the chronology of research and researchers, basic bibliography, and terminology. Terminology is especially important because search terms are the key to the literature. (See Chapter 8. Sample search terms are included in the bibliography on page 19.)

ASSEMBLING A PRELIMINARY BIBLIOGRAPHY

The second step is to assemble a preliminary bibliography of relevant sources. To do this the student must acquaint himself with the tools for locating the literature. Accessing tools, as these are called, are not the technical literature itself. The tools do not provide the data the researcher wants, but only lead him to the sources that contain it.

This section describes six accessing tools of special value to student and professional scientists and engineers: (1) the card catalog, (2) guides to the literature of subject areas, (3) bibliographies, (4) indexes and abstract services, (5) guides to government publications, and (6) information centers. The student should spend some time familiarizing himself with the scope, coverage, and method of each tool. As important as knowing a fact is knowing how to find it—indeed, the latter may be more important.

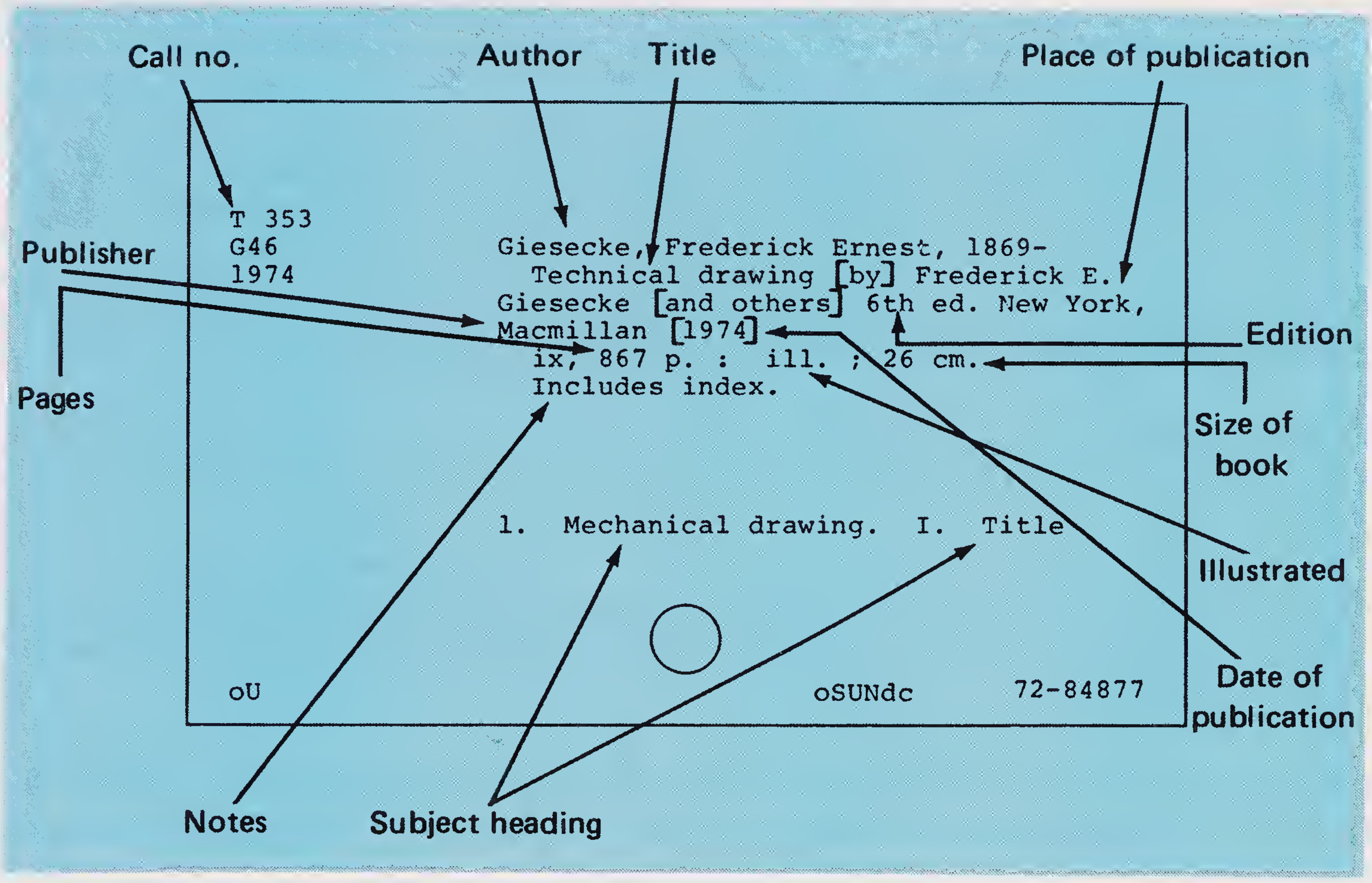
The Card Catalog. The card catalog is an index to the holdings of a single library, classified according to author, title, and subject.

Most students turn first to the card catalog when they must assemble a preliminary bibliography. This is wise, particularly at a large library, because the card catalog serves two functions: (1) It indexes books, monographs, serials, reports, proceedings, handbooks, transactions—separately published items; (2) it shows what items are available at the library.

The subject listings in the library's card catalog provide a start for a preliminary bibliography. But this source is not reliably comprehensive because many items on a subject may not be available at the library whose catalog one is checking. An initial check of the catalog should be used mainly to find out where (and whether) items whose citations have been encountered elsewhere may be found in this particular collection.

The catalog may be in the form of cards, a book, microfilm, or computer tapes. Whatever the form, each entry usually appears as in the card shown in Figure 2-1. Each card gives the author's name, the title of the book, its imprint (place of publication, publisher, date of publication), collation (physical description of the book such as the number of pages, size, and notes about features like illustrations, tables, maps, indexes), and call number.

Figure 2-1. Sample catalog card.



With few exceptions, the card catalog is a simple tool to use. The best rule for locating entries under subject headings is to proceed from specific terms to more general ones. The most difficult searches are usually those for documents having complex entries (like symposia and conference proceedings), having complex or changing titles, and having acronyms and abbreviations in the title or subject listings. As the student uses the catalog, he will learn how to deal with these self-effacing sources. If he has questions, he should of course consult a librarian or ask for a user's guide to the catalog.

It is helpful to learn the call numbers of works on subjects of interest. Then the student can browse in the appropriate sections of the stacks to locate useful information. Browsing should supplement rather than replace the systematic approach of using the catalog and printed guides.

Guides to the Literature of Subject Areas. Specialized guides to the literature of a particular topic or discipline should be consulted early in a literature search. These guides list more specific guides, bibliographies, indexes, abstracts, and specialized dictionaries. For example, the brochures published by the Engineering Libraries Division of the American Society for Engineering Education assist engineering students in preparing a preliminary bibliography. The guides cover the following fields: Computers, Electrical and Electronics Engineering, Environmental Sciences, Industrial Engineering, Mechanical Engineering, Metallurgical Engineering, Chemical Engineering. Here are some other guides:

American Chemical Society, *Searching the Chemical Literature*, Washington, D. C., 1961.

Blanchard, J. R. and H. Ostvold, *Literature of Agricultural Research*, University of California Press, Berkeley and Los Angeles, 1958.

Herner, S., *A Brief Guide to Sources of Scientific and Technical Information*, Information Resources Press, Washington, D. C., 1969.

Kobe, Kenneth A., *Chemical Engineering Reports: How to Search the Literature and Prepare a Report*, Wiley-Interscience, New York, 1957.

Malinowsky, H. Robert, *Science and Engineering Literature: A Guide to Reference Sources*, 2nd ed., Libraries Unlimited, Littleton, Colo., 1976.

Sheehy, Eugene P., *Guide to Reference Books*, 9th ed., American Library Association, Chicago, 1976. Updated by periodic supplements.

Smith, Roger C. and W. Malcolm Reid, *Guide to the Literature of the Life Sciences*, 8th ed., Burgess Publishing Co., Minneapolis, 1972.

Walford, A. J., ed., *Guide to Reference Material*, Vol. 1: *Science and Technology* (1973), 3rd ed., Vol. 2: *Social and Historical Sciences, Philosophy and Religion* (1975), The Library Association, London.

White, Carl M. and associates, *Sources of Information in the Social Sciences*, 2nd ed., American Library Association, Chicago, 1973.

Bibliographies. A bibliography is a listing of published items by an author or on a subject (see Appendix A for more about bibliographies). Bibliographies are often published separately and are therefore limited to materials that appeared in print as many as several years before the publication of the bibliography itself. Following is a sample bibliography.

FOOD ADDITIVES
COMPILED BY DIANA NISKERN

Scope: Substances or mixtures of substances, other than foodstuffs, present in foods as a result of any aspect of production, processing, storage, or packaging. The additives may be either intentional or incidental; this guide emphasizes the intentional additives and does not take chance contaminants into consideration.

Introductions to this topic appear in:

Sapeika, N. Food additives. *In his* Food pharmacology. Springfield, Ill., C. C. Thomas, 1969. pp. 108-126. RC143.S25

Weiser, Harry Howard, George J. Mountney, *and* Wilbur A. Gould. Food additives. *In their* Practical food microbiology and technology. 2d ed. Westport, Conn., Avi Pub. Co., 1971. pp. 299-309. Includes bibliography. QR115.W38 1971

Subject Headings under which *books* on food additives can be located in the LC card catalogs include the following:

Food Additives (Highly relevant)
Food—Analysis (Relevant)
Food—Preservation (Relevant)
Color of Food (Relevant)
Food Industry and Trade (More general)
Flavoring Essences (Related)

Basic Texts

Jacobson, Michael F. Eater's digest: the consumer's factbook of food additives. Garden City, N.Y., Doubleday, 1972. 260 pp. Bibliography: pp. 251-252. TX553.A3J23

National Research Council. *Food Protection Committee.* Chemicals used in food processing. Washington, D.C., National Academy of Sciences-National Research Council, 1965. 294 pp. (National Research Council. Publication 1274) TX553.A3N26

Additional Texts

Ellinger, Rudolph H. Phosphates as food ingredients. Cleveland, CRC Press, 1972. 190 pp. Bibliography: pp. 167-185. TX553.A3E55

Ikeda, Robert M., *and* Donald G. Crosby. Chemicals and the food industry. Berkeley, University of California, Division of Agricultural Sciences, Agricultural Experiment Station, Extension Service, 1960. 126 pp. (California Agricultural Experiment Station and California Agricultural Extension Service. Manual 26) Includes bibliography. TX553.A3I5

National Research Council. *Food Protection Committee.* Evaluating the safety of food chemicals. Washington, D.C., National Academy of Sciences, 1970. 55 pp. Includes bibliographical references. TX553.A3N27

Handbooks, Encyclopedias and Dictionaries which contain information on food additives include:

CRC handbook of food additives. 2d ed. Cleveland, CRC Press, 1972. 998 pp. TX553.A3C2 1972

Encyclopedia of chemical technology. 2d ed. v. 10. New York, Interscience Publishers, 1966. pp. 1-22. Includes bibliography. TP9.E685

McGraw-Hill encyclopedia of science and technology. v. 5. New York, McGraw-Hill, 1971. pp. 411-415. Includes bibliography. Q121.M3 1971

National Research Council. *Food Protection Committee.* Food chemicals codex. 2d ed. Washington, D.C., National Academy of Sciences, 1972. 1039 pp. TX553.A3N282 1972

Bibliographies

Food and Agriculture Organization of the United Nations. *Documentation Center.* Food and agricultural industries, annotated bibliography, author and subject index. Rome, 1970. 1 v. Z7164.F7F66

Winton, Harry N. M. Food additives. *In his* Man and the environment: a bibliography of selected publications of the United Nations system, 1946-1971. New York, Unipub, 1972. pp. 121-126. Z5322.E2W56

Government Publications

Food additives. Eligibility of substances for classification as generally recognized as safe [GRAS] in food. *In* United States. Federal register, v. 36, June 25, 1971: 1093-1094. J1.A2

United States. *Congress. House. Committee on Government Operations. Intergovernmental Relations Subcommittee.* Regulation of food additives and medicated animal feeds. Hearings before a subcommittee on Government Operations, House of Representatives, Ninety-second Congress, frist session. Washington, D.C., U.S. Govt. Print. Off., 1971. 647 pp. Includes bibliographical references. KF27.G663 1971a

United States. *Food and Drug Administration.* Requirements of the United States Food, Drug, and Cosmetic Act. Revision. Washington, D.C., U.S. Govt. Print. Off., 1967. 56 pp. (FDA publication no. 2)

State-of-the-Art Reviews and Conference Proceedings

International Symposium on Food Protection, Ames, Iowa, 1962.

Chemical and biological hazards in food; [proceedings] Ames, Iowa State University Press, 1962. 383 pp. Includes bibliographies. TX511.I55 1962

Symposium on Chemical Additives in Food, Coventry Technical College, 1965. A symposium on chemical additives in food. London, Churchill, 1967. 128 pp. Includes bibliographies. TX553.A3S93 1965

Symposium: Phosphates in Food Processing, University of Guelph, 1970. Symposium: Phosphates in Food Processing, University of Guelph, Ontario, Canada, 1970. Westport, Conn., Avi Pub. Co., 1971. 242 pp. Includes bibliographies. TP368.S9 1970

Symposium on food additives and contaminants. In Nutrition Society. Proceedings, v. 31, no. 1, May 1972: 1-44. Includes bibliographies. TX501.N9

Use of human subjects in safety evaluation of food chemicals; proceedings. Washington, D.C., National Academy of Sciences, National Research Council, 1967. 273 pp. (National Research Council. Publication 1491) Includes bibliographies. TX553.A3U56

Journal Articles and other literature on food additives are indexed primarily in the following abstracting and indexing services:

Applied Science & Technology Index (1913-) Z7913.I7 See: Food Additives

Bibliography of Agriculture (1942-) Z5073.U572 See: Food—Additives

Biological Abstracts (1926-) QH301.B37 See: Food Additive(s)

Biological & Agricultural Index (1916-) Z5073.A46 See: Chemical Additives in Food

Bioresearch Index (1967-) Z5321.B672 See: Food Additives

Food Science and Technology Abstracts (1969-) TP368.F678 See: Additives
Names of individual additives

Index Medicus (1960-) Z6660.I422 See: Food Additives

Nutrition Abstracts and Reviews (1931-) RM214.N8 See: Food, Additives
Names of individual additives

Readers' Guide to Periodical Literature (1901-) AI3.R45 See: Food Additives

Science Citation Index (1961-) Z7401.S365 see especially *Permuterm Subject Index* (1966-) for entries under Food—Additives

Other indexes, listed here, should be used for an exhaustive search. Only a limited return can be expected for the time spent. Directions are generally given in the front of each issue.

British Technology Index (1962-) Z7913.B7 See: Food: Additives

Engineering Index (1884-) Z5851.E62 See: Food Products—Chemical Additives

International Pharmaceutical Abstracts (1964-) RS1.I63 See: Food—Additives

Monthly Catalog of United States Government Publications (1895-) Z1223.A18 See: Food Additives

Pharmacology and Toxicology, Experimental and Clinical (*Excerpta Medica*, Section 30) (1965-) RM1.P48
See: Food, Additives
Food Additives

Pollution Abstracts (1970-) TD172.P65 See: Food Additives

Primary Journals that often contain articles relevant to food additives are

Flavour Industry TP450.F55

Food and Agriculture Organization of the United Nations. *FAO Food Additive Control Series*

Food and Agriculture Organization of the United Nations. *FAO Nutrition Meetings Report Series* S401.F63

Food and Cosmetics Toxicology RA1190.B715

Food Chemical News (current issues only)

Food Engineering TX341.F87

Food Technology TP370.F63

Selected Representative Journal Articles on food additives include:

Damon, G. Edward. Primer on food additives. FDA consumer, v. 7, no. 4, May 1973: 10-16.

Gardner, Judy. Debate intensifies over law banning cancer-causing food additives. National journal, v. 4, Sept. 30, 1972: 1934-1943. JK1.N28

Grasso, P., *and others.* Physiochemical and other factors determining local sarcoma production by food additives. Food and cosmetics toxicology, v. 9, no. 4, Aug. 1971: 463-478. RA1190.B715

Gross, M. A., O. G. Fitzhugh, *and* N. Mantel. Evaluation of safety for food additives: an illustration involving the influence of methyl salicylate on rat reproduction. Biometrics, v. 26, no. 2, June 1970: 181-194. QH301.B48

Kermode, G. O. Food additives. Scientific American, v. 226, March 1972: 15-21.

Lower, Gerald M., *and* G. T. Bryan. Guidelines for production of food additives and other chemical commodities with least carcinogenic potential: a biochemical approach. Journal of milk and food technology, v. 34, no. 8, Aug. 1971: 394-409. 104 refs. SF221.I532

Maisel, Albert Q. What are the facts about food additives? Reader's digest, v. 98, no. 589, May 1971: 81-95. AP2.R255

Oser, Bernard L. Food additives: the no-effect level. Archives of environmental health, v. 22, no. 6, June 1971: 696-698. RC963.A22

Too much of a good thing. Food and cosmetics toxicology, v. 9, no. 1, Feb. 1971: 135-137. RA1190.B715[3]

Indexes and Abstract Services. Two forms of accessing tools frequently used by scientists and engineers are indexes and abstract services. These are keys to periodical literature, the chief source of current information. An index is a listing of items classified by subject and author. Horizontal (or subject) indexes survey the literature of a single subject or field (for example, chemistry, agriculture, architecture). Vertical (or publication) indexes survey a single publication (for example, the yearly index to *Science*). Indexes are similar to bibliographies but are generally issued serially and are therefore usually more current; many appear biweekly or monthly and in cumulative form each year.

An abstract journal is, like an index, issued serially and arranged according to author, title, or subject. The difference is the abstract itself, a short summary of the contents of an original document that follows the citation (see Chapter 8).

Table 2-1 lists some of the most valuable and widely used indexes and abstracts keyed in order of importance to students in different disciplines.

Indexes and Abstracts to Periodical Literature.

Agriculturally related indexes/abstracts published by the Commonwealth Agricultural Bureaux, Farnham House, Farnham Royal, Slough, SL2 3BN, U.K.:

Animal Breeding Abstracts, 1933-
Field Crop Abstracts, 1948-
Horticultural Abstracts, 1931-
Review of Applied Entomology, 1913-
Feed Abstracts, 1951-
Food Science & Technology Abstracts, 1929-
Dairy Science Abstracts, 1939-
Forestry Abstracts, 1939-
World Agricultural Economics & Rural Sociology Abstracts, 1959-

Table 2-1. Indexes and Abstracts Keyed in Order of Probable Use by Subject Area

Key: 1, most probable source; 2, likely source; 3, possible source.

	Agriculture	*Architecture*	*Home Economics*	*Engineering*	*Natural Science*	*Physical Science*
Applied Science and Technology Index	2		1	1	3	2
Architectural Index		1	3			
Art Index		1	1		3	
Atom-Index (replaces Nuclear Science Abstracts)	3			1		1
Bibliography of Agriculture	1		1	2	1	
Biological Abstracts	1		1		1	
Biological and Agricultural Index	1		1	2	1	
Business Index	2	3	1	2	3	
Chemical Abstracts	2			2		1
Child Development Abstracts			1			
Computer and Control Abstracts				1		3
Education Index	3		2	3		
Electrical and Electronic Abstracts				1		3
Engineering Index	3	2		1		3
Food and Nutrition Abstracts	2		1			
Forestry Abstracts	2				1	
Index Medicus	3	3	2	2		
International Aerospace Abstracts	3			1		3
Metals Abstracts				1		3
Monthly Catalog of U. S. Government Publications	1	3	1	2	2	
Nuclear Science Abstracts (NSA)	3			1		1
PAIS Bulletin	3	3			2	
Physics Abstracts				3		1
Psychological Abstracts	3	2	1		3	
Readers' Guide to Periodical Literature	3	3	2	3	3	3
Scientific and Technical Aerospace Reports (STAR)				1		3
Social Sciences Abstracts	3		2			
U. S. Government Research Announcements & Index (GRAI)	2		3	1		3
Research in Education (RIT)	2		1			
Science Citation Index (SCI)	1		3	2	1	1
Social Science Citation Index	2	2	2			

Applied Science and Technology Index, H. W. Wilson, New York, 1958- , 11 issues a year with annual cumulation.

Subject index to over 200 periodicals in areas of applied science and technology. Good for general overview or preliminary search. For material prior to 1958, see *Industrial Art Index* (1913-1957).

Art Index, H. W. Wilson, New York, 1929- , 4 issues per year with annual cumulation.

Author and subject index to selected periodicals in archeology, architecture, art history, arts and crafts, city planning, fine arts, graphic arts, industrial design, interior design, landscape design, photography, and film.

Bibliographic Index: A Cumulative Bibliography of Bibliographies, H. W. Wilson, New York, 1937- .

Lists separately published bibliographies as well as those in books and periodicals.

Bibliography of Agriculture, National Library of Agriculture, Washington, D.C., 1942- , monthly with annual cumulations.

Comprehensive coverage of international literature of agriculture and related sciences. Indexed by individual and corporate author. Geographical index provided for appropriate articles. Subject approach also provided. Contains lists of publications from the U.S. Department of Agriculture, State Agricultural Experiment Stations, State Agricultural Extension Services, and Food and Agriculture Organization of the United Nations.

Biological Abstracts, BioScience Information Service of Biological Abstracts, Philadelphia, 1926- , biweekly with semiannual cumulations.

Single most comprehensive index and abstract to the world's bioscience research. Covers theoretical and applied biology from over 5000 periodicals. "Keyword in context index" is prepared by computer.

Biological & Agricultural Index, H. W. Wilson, New York, September 1964- , 11 issues with annual cumulations.

Subject index to approximately 230 English language periodicals in areas of or related to biology and agriculture. (Supersedes *Agricultural Index*, which was published from 1916 to 1964 and included many U. S. government publications of agricultural interest.)

Business Periodicals Index, H. W. Wilson, New York, 1958- , 11 issues, cumulated annually.

Subject index to English language periodicals in all areas of business, accounting, advertising, banking and finance, communications, insurance, labor and management, marketing, public administration, taxation, and specific business and industry. Companion volume to *Applied Science and*

Technology Index, with which it was published under the title *Industrial Arts Index* (1913-1957).

Chemical Abstracts: Key to the World's Chemical Literature, American Chemical Society, Columbus, Ohio, 1907- .

A comprehensive abstracting and indexing service to the world's chemical literature. Covers over 15,000 journals; indexing is detailed. Covers patents and books as well as papers.

Child Development Abstracts and Bibliography, University of Chicago Press for the Society for Research in Child Development, Chicago, 1926- .

Covers approximately 128 journals in education, medicine, psychology, sociology; arranged by subject and indexed by author.

Computer & Control Abstracts: Science Abstracts, Series C, Institution of Electrical Engineering, London, Institute of Electrical and Electronic Engineers, New York, 1898- , monthly with semiannual cumulative indexes.

Comprehensive coverage of international literature in computer and control engineering. Includes journals, books, conferences. Separate index to bibliography, i.e., books, conferences, and corporate authors. Companion service to *Electrical & Electronic Abstracts* and *Physics Abstracts* (*Science Abstracts, Series Band A*, respectively).

Education Index, H. W. Wilson, New York, 1929- .

Subject and author index to approximately 235 periodicals, proceedings, and yearbooks in education, counseling and guidance, teacher education, etc. Limited to titles in English. Includes some U.S. government material. Ten issues per year with periodic and annual cumulations.

Electrical & Electronic Abstracts: Science Abstracts, Series B, Institution of Electrical Engineering, London, and Institute of Electrical and Electronic Engineers, New York, 1898- , monthly with semiannual cumulative indexes.

Indexes and abstracts international electrotechnology literature by author and subject. Has separate index to bibliographies, books, reports, conference proceedings, and patents. Companion service to *Physics Abstracts* and *Computer & Control Abstracts* (*Science Abstracts, Series A and C*).

Engineering Index, Engineering Index, Inc., New York, 1884- , monthly with annual cumulations.

General index to engineering literature; arranged by subject, indexed by author. Contains abstracts of articles from over 3500 journals as well as reports and proceedings.

Home Economics Research Abstracts, American Home Economics

Association, Washington, D.C., 1966- .

Abstracts doctoral dissertations and master's theses completed in colleges and universities offering graduate programs in home economics. Abstracts are arranged in seven broad subject categories and indexed by author.

Index Medicus, National Library of Medicine, Washington, D.C., 1960- .

Comprehensive subject and author index to the world's medical literature. Covers several thousand titles. Published monthly by the National Library of Medicine and cumulated annually by the American Medical Association. Special feature, 1965- : "Bibliography of Medical Reviews. . .," a guide to review papers. Computerized literature searches are available from MEDLARS (Medical Literature Analysis and Retrieval System).

International Aerospace Abstracts (IAA), American Institute of Aeronautics and Astronautics, Inc., New York, 1961- , semimonthly with annual cumulations.

Abstracts published literature of interest to aerospace science and technology. Includes books, periodicals, conference papers, and translations. Indexed by subject and author. Companion service to *Scientific and Technical Aerospace Reports (STAR)*, which covers "unpublished" material on the same topics.

Metals Abstracts, Institute of Metals, London, and American Society for Metals, Metals Park, Ohio, 1968- , monthly.

Comprehensive index to international metallurgical engineering literature. Continues *ASM Review of Metal Literature* (1944-1967) and *Metallurgical Abstracts* (1909-1967). Cumulated annually. Has companion index published separately: *Metals Abstracts Index.*

Nuclear Science Abstracts, U.S. Energy Research and Development Administration (ERDA), Washington, D.C., 1948-1975.

Abstracts and indexes published and unpublished literature in nuclear science and technology in both life and physical sciences. Lists reports of the U.S. Atomic Energy Commission (AEC) and its successor ERDA (1974-). Coverage continued by *ERDA Research Abstracts and Atom-Index* (IUAEA).

PAIS Bulletin, Public Affairs Information Service, Inc., New York, 1915- , available weekly, quarterly, and annually.

Subject index to books, pamphlets, periodical articles, government documents, etc., in economics and public affairs. Emphasizes factual and statistical information. Originally intended for legislative and municipal references use. Limited to English language material.

Physics Abstracts, Science Abstracts, Series A. Institution of Electrical Engineering, London, and Institute of Electrical and Electronic

Engineers, New York, 1893-   , monthly with semiannual indexes.

Indexes and abstracts international physics literature. Companion abstracts to *Computer & Control Abstracts* and *Electrical & Electronic Abstracts*. Has separate index to bibliographies, books, conferences, patents, and reports.

Psychological Abstracts, American Psychological Association, Lancaster, Pa., 1927-   .

Author and subject index to books, documents, periodical articles, and dissertations. Topics include developmental, educational, personal, industrial, and social psychology.

Readers' Guide to Periodical Literature, H. W. Wilson, New York, 1905-   , 8 issues a year with periodic and annual cumulations.

Indexing is retrospective to 1900. Provides author and subject access to approximately 160 general interest periodicals published in the United States. Includes such scientific and technical titles as *Science*, *Scientific American*, *Monthly Labor Review*, and *Consumer Reports*.

Resources in Education, Educational Resources Information Center, U.S. Government Printing Office, Washington, D.C., 1975-   .

A monthly abstract journal reporting literature in education. Indexed by author, subject, and institution. Documents covered are available in paper copy and on microfiche. Many libraries subscribe to entire microfiche set. For education-related report literature 1955-1975, see *Research in Education*. Both sets are commonly referred to as "ERIC Documents."

Science Citation Index, Institute for Scientific Information (ISI). Philadelphia, 1961-   . Quarterly with annual cumulations.

The publication differs substantially from conventional indexes. It traces in effect the offspring of an article by indicating all the articles in which a known article is cited.

Scientific and Technical Aerospace Reports (STAR), U.S. Government Printing Office, Washington, D.C., 1963-   .

Abstracts worldwide, unpublished reports on the science and technology of space and aeronautics, especially U.S. NASA reports. Indexed by subject, report number, accession number, individual and/or corporate authors. Companion service to *International Aerospace Abstracts*.

Social Science Citation Index, ISI, Philadelphia, 1974-   .

Coverage begins with 1973. Includes material in social and behavioral sciences and related disciplines. Has author, subject, and source index. Companion publication to *Science Citation Index* (see description).

Social Sciences Index, H. W. Wilson, New York, June 1974-   .

Author and subject index to over 270 periodicals in anthropology, area studies, economics, environmental science, geography, law and criminology, medical science, psychology, public administration, sociology, and related subjects.

U.S. Government Reports Announcements & Index, U.S. Department of Commerce, National Technical Information Service (NTIS), 1971- , semimonthly with annual cumulations.

Indexes and abstracts unclassified reports of U.S. government contractors in public and private sector. Index is by individual and corporate author, subject, report number, and accession number. Many documents listed are available in other than report form; the *GRA I* lists alternate sources of availability when known. Has been published since 1946 by different agencies and under different titles.

Newspaper Indexes. Newspaper indexes are handy sources for establishing dates of events or announcements, which, in turn, provide access to other information sources. Information on public reaction and policy as well as contemporary happenings may not be otherwise retrievable for months, if, in fact, at all.

Newspaper Index, Bell & Howell, Wooster, Ohio, 1972-

Subject and personal name index to the *Chicago Tribune*, *Los Angeles Times*, *New Orleans Times-Picayune*, and *Washington Post*.

New York Times Index, New York Times, New York, 1913- .

A subject index to *The New York Times* that not only references the date, page, and column of the item but also gives a brief summary of each entry. Useful as a guide to dates and reporting of current events in other newspapers as well. Although first published in 1913, it is retroactive to 1851. Index is by person, subject, and organization.

Wall Street Journal Index, Dow Jones Co., New York, 1958- .

A subject index to articles in the *WSJ*. Index is divided into two sections: corporate and general news. Index is arranged by subject and corporation.

Technique for Using Indexes and Abstracts. The researcher must apply his search terms to the indexes and abstracts with some ingenuity. He may have to think of other words if his initial terms produce no results. Several indexing and abstracting services issue thesauruses that the researcher can check for relevant terms. Since terms also change in meaning over time, new categories may have to be entered in extensive searches.

It's best to begin the search with the current literature and work backward. The latest articles offer clues to earlier work. One should look in particular for review articles on his subject (see Chapter 13 for a discussion of review articles). These summarize the literature on a topic and list extensive bibliographies. Sample index and abstract entries are shown in Figures 2-2 and 2-3.

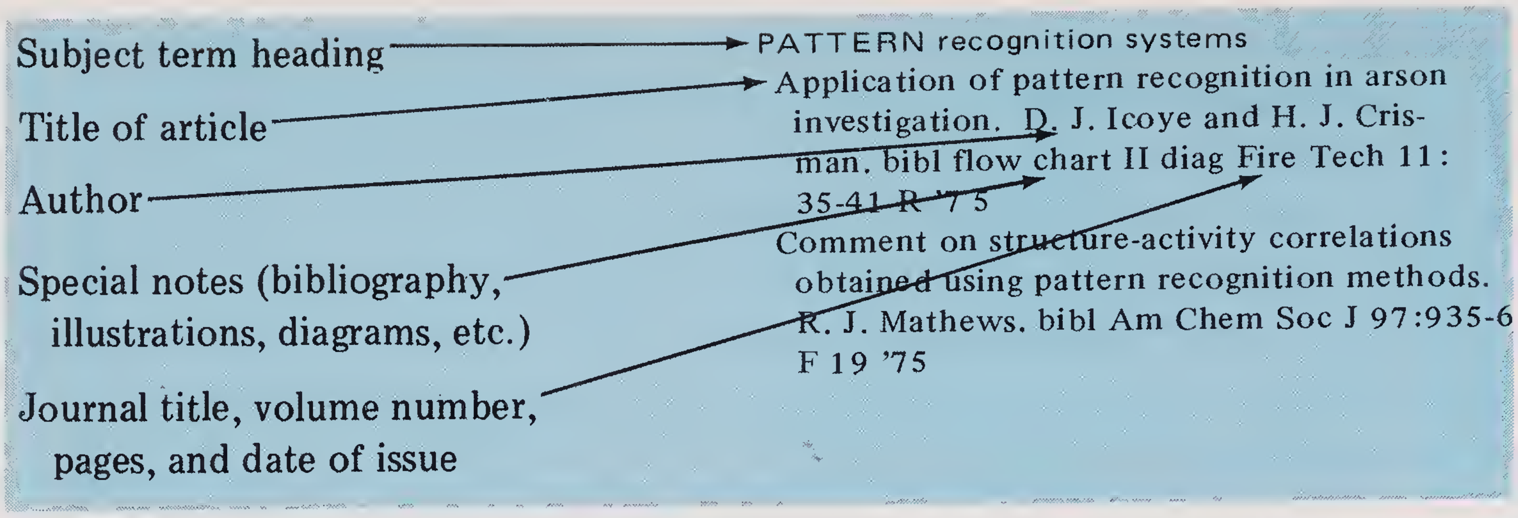


Figure 2-2: The parts of an index entry. (From *Applied Science & Technology Index*. Copyright © 1975, 1976 by The H. W. Wilson Company. Material reproduced by permission of the publisher.)

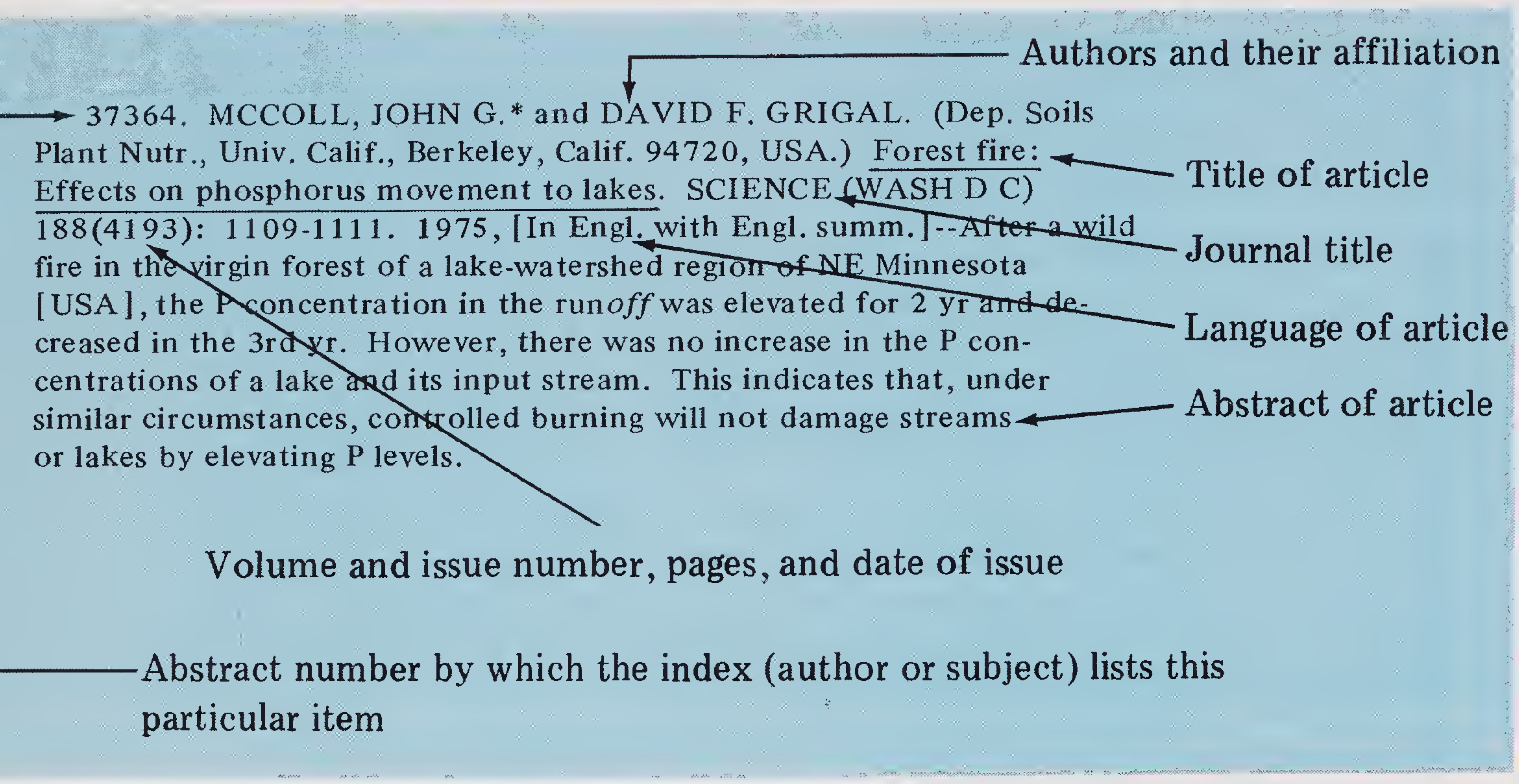


Figure 2-3. The parts of an abstract entry. (From *Biological Abstracts*. Reprinted with permission of BioSciences Information Service of Biological Abstracts.)

Guides to Government Publications. Because the government is the most prolific single source of information, the student should be aware of how to find government publications. Here are some selected tools:

Code of Federal Regulations, U.S. Government Printing Office, Washington, D.C., 1938– .

Contains executive and administrative rules and regulations, both general and permanent. Information within appears first in the *Federal Register*.

Congressional Index, Commerce Clearinghouse, New York, 1937- .

Published in looseleaf form and updated frequently. Indexes congressional bills and resolutions by subject, author, and bill number. Useful as a key and status checking tool for current legislation.

Congressional Record, U.S. Congress, U.S. Government Printing Office, Washington, D.C., 1873- .

Contains the proceedings and debates of Congress, including the record of votes and presidential messages. Useful for tracing bills and resolutions from their introduction to passage and signing. Bills are indexed by number and subject.

Federal Register, U.S. Government Printing Office, Washington, D.C., 1936- .

Contains texts of presidential proclamations, executive orders, and other administrative rules and regulations. Published Tuesday through Saturday except on days following holidays. Annual index is codified and published in the *Code of Regulations.*

Monthly Catalog of United States Government Publications, U.S. Government Printing Office, Washington, D.C., 1895- .

The *Monthly Catalog* lists publications of all government departments, bureaus, and agencies by key word in the issuing agency's name (example: Interior instead of Department of the Interior). Published monthly with an annual cumulative index. A cumulative subject index for 1900-1971 is also available.

U.S. Bureau of the Census: Statistical Abstract of the United States, U.S. Government Printing Office, Washington, D.C., 1879- , annual.

A one-volume summary of U.S. political, social, and economic statistics. Use as first source for statistics and as a guide to further sources. Abstracted from U.S. census data.

U.S. Congressional Directory, U.S. Government Printing Office, Washington, D.C., 1809- , annual.

Biographical information on congressmen: notes committee members, department and agency officers.

U.S. Government Manual, U.S. Government Printing Office, Washington, D.C., 1973/1974- .

A guide to purposes and programs of government agencies with emphasis on activities rather than structure. Lists key personnel of agencies. Continues *U.S. Government Organization Manual*, -1972/1973.

Information Centers. Information centers are another accessing tool. They provide information in the form of answers, bibliographies, or citations rather than the actual documents. Information centers are often highly specialized. They are sponsored by universities, professional societies, and governmental or commercial organizations. Many use computers to search the standard tools. Several abstracting services run individual searches of their data bases.

A specialist at the center confers with the researcher to draw up a search plan or "profile" that the computer can understand; it is simply a string of subject terms that are run against the file to extract matching citations. The Metals and Ceramics Information Center of Battelle Memorial Institute, for example, conducts individualized searches and produces reviews and bibliographies on metals and ceramic technology at regular intervals. The Science and Technology Division of the Library of Congress maintains a National Referral Center that answers individual questions about and produces a series of guides to other government agencies and private associations that provide information on specific topics (for example, "Natural Disasters"). The Reference Section of the division also produces bibliographies on important topics (see the bibliography on "Food Additives" reprinted earlier in this chapter; the bibliography serves as a good model for student bibliographies). The National Technical Information Service, the chief clearinghouse for government reports, provides summaries of current research, conducts custom searches, and distributes actual documents. Information centers may be identified in such directories as *A Directory of Information Resources in the United States: Physical Sciences and Engineering* (U.S. Government Printing Office, Washington, D.C., 1971). This publication, and other similar directories, gives the names, addresses, and phone numbers of information resources as well as a brief description of their services and holdings. Most centers charge for their services.

Selecting the Right Accessing Tool. Once the student has learned what each tool can offer, he will frequently find that several tools overlap in their coverage. He may locate a reference to the same monograph, for example, in a bibliography, index, specialized guide, and card catalog. Although this duplication may lead the researcher to think that he can narrow his search to only one or two tools, he should resist the temptation. Some research problems, it is true, may require only a single locating tool: for example, if one wants to know what has been written in the last 6 months in chemical journals about the carcinogenic properties of polyvinyl chloride (PVC), one can safely use *Chemical Abstracts* alone. But most projects require an investigation of the entire range, because vital material may well turn up in unexpected places. For this reason the researcher must familiarize himself early with all locating tools so that he can quickly and easily isolate the technical literature he wishes to read.

The product of this phase of the search, in addition to a growth in self-confidence and ease in using the library, is the preliminary bibliography. The researcher should copy citations from the indexes, abstracts, card catalog, and other guides—and make sure they are accurate. The best system for citation is a standardized one (not just jottings on the backs of miscellaneous envelopes); 5 X 8 inch cards are probably the best. Cards are easily stored and easily rearranged for the final bibliography of the report.

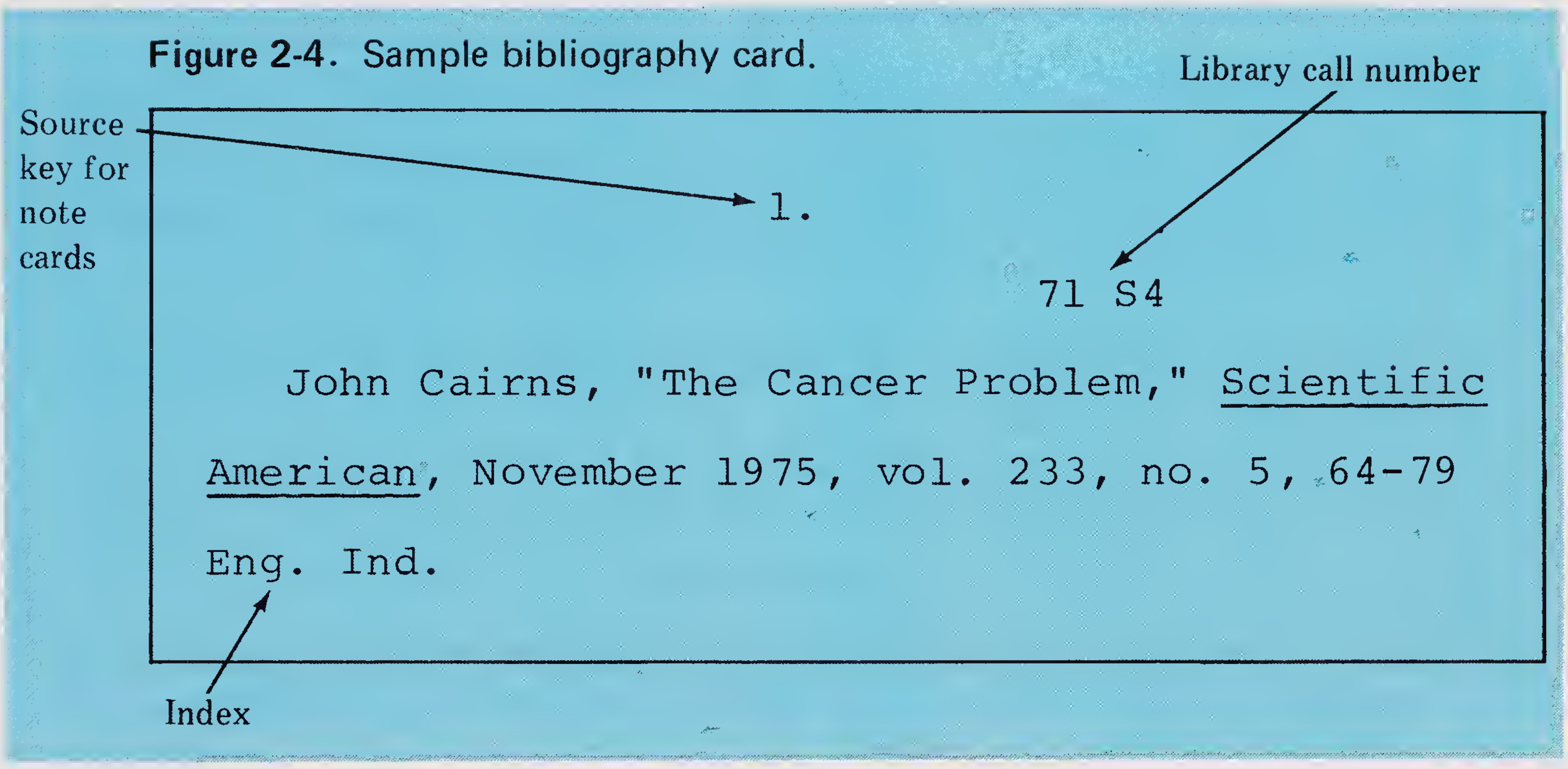


Figure 2-4. Sample bibliography card.

PROCURING THE DOCUMENTS

The third step in the search is to procure the documents. Unfortunately, a student cannot assume that listed items will be on the library's shelf when he wants them. He should get an early start on a project to allow time to assemble the sources. When a particular document has at last been found, the entry on the bibliography card should be checked against the actual work for errors or needed amplification. The documents themselves also often suggest further items to be added to the preliminary bibliography and checked in turn. Methods for reading and evaluating the documents—the next step—are discussed in Chapter 3.

Something to Say

Armed with his preliminary statement of purpose, the researcher stockpiles data from the field, the laboratory, and the library with some assurance they will be relevant in the end. He assesses the data as he collects them. Then during a kind of gestation period after most of the data are in, he allows his conscious and unconscious mind to work on his material. He sorts his findings, digests them, evaluates them, thinks about their implications, determines their possibilities and their limits, decides what they mean. Eventually, he derives generalizations to fit his findings. He decides what he needs to satisfy the reader. Perhaps he will have to go back to the library or laboratory to fill in gaps. Finally, he converts the most relevant, most significant of his materials into the prose form of the report.

GENERAL SOURCES FOR MISCELLANEOUS FACTS AND STATISTICS

The reference section of any library will contain a variety of directories, dictionaries, guides, and summaries for all kinds of general and miscellaneous information. Examples follow.

Abbreviations Dictionary, 4th ed., by Ralph De Sola, American Elsevier, New York, 1974.

Acronyms & Initialisms Dictionary, 4th ed., Bowker, New York, 1973, supplement, 1975.

Books in Print, Bowker, New York, 1948-   .

Index to *Publishers Trade List Annual*, which lists books in print and therefore available for purchase. Ordering information, publisher, and publisher's addresses are provided. Has author, title, and subject approach; presently published in six volumes annually with supplements periodically. Has companion publication *Paperback Books in Print*.

A Dictionary of Acronyms & Abbreviations, by Eric Pugh, Clive Bingley Ltd., London, and Archon Books, New York, 1968.

Encyclopedia of Associations, 9th ed., Gale Research, Detroit, 1975.

A classified listing of national organizations in the United States. Has key word, geographical, and executive index. Useful for addresses, purpose, and publications of the association as well as brief membership information and names of executive officers.

Information Please Almanac, Simon and Schuster, New York, 1947-   , annual.

The World Almanac and Book of Facts, Newspaper Enterprise Association, New York, 1868-   , annual.

Almanac of miscellaneous information especially useful for quick reference to general interest facts, summaries, statistics, maps, and news chronology.

McGraw-Hill Dictionary of Scientific and Technical Terms, McGraw-Hill, New York, 1974.

A dictionary of the vocabulary of science and technology with over 2500 illustrations. Each term is identified with the field in which it is primarily used. Emphasis is on definitions (not pronunciation), derivation, and syllabication.

McGraw-Hill Encyclopedia of Environmental Science, McGraw-Hill, 1974.

A one-volume encyclopedia for the nonspecialist that emphasizes the study of the external conditions affecting and influencing life. Most articles have a bibliography for further reading. A quick reference source.

Thomas' Register of American Manufacturers, Thomas Publishing Co., New York, 190?-   , annual.

Source book to product manufacturers and manufacturers' addresses.

Ulrich's International Periodicals Directory, 16th ed., by Eileen C. Graves, Bowker, New York, 1975-1976.

A classified list of approximately 57,000 currently published periodicals. Titles are grouped by subject. Entry gives publisher, publisher's address, price, editor, beginning date, and frequency. Useful for determining periodicals in a given field. Complemented by *Irregulars and Annuals*, which provides the same information for titles published annually (yearbooks, annual reports, etc.) and irregularly.

U.S. Bureau of the Census: Statistical Abstract of the United States, U.S. Government Printing Office, Washington, D.C., 1879-   , annual.

(See entry under "Guides to Government Publications," p. 30.)

BIOGRAPHICAL SOURCES

Biographical encyclopedias, dictionaries, and indexes are numerous. Some common ones are listed here. In addition, newspapers and newsmagazines may be useful for biographical material, obituary notices not excluded.

American Men and Women of Science, 13th ed., Jacques Cattell Press/Bowker, New York, 1976.

Important standard biographical dictionary. Published periodically since 1906. Divided into science and social science; also published in selected subject subset volumes such as *American Men and Women of Science: Agricultural, Animal and Veterinary Sciences.*

Dictionary of Scientific Biography, Charles Scribner's Sons, New York, 1970.

A multivolume set that aims to provide information on the history of science through biographies of scientists from antiquity to modern times. Emphasis is on scientific accomplishments and careers rather than personal biography. General scope: mathematics, astronomy, physics, chemistry, biology, and earth sciences.

Who's Who in America, Marquis, Chicago, 1899-   .

Probably the best known and most useful general dictionary of contemporary biography. There are numerous other *Who's Who* works such as *Who's Who in Aviation* and *Who's Who in the Midwest.*

DISSERTATIONS

The most comprehensive source for information about dissertations is listed here as a guide to this type of research.

Dissertations Abstracts International, Section A: Humanities, Section B: Sciences, University Microfilms, Ann Arbor, Mich., Vol. 20-   , 1970-   .

Abstracts doctoral dissertations from over 350 institutions as listed inside the cover of each issue. Author and subject indexes are included. Continues *Dissertations Abstracts* (1952-1969), which covers 1938-1969. Provides complete ordering information for purchasing items listed.

HANDBOOKS

Handbooks are reference books or manuals that compile specific information, often statistics and tabular data, on either a general subject or a limited subfield. Some examples are the following:

Altman, Phillip and Dorothy S. Dittmer, ed. and comp., *Biology Data Book*, 2nd ed., Federation of American Societies for Experimental Biology, Bethesda, Md., 3 vols., 1972.

Altman, Phillip and Dorothy S. Dittmer, ed. and comp., *Environmental Biology*, Federation of American Societies for Experimental Biology, Bethesda, Md., 1966.

American Institute of Physics Handbook, 3rd ed., McGraw-Hill, New York, 1972.

T. Baumeister, ed., *Standard Handbook for Mechanical Engineers*, 7th ed., McGraw-Hill, New York, 1967.

Besacon, Robert M., ed., *The Encyclopedia of Physics*, 2nd ed., Van Nostrand, New York, 1974.

CRC Handbook of Chemistry and Physics: A Ready Reference Book of Chemical and Physical Data, CRC Press, Cleveland, Ohio, 1914- , annual.

Metals Handbook, 8th ed., American Society for Metals, Metals Park, Ohio, 10 vols., 1961-1975.

NOTES

1. For a discussion of the methods and logic of science, see Meta Riley Emberger and Marian Ross Hall, *Scientific Writing*, Harcourt Brace, New York, 1955.
2. D. W. King, *Statistical Indicators of Scientific and Technical Communication, 1960-1980*, Vol. I, U.S. Government Printing Office, Washington, D.C., 1976.
3. *LC Science Tracer Bullet*, Reference Section, Science and Technology Division, Library of Congress, Washington, D.C.

EXERCISES

1. Devise a plan for gathering material to write a report on one (or more) of the topics suggested in the first exercise at the end of Chapter 11. Classify the research problem, decide on (and list) the necessary accessing tools, and arrange a preliminary bibliography.

2. How would you find
   - The melting point and composition of beeswax?
   - The name and address of the editor of *Corrosion*?
   - The current price of an ounce of plutonium?
   - Who has quoted from Dr. X's 1974 paper published in the *Journal of the Society of American Foresters*?
   - Which drugs are used to control blood pressure?

3. List ten subject headings (key words) that would be useful for a literature search of one topic. Then consult one index, one abstracting service, and the card catalog. Record any cross-references and other terms that seem relevant as you proceed. See which terms are the most current and effective in gaining the right material.

4. Examine one index and two abstracting services in your subject area. Compare them for
   - Scope (What do they include?)
   - Purpose (For whom are they prepared? What kinds of inquiries should they satisfy?)
   - Type of information given (What are the details provided in each entry? What approaches are provided: author, subject, patent, key word, or preselected terms?)

5. Locate an article on some aspect of public science policy or a particular ruling that was issued within the last 6 months, for example, rulings of the federal Food and Drug Administration or accidents reported to the Nuclear Regulatory Commission.

6. Examine the list of subjects in exercise 1 of Chapter 11. Decide if each is a problem of fact, means, or value.

7. Write an annotated bibliography (see Appendix A) on the topic for your formal report.

8. Which of the following is a fact and which is an interpretation?

   - Red Dye No. 2 causes cancer in rats.
   - Nuclear energy is more efficient than solar energy.
   - Since 1970, more than 200 fertilizer plants have opened in the United States.
   - The failure was caused by stress-corrosion cracking.
   - The atomic weight of oxygen is 16.
   - Storm windows on a house help to keep in the heat.
   - Water boils at 100°C.
   - The National Science Foundation supports scientific research.
   - The Surgeon General has determined that cigarette smoking is dangerous to your health.
   - More college football players come from western Pennsylvania than from any other area of the United States.
   - The best lobster in America comes from Kennebunkport, Maine.
   - Engineering students score higher on quantitative aptitude tests than English majors.
   - Light cars use less gas than heavy ones.
   - High-cholesterol diets lower life expectancy in white males.
   - Decreasing the number of windows in skyscrapers lowers heating costs.
   - Aluminum resists corrosion better than iron.
   - Computers provide faster access to files of data than do human clerks.
   - Paperbound books cost less than hardback ones.
   - Identical twins have similar IQs.
   - The life expectancy for men is lower than that for women in the United States.
   - The Inland Steel building in Chicago was designed by Skidmore, Owings, and Merrill.

9. Where would you look to find facts to support the interpretations you identified in exercise 8?

CHAPTER 3

Using Printed Material

Read not to contradict and confute, nor to believe and take for granted. . . but to weigh and consider.

Francis Bacon

Through systematic use of the proper tools—good detective work—the student or professional researcher locates published information pertinent to his case (see Chapter 2). Then he has to read what he has found. He needs to read effectively and efficiently; that is, he reads the right material, and he reads the material right. He takes accurate and useful notes to ease the job of writing his report later on. He not only understands what he reads but also evaluates it. He weighs and considers, testing the validity of both the facts and the interpretations presented.

Reading

To quote Bacon again: "Some books are to be tasted, others to be swallowed, and some few to be chewed and digested." The researcher is aided in his decision about whether to taste, swallow, or chew by his preliminary outline (Chapter 2), which controls what he is looking for. His first step is to skim the book, article, or report, looking in the title and the text for the key words that represent his research interest.

To skim a *book*, he should

- Read the preface (it gives the author's purpose and direction).
- Assess the author's credentials if available.

- Flip through the entire book to note chapter heads, where items are located.
- Examine figures and tables, which often epitomize the author's material.

To skim a journal *article*, he should

- Read the title (short, general titles often indicate broad discussions; longer titles suggest more specialized treatment).
- Read the abstract.
- Read headings.
- Examine figures and tables.
- Read the first and last paragraphs.
- Read topic sentences of paragraphs; these often establish a pattern of discussion.
- Look for key and signal words and phrases.

Through skimming, the researcher decides what is pertinent. He also gets an overview of the subject and a sense of the general direction of the literature. At this point he is ready to read pertinent material carefully, looking both for information to fill in his original design and for confirmation that authorities support his projected reasoning. His clear sense of purpose helps him to be more than, in Pavlov's phrase, an "archivist of fact." He has a plan. But his preliminary outline shouldn't strangle him; he should be sensitive and open to significant information that he had not considered at all, or had considered unessential, in the beginning.

A HOLDING PLACE: NOTES

As he reads, the researcher needs a holding place where information from multiple sources may be stored and then sorted for distribution in his report. Notes serve this function. Good notes take the writer a long way toward his final report if they represent a real digestion of the source and a reorientation of its material to the researcher's needs. If the notes are in the writer's own words, he begins the final report with some writing in hand. To be good, notes should be accurate and should be flexible enough to allow the researcher to move items easily into different trial arrangements for final presentation.

The best system for taking notes is, of course, whatever works best: jottings on backs of envelopes, entries in bound notebooks, marginal comments and underlinings on photocopied sources (never on library copies). Note cards, however, are best for those at work on long, complicated presentations. They are the most flexible form of notes, subject to the best checks and arrangements. Cards (3 X 5, 4 X 6, or 5 X 8 inches) or slips of paper are used. For ease of sorting, the card should be different in size or color from the bibliography cards (Figure 2-4).

Each note card records a single unit of information. A "unit" may be defined as an item that cannot be subdivided into component items of any practical use. One document may provide information for several cards, each of which records a different fact, interpretation, or quotation. The item is recorded in the center of the card. Above it appears a topic heading or number indicating the category in the preliminary outline that it supports. Below it appears an indication of the source. This may consist of a number (or letter) keyed to a bibliography card or an abbreviated citation. A page notation should also be included (Figure 3-1).

A card may summarize the line of reasoning of an entire article. It may paraphrase—that is, restate in the reader's words—a passage from the original. Or it may record one fact, opinion, or direct quotation. The note, which serves as a reminder to the reader, is written in the briefest form consistent with clarity and accuracy. Notes for a short paper that is based on a few readily available sources and is to be written immediately following the note taking can be sketchy—just a few words—and still work. The reader can probably trust his memory to fill in both the context and the detail. However, if the final report will be long, based on many sources, and written over several weeks or months, then the notes should be detailed. They may be best expressed in complete sentences. Abbreviations may be used if used consistently (one often errant abbreviation is "ex," which has been used by some note takers to mean both *example* and *exception*, with disastrous results). In adjusting the original to his own language the researcher should be careful to avoid near quotation. He should also check his version against the original to make sure that his interpretation is accurate. Such checking during note taking saves time—and worry—during the writing, especially if the document is not available again (see Appendix A for details on documentation).

Figure 3-1. Sample note cards. (Based on a reading of John Cairns, "The Cancer Problem," *Scientific American,* 233 [November 1975], 64-78.)

SUMMARY

Title of article summarized

Cairns, "The Cancer Problem"

Discusses mechanisms of cancer, organ by organ, incidences and methods of surveying; stresses <u>environmental</u> causes--smoking, diet (especially high levels of meat eating); need to control these to prevent disease rather than hope for a cure

1.

Reference to bibliography card

PARAPHRASE

Topic heading

<u>Environmental effects</u>

Role of environment in causing cancer is shown in statistics on immigrants from one country to another. Children of Japanese who move to U.S. don't have stomach cancer (common in Japan) in same high numbers as parents did; children of migrants to Israel show same low incidence of cancer as locals, even though parents' rates the same as in their native country

Cairns 1. pp. 67-68

Source and pages
(reference to bibliography card)

ENVIRONMENTAL FACTORS

Knowledge of the relation between age and death rate does not tell us what causes a cancer, only that the steps leading up to it are probably accumulated over many years. What we want to know is whether or not the main causative factors are environmental (and therefore potentially avoidable). For example, if the steps in forming a cancer are mutations, we want to know whether they are induced by environmental mutagens or arise as spontaneous errors during the replication of DNA. The distinction can be made by observing what happens to cancer incidence when people migrate from one country to another. Many populations have been studied; they all show that environment plays a decisive part. For example, cancer of the stomach is much commoner in Japan than it is in the U. S., but cancer of the large intestine, the breast and the prostate are much less common. When Japanese emigrate to the U. S., these differences are lost within a generation or two . . . . Because the Japanese immigrants and their children tend to marry within the group, the change in incidence must be caused by the changed environment rather than by genetic factors; moreover, since the incidence of the various cancers takes more than one generation to reach levels typical of the U. S., some of the causative agents must be factors such as diet, which tend to persist as part of a cultural heritage, rather than factors such as air pollution, which tend to be the same for everyone in a given place. Similarly, Jews who migrate to Israel from Europe or the U.S. have an incidence of cancer that is typical of their country of origin, but their children born in Israel have a much lower incidence of almost all kinds of cancer. In this respect they have become more like the indigenous Jewish and Arab populations and the Jewish immigrants from Asia and Africa . . . .

Item from original

ONE FACT

Topic heading

<u>Incidence of cancer</u>

About half of all cancer deaths caused by cancers of three organs--lung, large intestine, breast

Cairns 1. p. 64

Source and pages

Quotations. Sometimes a researcher decides to copy an especially well-phrased or significant term, sentence, or passage directly from the text. He may use this quotation to add interest and authority to his final report. Direct quotations in the notes should be clearly separated from the reader's own words. The quoted matter is surrounded by quotation marks and copied exactly. No abbreviations are used unless they appear in the original. Omitted words within the quotation are represented by ellipsis points (. . .) for words left out within a sentence; four points rather than three are used when it is necessary to show that the omitted words completed the original sentence. The note taker may adjust or interpolate the quotation slightly to clarify a context. These adjustments are shown in square brackets to indicate that material inside is not in the quotation:

"this procedure [hydrolysis] . . . ."

"they [Ferguson and Anderson] . . . ."

Arrangement of Cards. The researcher accumulates note cards as he reads and files them under the assigned topic headings. When the time comes to assemble the final report, the cards can be laid out easily in different trial arrangements and adjusted under any new headings suggested by the research. Such arrangements are more easily accommodated when items are on individual cards than when they are locked into consecutive entries in a bound notebook. The notes may be reviewed and checked off as the draft of the final report is written and verified against them. Moreover, quotation cards—as well as others with, perhaps, complicated statistics—may be taped or stapled directly onto the pages of the first draft and removed and reused for later drafts. This flexibility avoids the need to recopy, thus saving time and assuring accuracy.

Weighing and Considering

Once an article, book, or report has been read and noted, the accuracy and reliability of what it says need to be tested. Such testing is the mark of the serious student or professional who, for good reason, does not accept everything he reads or hears. There is much to be gained from the literature but only when one reads wisely and well: reads the lines and between the lines. As the careful researcher scrutinizes his own instruments, observations, and reasoning, so he must also scrutinize what he reads.

INFORMATION POLLUTION

Scrutiny is necessary because information may be polluted. The pollution, either intentional or accidental, takes several forms. The rest of this chapter presents methods of detecting it.

Some printed materials are sloppy, ambiguous, misleading—or simply wrong. They may be wrong because the researcher received his data over the telephone and did not hear right, could not read a dim photocopy, miscopied a notation, used a poor or faulty technique, and so on. The science itself may be wrong, or the researcher may have used misleading language in writing up the results. Authors have been known to publish results too early in an investigation, to exaggerate or overdramatize their findings, or to falsify findings deliberately.

Scientists and engineers called on to speak in public forums may make value judgments or policy statements beyond what their data can support. In doing so, they may fail to separate clearly their facts from their personal standards and opinions. They may take advantage of their authority in one field to draw and apply conclusions to others.

Valid evidence may be distorted to suit a political or commercial cause. Some politicians insist that "a reputable scientist can be found to support any side of any controversy, that scientists have used their disciplines to reinforce their political convictions, and that scientists are interested primarily in feathering their own nests."[1] Politicians themselves may leap to one side of a scientific controversy to gain popularity when the facts may not be clear one way or another. Businessmen may distort evidence to gain profit; they may exploit popular belief in the validity of assertions that are "scientifically proved" in marketing products without cautioning the buyer about side effects or acknowledging contradictory test results.

SCIENCE AS CUMULATIVE

Science and technology are cumulative: the work of one scientist is grafted onto another's. Publications—both professional and popular—are essential in recording what scientists and engineers need to say to each other and to the public. They provide a vehicle for the exchange of information. Barry Commoner, himself a controversial scientist, remarks:

> The reason why the scientific enterprise has a well-deserved reputation for unearthing the truth about natural phenomena is not the "objectivity" of its practitioners, but the fact that they abide by a rule long established in

> science—open discussion and publication. Whatever his personal aims, values, and prejudices, when a scientist speaks and publishes openly—presenting facts, interpretations, and conclusions—he has done his service to the truth. For science gets at the truth not so much by avoiding mistakes or personal bias as by displaying them in public—where they can be corrected.*

The professional literature offers a forum for criticism and debate, for accepting what is true and ignoring—or condemning—the rest. The reader, however, must beware.

Tests for Reliability

Testing the literature for misuses of information is a tricky procedure. It requires a bit of sleuthing. The reader may test at three points: (1) the source, (2) the author, and (3) the material.

THE SOURCE

The source of a document may be an industry, a company, a research laboratory, a commercial publisher, or a professional society—all of which offer a wide range of publications. Some of the material produced is meant to have mass appeal and broad circulation; some is restricted to readers who can understand complex theories expressed in detailed, technical language. The purpose of publishing ranges from a low-keyed sharing of information to hard sell. The nature of the source should thus be established. Is the source likely to be accurate, or is it subject to error? What is the reliability of other reports that it puts out? Might it distort information in an attempt to deceive or conceal materials from the audience, to raise its profit, to provide (or avoid) opposition, to support a prejudice, or to take advantage of a situation? A report from a paper company about air pollution may differ in its presentation and interpretation of evidence from the account of an environmental group.

In particular, possible biases of the publisher of a journal should be assessed (see Chapter 13). *Nuclear Safety*, sponsored by the U.S. Nuclear Regulatory Commission, supports the development of nuclear reactors and has a set of biases different from those of the *Bulletin of the Atomic Scientists: A Magazine of Science and Public Affairs*, published by the Educational Foundation for Nuclear Science, which stresses the dangers in nuclear development. When the reputation of a source is critical, colleagues and professors can be asked to rank the journals in a field. Which journals are cited by leading researchers? Which journals do *they* publish in? Who are the

**The Closing Circle: Nature, Man and Technology*, Alfred A. Knopf, New York, 1971, pp. 86-87. Copyright © Alfred A. Knopf, Inc. Reprinted by permission.

editors and editorial board? Are articles reviewed by experts before publication? Moreover, although longevity is not itself a guarantee of truth, older, longer-published journals have some claim to reliability because they have had more years to be scrutinized, to have had biases uncovered.

THE AUTHOR

In addition to assessing the reliability of the source, the reader should consider the author. The author's credentials should be established: education, employment, chief interests, publications, professional activities. If the author is both scientist and public figure, the reader should make sure that the author is speaking in his own field and is up to date. How reliable have his other reports been? Did he obtain the data he uses, or are they secondhand? Does he seem knowledgeable about his subject? Has he clearly separated interpretations from fact? Might he be susceptible to pressures—personal, institutional, political—that would cause him to alter or suppress information?

Articles in some trade journals, and some industrial brochures and reports, are published without the author's being identified. But, wherever possible, it is important to know who the author of a document is. Indeed, journals and books often publish biographical information with their articles. The following entry from a page devoted to "The Authors" in *Scientific American* supports the credibility of the author of an article titled "The Necessity of Fission Power."*

> H. A. BETHE ("The Necessity of Fission Power") has devoted much of his time and effort in the past few years to a study of the role of nuclear power in the context of the world energy problem, particularly since his retirement last July from active teaching at Cornell University. Born and educated in Germany, Bethe joined the Cornell faculty in 1935 after working at universities in Germany and Britain. His years at Cornell were interrupted by World War II, when he worked first at the Radiation Laboratory of the Massachusetts Institute of Technology and later as head of the theoretical-physics division of the Los Alamos Scientific Laboratory. His basic research on the theory of the atomic nucleus has won him many honors, among them the Nobel prize for physics, awarded in 1967 for his discovery in the late 1930's of the nuclear reactions that power the stars. Over the years he has also served as a consultant to both Government and industry on the design of nuclear power reactors. His current "one-man campaign for increasing our energy sources other than oil and gas," the latest in a series of activities that have involved him in national issues, stems from a conviction that "the general public is not well enough

Scientific American, 234 (January 1976), 16.

informed about science and technology and their role in our society. This allows any number of nuts to dispense misinformation couched in noble rhetoric. I only take on issues for which I feel my professional background qualifies me; I don't want to make a career of public advising."

THE MATERIAL

The third test of reliability is a critical examination of what the author says—of his material. The author's facts, the chain of interpretations that extends beyond what he directly observed, and his language must be examined. It is not easy, especially for a beginning researcher, to determine whether an author has worked accurately and considered all sides of a possible interpretation. However, one author's interpretations can be matched against another's to help sort out the facts from the interpretations, and a search can be made for common errors in reasoning that the author may have slipped into. The next two subsections discuss methods for analyzing generalizations—especially hypotheses—and hunting out fallacies. Chapter 6 discusses in detail the building of a chain of interpretation through induction and deduction. Chapter 4 discusses distortions of language.

Testing Generalizations. Scientists use generalizations to make sense of facts and give them significance. As important as making discoveries is what one makes *of* them: how an investigator relates them to other information and to his own experience, how he reasons from them. One major form of scientific reasoning is the creation of a hypothesis. A hypothesis is a form of generalization that aims to explain something; it is a working proposition subject to proof.

Creating a Hypothesis. The following facts were collected recently by four British scientists:

- Small, counterclockwise whirlwinds are produced when cars driving on the right pass oncoming cars on the left.
- Tornado reports in the United States over the last 40 years have increased sixfold.
- National figures show there are 15 per cent fewer tornadoes on weekends in the United States than on weekdays.

The scientists correlated the data with the well-known rise in motor traffic over the last 40 years and came up with the hypothesis that tornadoes occur in the United States because people here drive on the right.[2] When conditions are suitable, those small, counterclockwise whirlwinds develop into the counterclockwise swirls of tornadoes in the northern hemisphere. That there are fewer tornadoes on weekends, they say, reflects the fact that fewer cars are on the road (no commuters) and most traffic moves in one direction (out of the city on Saturday and back on Sunday). Other scientists, however, doubt the interpretation, their chief point being that the data are amenable to several interpretations. One scientist in response argued for a correlation with X-rated movies because hot, steamy air is needed to start a tornado. Further data show a shift in tornado activity to the south and west; this might be explained not by automobiles but by increased irrigation, which increases the humidity and so leads to tornadoes.

The tornado hypothesis has been presented here tongue in cheek (although the authors thought they had something). But the process of creating and testing hypotheses is basic to all research. With hypotheses the scientist tries to explain something or show what produced a particular condition. He may indicate a relationship among seemingly miscellaneous things or state that a generalization that holds true for a sample of items of a certain class holds true for all members of the class. Moreover, the investigator may go beyond his explanations to conclusions and recommendations; he may suggest, for example, that Americans (like the British) should drive on the left.

Testing Hypotheses. How does a reader know what explanations are right? In part, he goes on the reputation of the source and the author; their reliability in other situations may lend credence to a particular hypothesis they present. But the reader also applies certain tests to the hypotheses themselves—the same tests that must be passed by the working hypotheses talked about in the laboratories and recorded in the journals before they are enshrined as principles or laws in science and engineering textbooks.

The reader checks to see if the sample on which the hypothesis is based is reasonably numerous and random. Exceptions should be demonstrably not typical and should be explainable. Generally, the simplest hypothesis is preferred. An explanation with too many exceptions, or one that is forced, is probably not useful. On the other hand, the hypothesis should not be exaggerated or oversimplified—as the British scientists' suggestions probably are. It should be based on consideration of all the facts; contradictory evidence must not be glossed over, and the hypothesis must not be pushed beyond what the positive evidence can support.

The hypothesis should pass the test of common sense. Of course, many great scientific achievements seemed farfetched in their day—the world does not *look* round—but genius is the exception, and common sense does work against silliness on lesser levels. Alternative explanations of the same data should be proved unworkable. And, finally, the hypothesis is more tenable—like the second law of thermodynamics—if it can be used to explain more than just the evidence on which it is based and if it makes accurate predictions. If the hypothesis works, it is probably right, at least for the present.

Hunting Out Fallacies. The reader, then, looks for any sleight of hand when an author turns facts into evidence to support a generalization. Following is a discussion of some common fallacies—errors in reasoning—that show up in student and professional writing. The list is representative rather than exhaustive, and some categories shade into one another. The examples can be multiplied many times.

Implied Assumptions. An assumption is something taken for granted in a discussion. In a technical article, for example, an author may assume that the reader is familiar with general accounting practices or the basic functioning of a computer and discuss more specialized matters. But sometimes the beliefs or concepts that underlie a discussion may be unverified, false, dubious, or otherwise disagreeable to the reader. Such implied assumptions can cause misunderstandings and mask erroneous interpretations of the evidence.

- "People who like their work ought not to get good salaries."—This conclusion implies that work ought not to be enjoyable or rewarding in itself and that good salaries ought to be the reward for suffering. These assumptions are obviously questionable.
- "Environment is a broad term embracing problems of air and water pollution, birth control, urban transportation and everything that affects or threatens the survival of man."—This definition (see Chapter 6), which begins a technical article, takes a neutral term, *environment*, and fastens onto it certain negative qualities ("problems of air and water pollution," "threatens") and specific aspects ("birth control," "urban transportation") with which the reader may well not agree.
- "If at first you don't succeed, try, try again."—This statement rides on the assumption that eventually one will succeed; however, in some situations, no matter how hard one tries one will not succeed.

Begging the Question. Begging the question is a special form of implied assumption in which something that needs proof is simply assumed. This difficulty is often hard to ferret out, especially if the reader is in sympathy with the author. Authors may also attempt to ignore the question or to divert attention by shifting the lines of argument. The often-cited example of begging the question is, "When are you going to stop beating your wife?" (which implies that you do beat her).

- "I worked 15 hours on this report, and did five revisions, and got a C; he tossed in his first draft and got an A. That isn't right."—The comment begs the question of the *quality* of the final product. The grade is not given for the amount of work but for what the work accomplished.
- "Private marijuana possession should not be decriminalized because young lawyers gain valuable courtroom experience in trying marijuana cases."—The comment (the substance of a statement from several senior law partners) begs the question of an individual's right to smoke marijuana in his home.
- "During the 7-day trapping period nine *Microtus* were captured, one in a live trap and eight in the snap traps. With a ratio of eight to one it is concluded that snap traps are more effective and easier to use than live traps in the capture of small mammals."—This begs the question of why the traps were "easier to use." The evidence helps support "effective" but not the second conclusion.

Post Hoc. Many opportunities for error lie in the path of the scientist who uses evidence to say that something caused something else (causal reasoning is examined in Chapter 6). The post hoc or "after the fact" fallacy and the mix-up mentioned next are two of the more common. The full phrase is *post hoc ergo propter hoc*: "after this therefore because of this." The error occurs when an investigator attributes a causal role to an event that preceded another event or to his activity before something happened, when in reality the preceding events did not influence the outcome. For example, biologists recognize a period in a person's daily cycle they call the "after-lunch lull." At first it was thought to be caused by eating, but after tests with subjects who did not eat lunch and had the same symptoms, some scientists suggested that the lunch does not cause the lull. They considered the relationship to be chronological, not causal. Certain medicines are thought by their users to relieve pain or other symptoms because the symptoms disappear after the medicine is taken. Under controlled circumstances, however, it may be shown that the medicine is not the cause of the relief but that some by-product or other activity is—like lying down after taking the medicine.

Mix of Cause and Effect. Sometimes the cause and the effect of something are confused by an author, with confusing results for whoever reads the report. Several scientists, for example, have correlated heavy smoking and drinking with heart disease. A recent study, however, suggests that both the smoking and drinking and the heart disease may be effects of yet another cause: early alienation of the subject from his family. The resultant tensions lead both to drinking and smoking and to hormonal changes that reduce the effectiveness of the body's immune system. Another study indicates that estrogens may not cause uterine cancer, as has been suggested, but that another factor that increases the likelihood of a woman's taking the estrogens may be the real cause of the cancer.

Non Sequitur. Another Latin phrase is used to describe the error in interpretation where two assertions are placed next to one another as in a sequence but the second does not follow from the first—*non sequitur* ("it does not follow"). The first statement may not lead to the conclusion, or the two parts may not be logically related at all.

- "The SST should have been developed in America because thousands of people lost their jobs when the project was abandoned."—These ideas, although emotionally related, do not form a logical sequence, because the aim of SST production was a plane, not employment, and the decision to abandon the program had to follow a judgment about the plane.
- "The material in this textbook presents 'plain facts'; there are already too many books on report writing that run to five and six hundred pages."—The number of pages is irrelevant to the plainness of facts.
- "Fishing is a popular sport as shown by a survey taken in 1975. In this survey the data indicated that the American public bought 90 million fishing licenses and only 9 million marriage licenses. It is therefore evident that fishing is ten times more popular than marriage."—Differences in licensing procedures, the valid duration of the respective licenses, and the nature of the two populations of those who fish and those who marry make the conclusion logically erroneous—if perhaps amusing.
- "Although the Moon is smaller than the Earth, it is farther away." (!)

Either/Or Fallacy. The either/or fallacy results if an author sees in a situation only two possibilities when more may realistically be present. For this reason it is also called the fallacy of the inevitable alternative. The linguist Alfred Korzybski calls this the "two-valued orientation," as opposed to the multivalued orientation that should inform scientific thinking. The following statement from a book review illustrates an either/or fallacy (and also contains an implied assumption):

- "A scientist with a soul, Loren Eiseley for more than 20 years has been attracting readers who yearn to bridge that gulf between the two cultures of science and the rest of life."—The reviewer sets up two alternatives: either science or "the rest of life." That division is suspect. There may be more than two cultures (divided, for example, into art, literature, engineering, science) or one embracing culture. The "gulf" is unproven. The implication that all scientists do not have a "soul" is also dubious.

Misuse of Numbers. We know that statistics can be manipulated to support almost any position; a popular book is *How to Lie with Statistics* (by Darrell Huff and Irving Geis [Norton, New York, 1954]). Because numbers are so frequently used in scientific and engineering prose, we should be careful to interpret them correctly and not place blind reliance on them. The numbers may be irrelevant or tangential, put in the text because the author knows the audience expects them rather than because they aid the discussion. Their significance may be greatly reduced when they are compared to other data and a larger sample. Their form in, for example, an average may be more argumentative than representative, may hide more significant extremes.

Frightening Statistics. Frightening statistics often take on a new dimension when the methods—and reality—they represent are fully disclosed. In provisional figures for the first 7 months of 1975, the National Center for Health Statistics announced a 5.2 per cent increase in cancer deaths over the first 7 months of 1974. The usual rise is about 1 per cent. The government's figures were corroborated by an insurance company's. But the apparent—and frightening—increase was later called illusory. The increase in deaths was partly a result of a flu epidemic in 1975 (which increased deaths from chronic diseases including cancer). The statistics were provisional, based on only a 10 per cent sample, and there were, according to the government sources, some "vagaries of data." In addition, the overall rate is considered less meaningful than rates subdivided according to age, sex, race, and type of cancer.[3]

Ambiguities in Annual Reports. One must take particular care in reading the annual reports of organizations and corporations. The goal of the report is often to present a rosy picture, even if the year wasn't rosy. The report may equivocate, may shift the blame for losses to a bad economy or other devils, or may try to cover a lack of information—or a lack of real productivity—with extraneous numbers, large photographs, or elaborate trivia to divert attention from the real issues. It is best to read the report backward, beginning with the auditor's opinion, a brief letter that generally says that a certified public accountant has examined the books, checked the bookkeeping, and found they reflect the company's condition according to "generally accepted accounting principles." If the letter is long, the company may be in trouble. The tables of numbers, headed "balance sheet," "changes in financial condition," or whatever, should be closely scrutinized, especially the footnotes, which may indicate changes in the company's accounting methods from year to year that make comparisons invalid or may reveal bookkeeping devices intended to gloss over the company's weaknesses in, for example, cash position.

Risks and Benefits. An increasingly common use of numbers is to assess the risks and benefits that accompany technological processes and devices.

- "The radioactive emissions from the nuclear power plants expected in 2000 would increase the number of cancer deaths by 8.7 per year."

This may seem bad, but compared to other risks considered normal the hazard turns out to be negligible. A scientist has concluded that, on an individual basis, equivalent risks include being a fraction of an ounce overweight, smoking 0.03 cigarette per year, and driving 1 mile a year.[4]

- "2,300 Scientists Petition U.S. to Reduce Construction of Nuclear Power Plants" (headline in *The New York Times*)

The article accompanying the headline concluded that this large number of opponents indicated that the scientific community strongly opposed construction of nuclear plants. In a later statement, however, an oil company countered that the 2300 represented only about 20 per cent of the 12,000 professionals polled, not enough to support the newspaper article's conclusion. The company presented its own statistics from other petitions signed by scientists in support of nuclear plants and from the results of a poll of engineers, 56 per cent of whom believed that nuclear power should receive immediate priority.

Predictions. Another misuse of numbers can occur when authors extrapolate from past data to predict future trends. This process is always risky and may ignore qualitative changes that could alter the results. The following passage from *Fortune* describes one such problem:*

THE CASE OF THE G.E. BABIES

The perils and complexities of birth forecasting were encountered last year, in rather extraordinary circumstances, by General Electric. Last January 14, G.E. announced that it would award five shares of its common stock to any employee who had a baby on October 15—the latter date being the company's seventy-fifth anniversary. Originally the company said it expected about thirteen winners. It arrived at this figure by applying a daily U.S. birth rate to its own 226,000 employees. This computation actually yielded a prediction of fifteen births; but a G.E. public-relations man thought it might be nice to trim the figure to thirteen, since the latter was the number of original G.E. investors. The mathematics suffered from more than public relations, however. G.E. employees, since they include no children and no one over sixty-five, are obviously a much more fertile group than the population as a whole. When this fact sank in, a company statistician made a new assault on the problem. He estimated that the size of an average G.E. family was 4.2. This meant that the total number of people in the G.E. families was close to a million. Applying the crude annual birth rate to *this* group, and dividing by 365, he came up with a new prediction of seventy-two births on the day.

As it turned out, there were not thirteen, fifteen, or seventy-two babies born to G.E. employees on October 15. There were 189.

Subtracting the company's highest expectation of seventy-two from 189 gives 117 "extra" babies. Where did G.E. go wrong? Well, among other things, the company made no allowance for the incentive provided by its own stock. This oversight, remarkable in a company that has had a lot to say about capitalist incentives, was apparently rectified by the employees. The latter not only enjoy having children but, it appears, they rather enjoy the idea of becoming capitalists. And they seem to have known a good thing. In a generally declining stock market, G.E. common rose, during the pregnant months, from 69 7/8 to 78 7/8.

Triviality. One final error should be mentioned: an author may simply push off trivia on his reader. He may state as a major finding something that is obvious or insignificant. He may marshal a welter of facts that seem impressive by sheer volume but are basically irrelevant to the topic at hand. They counterfeit for evidence. Playing the trivia game is great at the cocktail hour, but such materials don't belong in publications. They do appear, however, as one result of the pressure to publish. Trivia needs to be shown up for what it is.

*Reprinted from the January 1954 issue of *Fortune* Magazine by permission; © 1953 Time, Inc.

When one has read, noted, and checked the validity of an article, report, or book, he is ready to move pertinent information from it into his own research and his own report. In using this information one must make sure that the original author's rights to credit for his ideas, evidence, and language and his intentions for their use are not violated. One furthermore needs to distance himself from the literature, to sit back and ask, "What does it all mean?" One must analyze and digest his materials in order to solve his own puzzle.

NOTES

1. Edward E. David, Jr., "One-Armed Scientists?" *Science*, 189 (1975), 679.
2. Walter Sullivan, "4 Researchers Link U.S. Tornadoes to Driving on Right Side of the Road," *The New York Times*, January 25, 1975, p. 53.
3. "Cancer Toll Rise in '75 a Mistake," *The New York Times*, January 29, 1976, p. 17.
4. Boyce Rensberger, "Scientists Find Public Is Often Misled by Faulty Research Data," *The New York Times*, February 2, 1975, p. 32.

EXERCISES

1. Using the accessing tools and forms of documents mentioned in Chapter 2, find and assess information on one of the following controversial topics. You may want to summarize your findings in a review of literature (Chapter 13).
   - Pesticides
   - Cyclamates and saccharin (artificial sweeteners)
   - Diet pills
   - The ethics of biomedical research
   - Microwave ovens
   - Safety of nuclear power plants (predictions of accidents)
   - Nutritional value of homemade as opposed to commercial baby food
   - Red Dye No. 2
   - Scientific approaches to determining whether something is a carcinogen (cancer-causing substance)
   - The role of food additives in causing hyperactivity in children

2. Discuss Mark Twain's use of numbers in the following passage:

> In the space of one hundred and seventy-six years the Lower Mississippi has shortened itself two hundred and forty-two miles. That is an average of a trifle over one mile and a third per year. Therefore, any calm person, who is not blind or idiotic, can see that in the Old Oölitic Silurian Period, just a million years ago next November, the Lower Mississippi River was upward of one million three hundred miles long, and stuck out over the Gulf of Mexico like a fishing-rod. And by the same token any person can see that seven hundred and forty-two years from now the Lower Mississippi will be only a mile and three-quarters long, and Cairo and New Orleans will have joined their streets together, and be plodding comfortably along under a single mayor and mutual board of aldermen. There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of facts. [from *Life on the Mississippi*]

3. Analyze several annual reports to see if you can spot trends in the economy in general or in the growth and changing image of one company. Look either at several corporations' annual reports for 1 year or at the reports of one company over several years. Pay particular attention not only to the financial statement but also to the language used in the rest of the report. Any euphemisms? jargon? (See Chapter 4.) How does the company appeal to the stockholders? Visuals are usually abundant in annual reports. Assess their function. (You might want to look at Chapter 7 for further information.)

4. Write a memo to fellow students in your major field evaluating for them the five most significant journals in your field. Give a complete citation for each journal, tell where copies are to be found on campus, and discuss the general topics of articles, their reliability, and the audience each journal addresses (see Chapter 13). Justify your choice of the journals as "significant."

5. A National Driving Center survey shows that a person with a master's degree is 28 times more likely to fall asleep while driving than someone with a grade school education. Can you think of some reasons why?

6. Discuss any possible distortions in the following presentation of budget cuts. What is the effect of expressing the numbers as percentages of the year's budget?

> Amounts of 1976-77 reductions and percentages of the year's budget represented by the cuts are: Academic Affairs, $540,000, or .5 per cent; Educational Services, $50,000, or .7 per cent; Student Services, $25,000, or .7 per cent; Business and Administration, $145,000, or .7 per cent; and other services (President's Office, Trustees, Personnel Services, Public Affairs-Development Fund, and Budget and Resources Planning), $40,000, or .9 per cent.

7. Point out any errors in reasoning that occur in the movement from fact to generalization in each of the following pairs (see also Chapter 6).

F. More accidents occur when women are in charge of children in the home than when men are.
G. Men are better caretakers of children than women.

F. The paper industry has invested more than $2 billion in pollution control.
G. The industry is committed to clean streams and clean air.

F. AWK Airlines had the best on-time record of any line on its New York to San Francisco run.
G. The business traveler should fly AWK Airlines.

F. More doctors recommend Scrape toothpaste than any other brand.
G. You should use Scrape toothpaste.

F. Skewed Data, Inc., had profits 15 per cent higher in 1978 than in 1977.
G. Skewed Data, Inc., would be a good choice for an investor in the stock market.

F. Rabbits and mice are both rodents.
G. Rabbits and mice both eat carrots and cheese.

F. More men than women become architects.
G. Men are better suited than women to be architects.

F. Many military pilots have reported seeing UFOs.
G. UFOs must exist (since military pilots are trustworthy).

SECTION II

EXPRESSION

CHAPTER 4

Technical and Scientific Style

The Right Style

"When it's right, you'll know it." So ran an advertisement for beer. The same is true for writing—but with a twist. The *reader* knows when the prose is right. It is easy to read. The writer has a harder time because he has to choose right all the way—the right words, the right linkage of words into phrases and clauses, the right balancing of phrases and clauses in the right form of sentence. It is often hard to tell what's right and wrong. There is a machinery to writing. When it works, the reader doesn't even know it's there. He is simply aware of clear meaning. This chapter examines the machinery of style and presents strategies for good technical and scientific writing so that the writer can tell what's right and convey what he means—not the roar of machinery—to his reader.

The right style may be defined as expression that is appropriate to the writer, the material (the subject and purpose), and the audience.

THE WRITER

Before he writes, the writer recognizes his biases, limits, and capabilities. He judges his relationship to his subject and audience and defines the occasion for his report. He decides what he can do.

THE MATERIAL

Also before he writes, the writer gathers his material (Chapters 2 and 3) in accordance with the purpose of the document he will write. When his gathering is ended, he matches his findings to his purpose, eliminates unnecessary information, and selects and tests the evidence he will present. Many problems in writing are problems in thinking; the writer has to know well what he wants to say before he can say it clearly. The writing itself helps to clarify material for him. Certain forms of expression, as we shall see, are best suited to certain kinds of material.

THE AUDIENCE

Most important, the writer assesses his audience. The audience is the final judge of the appropriateness of style. Much of what a technical writer writes has been specifically requested—by an instructor, a supervisor, a client, or a sponsor of research. The writer must assess the audience's education, experience, motivation to read, and capacity to act. The writer adjusts the approach, the method of appeal, the arrangement of materials, the extent of discussion, the structure of sentences, and word choice to meet the audience's ability to understand. He strives to keep the reader receptive to what he wants to say. He writes for the reader—not for himself. (To remind himself of his audience, a market analyst who frequently wrote reports for the vice-president of an insurance company always kept an 8 × 10 inch glossy photograph of the officer on his desk when he was writing.)

The audience may be one person or may be several persons with similar or different purposes in reading.[1] A student may, for example, write a formal report outlining an irrigation system for a farmer and addressed to the farmer, but with the realization that an English instructor will evaluate it. A chemist in a research laboratory may report to a sponsor—for example, the National Institutes of Health (NIH)—about tests on certain drugs but have as other audiences his supervisors within the company and the drug manufacturers who may use the results in developing products. A computer specialist may design a computer system for a bank; his audiences would be his supervisors, the managers of the bank, and ultimately the programmers who would have to learn the new system. A consulting engineer may recommend a water storage system for a city. His report, addressed to the city engineer, may have to be approved by his company before it is sent to its destination. It may also be read by voters. The farmer, the NIH, the bank, and the city engineer are, in each instance, the *primary* audience; their needs must be satisfied first. But along the way the writer must also meet the needs of the *immediate* audience (the supervisors who will approve and route the report) and any *secondary* audiences who will be affected by the actions suggested in the report (the drug manufacturers, the computer programmers, and the residents of the city).

Many documents compete for a reader's time. The writer who wants to be read must make it easy for the reader. He has to be clear and efficient. Understanding words and sentences and using them well are critical tasks for the technical writer.

Words

Words are symbols, things that stand for other things. What the word stands for or symbolizes is its *referent*. When the referent can be recognized through one of the five senses, we say that the word standing for it is *concrete*. When the referent is not one detectable by the five senses, we say that the word is *abstract*. The goal in writing is to use the appropriate concrete words whenever possible and to make abstract terms clear to the reader through specific definition.

DENOTATION AND CONNOTATION

Words have two kinds of meaning. The *denotation* of a word is the meaning or meanings stipulated in a dictionary. The *connotation* is the more subtle meaning that becomes current as the word is used. Connotation is what the reader reads into the word based on his experiences. Words are both informative and suggestive; the connotations are the overtones. Words evoke emotional responses in the reader—they are, in effect, emotionally *charged*. In the following groups of words all three in each group have the same referent, but different connotations:

Negative (−)	*Relatively Neutral*	*Positive* (+)
broken	out of order	inoperative
vain	self-composed	confident
peddling	selling	marketing
clandestine	secret	confidential

Students and professionals should be aware of the connotations of what they say. Readers may find hidden between the lines a different message from what the writer intends, as in this statement from a student proposal: "I will be able to assure good coverage of the event because I have had various relationships with members of the press."

Sometimes a writer will use a positive-sounding word to cover a negative referent—or at least a referent he is uncomfortable discussing realistically. These positive words are called *euphemisms*. American English is particularly filled with euphemisms for bodily functions and the places where they are performed ("comfort facilities," for example). Scientists also use euphemisms, as when they talk about "sacrificing" an animal—when they mean kill, slaughter, electrocute. The laboratory act is hardly the sacred rite the term implies. It's best to be direct.

INVERTED PYRAMID OF ABSTRACTION

Abstract terms are especially likely to cause problems in meaning. They are so inclusive that they can legitimately mean different things to different people. What do these terms mean to you?

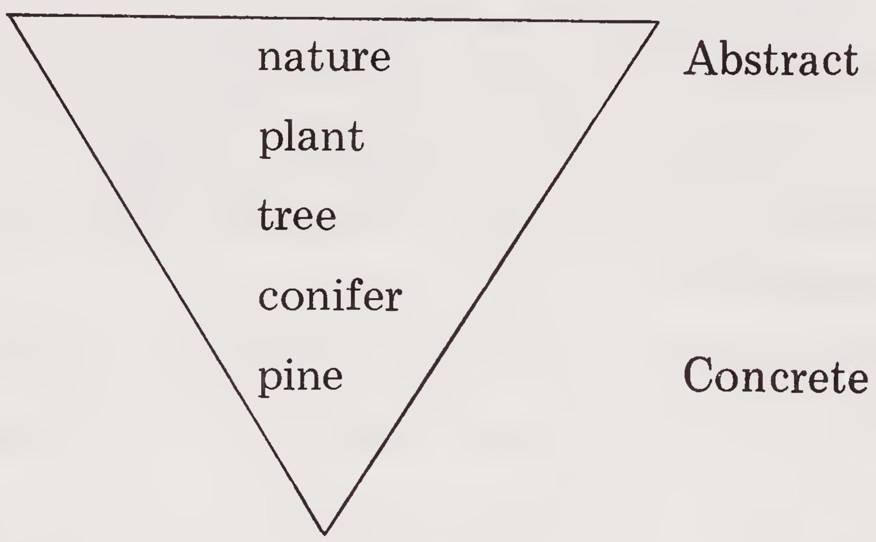
corporate responsibility

motherhood

sound fiscal policy

environment

The relationship between a word and its referent can be shown in an inverted pyramid:



At the top of the pyramid the term is abstract; downward the terms become more concrete. That is, the referents of the words grow smaller in number and more precise in their relationship to the words. Movement down the pyramid is really movement toward exclusion, toward the point (the apex) at which one and only one referent is named by the term. Whereas many referents may be covered by *nature* (beavers, crabgrass, clouds, and people), fewer are covered by *plant*, fewer still by *tree*, even fewer by *conifer*, and a relatively small number by *pine*. Of course, one could become even more concrete by adding modifiers to *pine* to locate a particular one: the 52-foot pine 9 feet from the northwest corner of the house on Moose Pond in Acton, Maine. Then one and only one pine could be meant.

For the technical writer the lesson of the inverted pyramid of abstraction should be clear: the possibility of confusion increases the higher up the pyramid one's word rests. The more concrete the term, the less likely it is to confuse the reader. A *mechanical fastening device* might mean a screw to one person, a stapler to another. A set of instructions ought to be specific.

Concrete terms add vigor, reality, and precision to prose:

Abstract	*Concrete*
facility	loading platform
transfer a liquid	syphon
connect	weld, bolt, screw
more than you think	$100
relatively long time	2 hours

The writer should be particularly careful to avoid overuse of the following terms (save them for when no other is possible): *aspects*, *factors*, *things*, *conditions*, *situations*, *areas*, *fields*.

CONTENT AND STRUCTURE WORDS

Words can also be classified by their grammatical function into content and structure words.

Content Words

- nouns (name persons, places, things)
- verbs (name an action or state of being)
- adjectives
- adverbs

Structure Words

- articles (*a*, *an*, *the*)
- prepositions
- verb auxiliaries (*have been*, *could have*, *will be*)
- conjunctions

- pronouns
- qualifiers (which modify adjectives and adverbs: *very*, *rather*, *wholly*, *quite*)

Content words do most of the work in the language. Structure words carry some meaning but serve mainly to provide transitions and a framework for other words. One good test for efficiency in prose is to see if the content words (verbs and nouns in particular) dominate. When structure words get out of hand, meaning dissipates and efficiency declines. Functionless qualifiers can simply be crossed out in revision. The writer should also remove excess connective phrases, the flabby tissue between ideas. Phrases like the following can usually be shortened (the structure words are italicized):

at the present [now]

during the time *that* [while]

in the event *that* [if]

in the neighborhood *of* [about]

with the object *of* [to]

due to the fact *that* [because]

owing to the fact *that* [because]

on the order *of* [about]

in the near future [soon]

subsequent to [after]

on a daily basis [daily]

by means *of* [by]

in the area *of* [about]

until such time *as* [until]

LEVELS OF USAGE

A scientist or an engineer writes for a variety of audiences: fellow specialists, managers, fellow students, perhaps the readers of *Scientific American* or *The New Yorker*, or an 11-year-old Boy Scout interested in gadgets. He must select words that match the expected vocabulary of the audience. He should be particularly careful in the use of technical terms. One technical writer asserts: "I'll defend to the death my right to discuss things electrical in terms electrical."[2]

Certainly. A physicist writing for a physicist may comfortably use *neutrino* or *linear accelerator*. No technical report or article can be written without technical terms. To do so would place an impossible burden on both writer and reader, as Mark Twain demonstrated humorously in this paragraph on how to hitch horses to a wagon:

> The man stands up the horses on each side of the thing that projects from the front end of the wagon, throws the gear on top of the horses, and passes the thing that goes forward through a ring, and hauls it aft, and passes the other thing through the other ring and hauls it aft on the other side of the other horse, opposite to the first one, after crossing them and bringing the loose ends back, and then buckles the other thing underneath the horse, and takes another thing and wraps it around the thing I spoke of before, and puts another thing over each horse's head, and puts the iron thing in his mouth, and brings the ends of these things aft over his back, after buckling another one around under his neck, and hitching another thing that goes over his shoulders, and then takes the slack of the thing which I mentioned a while ago and fetches it aft and makes it fast to the thing that pulls the wagon, and hands the other things up to the driver.

Technical terms are developed to match new perceptions and discoveries; it is said that more new words have come into being during the past 50 years than in the 900 years preceding the twentieth century. Many of these were introduced by scientists and engineers. Each term has only one meaning, agreed on by the experts. There are no synonyms for technical terms. Some terms have become part of the general vocabulary, like *digital computer*, *Rh factor*, *stereophonic*, *antihistamine*, *laser*. But others have not. The writer should judge the ability of his audience to understand such terms and delete highly technical ones from a popular account. Moreover, he should never use a technical term metaphorically: don't use *interface*, for example, when you mean simply *discuss*.

The level of usage should be consistent in any one document; unwarranted mixing can be a source of confusion—and humor:

> After going out on your property for a visual concept of the situation I have come up with three notions about taking care of your woodlot.

That *visual concept* doesn't match the casual tone of the rest of the sentence.

Jargon

Some authorities consider jargon a separate level of usage. It goes by many names: *gobbledygook*, *officialese*, *Pentagonese*, *bureauquack*, *sciench*, *engineerese*. A student often has to fight his way through it in reports and journals. He should not indulge in it in his own writing.

Here is a sample of jargon from a government agency:

> This proposal calls for a centralized resource to effect a comprehensive and coordinated network of services comprising early detection and prevention, appropriate intervention, comprehensive diagnosis, empathetic approaches to treatment and provision for a variety of appropriate treatment modalities, with the ultimate goal of preventing the occurrence or recurrence of abuse and neglect and alleviating its consequences when it does occur.

And one from a journal:

> But interleaved with these verifiable or at least falsifiable propositions, there is generally another set of propositions or tacit presuppositions that is essentially unverifiable and unfalsifiable, and yet is indispensable though it has its own history of rise and fall.

Each of these samples consists of one long (60 words in the first, 40 in the second), highly abstract sentence whose meaning can only be guessed at. The authors manage words to impress the reader rather than to express a meaning. Instead of being tailored to the rhetorical situation (see Handbook on *-ize* and *-wise* words), the language is automatic, without real content. The verbiage substitutes for thought.

At its worst, jargon is a device the writer uses to hide from the reader. Such language avoids the duty to say something that can be understood and thus perhaps criticized. It is used to disguise both a lack of understanding and a lack of results.

G. B. Shaw called professions—and by implication the language they use—conspiracies against the laity. James Thurber said that jargon was language "full of sound and fury, dignifying nothing." One engineering manager said reading a report filled with jargon was like running a steeplechase. The ambiguities and abstractions created obstacles that made deciphering a sporting proposition. But few people have time for such games.

In a technical report or article the language is indeed *instrumental.* It should convey one clear meaning—no games of chance. It should call attention not to itself but to its content. It should be precise and accurate (see the Handbook for a list of frequently misused words).

In 1733 Benjamin Franklin summarized the qualities of good writing in terms valid today:

> Good writing should proceed regularly from things known to things unknown, distinctly and clearly without confusion. The words used should

be the most expressive that the language affords, provided that they are the most generally understood. Nothing should be expressed in two words that can be as well expressed in one; that is, no synonyms should be used, or very rarely, but the whole should be as short as possible, consistent with clearness; the words should be so placed as to be agreeable to the ear in reading; summarily it should be *smooth*, *clear*, and *short*, for the contrary qualities are displeasing.[3]

Options in Sentence Forms

The writer chooses individual words and orders them in sentences. In a sentence he names a subject and then affirms or denies something about that subject in a predicate. He sorts out major and minor elements and controls emphasis—the effect he wants to achieve for the reader. Moreover, he aims, as Franklin said, to achieve smoothness, clarity, and economy in his sentences. The following pages highlight the options available to technical writers in the forms of sentences. A more detailed discussion of points of grammar and common errors in punctuation and sentence construction is contained in the Handbook.

WORD ORDER

In English, the order of words indicates the meaning. Note the difference between "John Jones hired Peter Smith" and "Peter Smith hired John Jones." The normal pattern is subject-verb-object (or complement):

S V O
People have different attitudes toward arterial disease and cancer.

S V C
The patient was delirious.

To achieve special effects or to avoid monotony, this pattern can be modified:

Toward arterial disease and cancer people have different attitudes.

GRAMMATICAL FORMS OF SENTENCES

Before we discuss the forms of sentences we need to define some terms:

- *Phrase*—a group of related words without a subject and predicate.

- *Clause*—a group of words with a subject and predicate. The predicate includes a *finite* verb—a verb that shows person, number, mood, voice, and tense.
- *Independent clause*—a clause that can stand alone as a sentence. Its meaning is complete.
- *Dependent clause*—a clause introduced by a relative pronoun (*who*, *whom*, *which*, *that*) or subordinating conjunction (*because*, *after*, and so on) that depends on another clause to complete its meaning.

Sentences may be of several grammatical types, depending on the number and relationship of independent and dependent clauses:

- *Simple sentence*—one independent clause
- *Compound sentence*—two or more independent clauses
- *Complex sentence*—one independent clause and one or more dependent clauses
- *Compound-complex sentence*—two or more independent clauses and one or more dependent clauses

The grammatical type of a sentence is significant for the technical writer because each type has particular functions. A simple sentence declares a fact. In a compound sentence the writer creates a pattern of *coordination*: the independent clauses have equal emphasis and weight. The pattern of the complex (and compound-complex) sentence is one of *subordination*: the independent clause states a central thought and then one or more dependent clauses qualify that thought. Because science usually concerns relationships (why or how something happened or what one thing did to another), subordination is an especially appropriate pattern for the technical writer.

Simple Sentences. A simple sentence has many advantages. It encourages brevity. It distinguishes assertions. Thus each can be analyzed separately. It is emphatic. It isolates action. It aids the reader by not taxing him beyond a single point or assertion. Some proponents see in simple sentences the salvation of prose. But overused, simple sentences are monotonous. They fail to show the necessary connections and priorities in the author's message. Amid other forms, however, the simple sentence offers a vigorous pattern for clear statement. (Every sentence in this paragraph is a simple sentence.)

Compound Sentences. Compound sentences contain two (or more) independent clauses joined by a coordinating conjunction (*and*, *but*, *or*, *for*, *nor*, *yet*) or by a semicolon. The clauses may supplement one another or show consequence:

> Spring is short, and thus most of the river flow and sediment influx occur during a remarkably short period.

> Scheduling is available for individual farms; well over 100,000 acres were scheduled this way last summer.

They may show contrast:

> To design a house with nature in mind is costly, but not to design for the site is costlier still.

They may show sequence or continue a narrative:

> The condensed water then runs down the cover to a collection device, and the concentrated brines are disposed of.

If overused, coordination can blur distinctions, fail to show proper stress, and thus distort meaning. Excessive coordination is often a problem in drafts; it reflects the "and-uh" quality of preliminary thoughts not yet formally structured. Revision discloses more precise links underneath the illusory balance.

Complex Sentences. The principal value of the complex sentence is its capacity to show relationships, particularly causality:

> Because soils and rainfall vary, the soil moisture in individual fields must be monitored.

Complex sentences are also handy for tucking in information, controlling detail, and tightening expression. Note the conversion of this compound sentence to a complex one:

> *flaccid*: DDT became available for public use in 1945, and it is the grandfather of the synthetic organic pesticides, and perhaps it is the best known insecticide.

> *taut*: DDT, which became available for public use in 1945, is the grandfather of the synethetic organic pesticides—and perhaps the best-known insecticide.

A dependent clause at the beginning of a sentence produces anticipation and prepares the reader for something significant:

> If we could once isolate the cause of the disease, then we could end the epidemic.

Clauses can also brush away the vagueness from an abstract noun and serve as the subject or object of a sentence:

What the scientific community should do is uncertain.

Compound-Complex Sentences. The fourth grammatical form is simply a hybrid of the two patterns that compose it:

Arterial disease is lethal when it affects the arteries supplying the heart or the brain; it now accounts for about 50 per cent of all deaths in the United States.

SENTENCE LENGTH

Each form of sentence may appear in various lengths. Control of the length of sentences is another option of the writer. Most measurements of readability are based on the assumption that short sentences are easier to read than long ones. Some authorities say that a sentence should not exceed 17 words; others, 34 words. Obviously, the proper length is dictated by the material and the skills of the reader (and the writer). A series of short sentences may bore the reader. Nonstop sentences may lose him. In a rough draft a writer rarely considers the length of sentences; he simply talks out what he wants to say. But in revision he should break up a succession of long sentences with a short one. Generally, complex matters should be assigned to short sentences, easy matters to longer ones. Whenever a draft shows three long sentences, the next should be short. The following sentence becomes more emphatic when divided:

Unfortunately, these resources are limited, and as their consumption has exponentially increased, their supply has dramatically decreased.

A writer who is having difficulty revising a sentence should not hesitate to chop it into two or more shorter ones.

DEEP AND SURFACE STRUCTURE

The same material can be assigned to different forms of sentences of different length. Here are some possibilities for one message (sentence types are shown in brackets):

specific statement: Storm doors help to keep a house warm. [simple]

negative statement: Without storm doors a house will not stay warm in the winter. [simple]

comparison: Houses with storm doors stay warmer in the winter than those without storm doors. [simple]

conditional statement: If storm doors are installed, the house will stay warmer. [complex]

prepositional beginning: Without storm doors a house will lose heat. [simple]

verbal: Lacking storm doors, a house will lose heat. [simple]

clause: What the house needs to help retain heat in winter is storm doors on each entryway. [complex]

These variations point to a further distinction in sentence construction between the deep and the surface structure of a sentence. The deep structure consists of the basic propositions the sentence conveys. These propositions, separately analyzed and stated, are

A house needs to be warm in winter.

Storm doors help keep out the cold.

Storm doors help keep in the heat.

A house with storm doors is warmer than one without them.

Heat can escape from a house.

Cold air can infiltrate a house.

The surface structure is the form in which these propositions are combined within the sentence. Often, when a sentence runs awry, the writer can begin his revision by sorting out the basic propositions and arranging them in different surface patterns. A writer uses different patterns to achieve different emphases, to lead into other sentences, and to meet the expectations of the reader.

Predication

Whatever the surface pattern of the sentence, the essential quality is proper linkage among words. The sentence must make sense. Verb ideas should be carried by verbs, noun ideas by nouns. The connection among subject, verb, and object must be clear and direct. Any interference leads to confusion. In particular, efficiency in sentences is a function of strong verbs. The writer's first rule is *guard the verb*.

Faulty predication results when false verbs are introduced and dissolve the action of the sentence. The following statement looks like a sentence, but of all those modifying clauses and phrases clustered around the subject none is a predicate:

> A method and system for the production of alumina Al_2O_3 from bauxite wherein the alumina is first extracted from the bauxite, by digestion with caustic soda NaOH, in the form of an unstable solution of sodium aluminate $AlNaO_2$ containing the bauxite "red mud" impurities in suspension, featuring a settling operation that produces "red mud" as underflow and the unstable sodium aluminate solution $NaAlO_2$ as overflow to be processed into aluminum hydrate $Al(OH)_3$ by decomposition and finally into the alumina by calcination, which settling operation is so conducted as to minimize decomposition of the aluminate in the settling tank or thickener, and thus minimize scale formation on the sludge raking structure and the need for shutdowns of the operation.

FALSE VERBS

The following sentence has a predicate, but it is too far from the subject to be easily understood; even the writer forgets his subject:

> The effects of body geometry and constraints on the propagation of stress waves through elastic media is discussed. [*are discussed*]

The writer of the following sentence changes subjects as he emerges from the relative clause. His main subject is *The study*, but he shifts (without telling the reader) to Dr. Harrison as the implied subject of the verb *has finished*:

> The study, conducted by Dr. D. Harrison, who is a consultant with several prison hospitals, has finished an extensive psychiatric study of 20 skyjackers across the country.

In this sentence the subject is not capable of the action stated by the verb:

> The purpose of this section of my report is to increase the fatigue strength of an already welded joint. [The report itself, even if jammed into the joint, could not increase its fatigue strength; the section can *discuss* how the strength might be increased, or the purpose of the investigation might be to determine how.]

The following predicates loop back upon the subject:

> The weight of the material collected on the filter paper is measured by weight. [How else can weight be measured?]
>
> Complication of operating procedures encompasses more than complexity of operation. [Subject and predicate are the same.]

FALSE SUBJECTS

In addition to false verbs, the writer needs to avoid the trap of false subjects. The apparent subject of the sentence must be the real subject. Sometimes the real subject lurks in a modifier:

> Input from first-line supervisors is probably the best source of information to aid in the identification. [The *real* source is locked into the prepositional phrase—the first-line supervisors. *revision*: The first-line supervisors are probably the best source. . . .]

Sometimes the writer thinks he has made one word the subject when in fact he has given another that responsibility. In the following sentence the writer thinks that *blades* is the subject:

> Inspection of the blades of such turbines in operation at the present time should be inspected for defects at the earliest convenient time. [The *blades*—not *inspection*—should be inspected.]

(For greater detail on agreement of subject and verb, see the Handbook.)

VAGUE REFERENCE OF PRONOUNS

A pronoun stands for a noun. Its noun antecedent thus must be clear to the reader. Writers should be particularly careful in using *this* at the beginning of sentences to refer to an entire preceding statement. The *this* may be clear, but it sometimes represents a writer's way of abandoning the complexity of his previous argument and hoping that the reader will supply the necessary interpretation. Such a hope is false. One must guard against sentences like the following:

> *This*, however, does not imply that *this* is the only stress-relief operation that is employed.

Relative pronouns (*who*, *whom*, *which*, *that*) should follow close on the heels of their antecedents and refer only to one word, not a clause:

Fatigue testing aims to design and construct mechanisms and structures in an economical manner that are less prone to failure. [The *that* seems to refer to *manner*; it is too far from *mechanisms and structures.*]

(See Section A in the Handbook.)

MISUSE OF THE PASSIVE

Extensive use of the passive voice is a characteristic of much technical and scientific writing. In a passive sentence the grammatical subject receives the action of the verb, and the actor or agent, if named, appears as the object of a preposition (usually *by*):

active: The customer bought 10 tons of steel.

passive: Ten tons of steel were bought by the customer.

The passive can be necessary—and effective—where there is no actor (as in an automated process) or when the actor is unimportant:

The cancers are divided into three broad groups.

The sludge containing the calcium sulfate and calcium sulfite is pumped from the settling tanks to small ponds where it is stabilized by the addition of fly ash and lime and partially dried.

The passive is also helpful when a writer wants to avoid accusing the person who is really at fault. A complaint manager might say, "The mower has not been lubricated according to warranty instructions," when someone complains about defects, instead of addressing the complainant with the less tactful, "You didn't oil the machine when you should have." The connotations are nicer.[4]

The passive keeps prose impersonal. Scientists and engineers use it to de-emphasize the actor and place the emphasis on the action because writing that includes an *I* or a *we* may not seem suitably objective.

But overuse of the passive increases the possibility for mistakes in grammar (especially dangling participles, because the subject is not expressed [see later]), starts trains of prepositional phrases, fosters roundabout expression, and encourages vagueness. The editor of a nationally known science magazine testifies that the passive is a defect in science writing; he says he eliminates at least 5 tons of passive verbs a month.[5]

The use of *I* is gaining acceptance for occasions when emphasis does indeed belong on the operator, where responsibility for an action needs to be defined, where (for example, in an introductory summary) the author wishes to indicate results and conclusions with no supporting data, and when the verb describes a mental process (*I learned*, *concluded*, *thought*, *deduced*, *decided*).

Many passive sentences are easily converted to active ones:

passive: The distribution along the ⟨111⟩ direction is markedly affected by temperature.

active: Temperature markedly affects the distribution along the ⟨111⟩ direction.

The active is more economical and direct. An occasional passive is good for variety, but long stretches of passives drain the life from one's prose. Whenever possible, the writer should keep his verbs active (see Section A in the Handbook).

SMOTHERED VERBS

The possibilities for transforming one part of speech into another add richness to the English language. But such variations also create traps for the writer. Vigorous writing depends on vigorous verbs, but often writers hide verbs under other parts of speech; they smother them.[6] In revision the writer should scout routinely for verbs lurking elsewhere in the sentence. Verbs can be smothered in several ways. One is the dissipated verb phrase built up with structure words and used where one strong verb would do:

make contact with [contact; *much better*, call *or* write]

make a purchase [buy *or* purchase]

give approval to [approve]

have a deleterious effect on [harm]

have a tendency to [tend to]

have an influencing effect on [influence *or* affect]

These phrases often center on such verbs as *make*, *get*, *is*, *have*, *do*, and *use*—verbs that themselves dominate scientific reports.

The second method of smothering is to shift the action to either the subject or the object. Such forms are seen frequently in technical prose: "Measurement of these compounds has been actively investigated since 1960." This shift to the noun *measurement* results, perhaps, from the author's concentration on the fact of measurement and his attempt to introduce that subject early in the sentence. Because nouns indicate designations, the author concentrates on the result of the testing, not the act. Moreover, the noun form may be used to link the sentence to a previous statement. Either form is correct, but placing the action in the verb increases the clarity of the action and the interest of the sentence and reduces sentence length.

Explanation of the variables is included. [*revision*: The variables are explained.]

Camouflaging the vehicle can be accomplished in several ways. [*revision*: The vehicle can be camouflaged in several ways.]

The forging of the blade was done properly. [*revision*: The blade was properly forged.]

Replacement of the failed fuel rod should be carried out. [*revision*: The failed fuel rod should be replaced.]

Mating of grizzlies takes place in the month of June. [*revision*: Grizzlies mate in June.]

There was a variation in weight. [This sentence uses a needless expletive *there was*; such a construction can often be changed to a direct statement. *revision*: The weight varied.]

A third method of smothering verbs is the creation of a static sentence with *is* when real action is intended:

At the end of the article in the conclusion is the only place where the authors try to stress the importance and applications of their research. [*revision*: The authors stress the importance and application of their research only at the end of the article.]

The origin of the fracture was at the dent. [*revision*: The fracture began at (or *originated at*) the dent.]

My previous experience with writing reports has been from researching and writing reports in other courses. [*revision*: I gained experience in researching and writing reports in other courses.]

The second type of animal is the type that is called herbivorous. [*revision*: The second type of animal is herbivorous.]

Usually, coolant loss is not for extended periods of time in reactors. [*revision*: Usually, reactors do not lose coolant for extended periods.]

A fourth method is the unnecessary use of the auxiliaries *may* and *can*. Much writing is weakened by the writer's expression of uncertainty when none need be accounted for. The subjunctive is also often misused.

> If you would be willing to join us, could you please inform me of several possible topics that you might address.

The writer means:

> If you are willing to join us, please let me know what topics you might speak on.

Only the final *might* is necessary; the other conditionals betray a cringing deference.

In the following example, the writer equates the subjunctive with the simple future:

> For the initial cut . . . the seed tree method would be [will be] best because it would [will] allow the tract to be regenerated by one species.

Modification

Proper predication assures a straight drive of energy from subject through verb to object. The writer needs to guard his verb and accept no false subjects. In addition, he needs to watch modifiers. Scientists and engineers frequently qualify their statements. Modifiers, however, are like weeds in a summer garden; they will take over the sentence if the writer lets them. He must sort out his priorities and express main ideas in main clauses, secondary ideas in dependent clauses, third-level ideas in phrases and single words. He needs to ensure the proper coupling of qualifiers and the words they qualify.

DANGLING MODIFIERS

The most discussed, and most popular, error in modification is the dangler—the word, phrase, or clause that floats in a sentence. It either modifies nothing or attaches itself, wrongly, to the nearest available noun. Participles—verbs made into adjectives by the addition of *-ing* in the present and usually *-ed* in the past—are particularly susceptible to dangling. This form has been the occasion for much witty (if unwitting) writing:

> The mouse was caught *using* the trap. [To catch the technician?]

> *Loaded* or *unloaded* the truck drivers arrive on time.

The material was bought from a vendor *impregnated* with radium. [poor vendor]

When *using* the D.C. apparatus, the fish can be observed swimming toward the positive electrode. [Do the fish use the D.C. apparatus?]

As in previous years, the evening concluded with a toast to the new president in champagne provided by the retiring president, *drunk* as usual at midnight. [The toast, not the retiring president, was drunk.]

But when danglers distort meaning they become a serious matter:

By *integrating* over the internal coordinates of the molecules, the isotopes have only slightly different effective potentials.

As it stands, the sentence says that the isotopes did the integrating. But they are incapable of the action in the participle; the experimenters did it. The modifier has nothing to attach to. To revise the sentence, the writer could bring in the actor:

On integrating over the internal coordinates of the molecule, we find [one finds] that the isotopes have only slightly different effective potentials.

Or the dangling phrase can be turned into the subject:

Integration over the internal coordinates of the molecules shows the isotopes to have only slightly different effective potentials.

Another example:

After reaching northern Alaska or the Arctic islands, breeding occurs in the lowlands.

To correct:

supply the proper subject: After reaching northern Alaska or the Arctic islands, the whistling swans breed in the lowlands.

expand participial phrase to clause: After the whistling swans reach northern Alaska or the Arctic islands, they breed in the lowlands.

rephrase participle to noun in prepositional phrase: On their arrival in northern Alaska or the Arctic islands, the swans breed in the lowlands.

One note: some participles are no longer considered adjectival but function as prepositions or adverbs. They may be accepted as modifiers of a whole clause (as long as the meaning is clear). Examples include some phrases beginning with *allowing*, *assuming*, *comparing*, *considering*, *failing*, *substituting*, *observing*, and the like, particularly surrounding equations in a text:

> Assuming $x = 2.4$ psi, the equation would read . . . .

MISPLACED MODIFIERS

Because the order of words in an English sentence contributes significantly to meaning, a writer may cause misunderstanding by misplacing modifiers. A modifier may squint in two directions:

> I've been trying to place him under contract here for 3 years. [Trying for 3 years? Or a 3-year contract?]
>
> The patient must be able to remember her dreams on the analyst's couch. [Where does she dream?]

Even professional writers sometimes let misplacements slip in, as did the physicist Sir James Jeans when he wrote, "It will be necessary to approach the problem of how a star emits its energy from the other end."

Another problem is assigning the qualifier to the wrong element; sometimes a modifier is assigned to the verb when it logically belongs to the noun (and vice versa):

> In the process, the heat released is mostly carried upward by the combustion products. [The author really means that *most of the heat* is carried upward.]

INVERTED SUBORDINATION

One final error in the use of participles, diagnosed by W. Earl Britton, is inverted subordination. This occurs when a writer fails to sort out the major and minor elements in the sentence and expresses as a modifier (a participle) something that ought to be expressed in a finite verb:

> Damage of surfaces by fretting is initiated by mechanical wear produced by the vibrating of the one surface on the other. [*revision*: Fretting occurs when one surface vibrates on the other.]
>
> Cracking is a serious problem causing reduction of strength. [*revision*: Cracking is a serious problem that reduces a material's strength.]
>
> The cutthroat trout is a spring spawner over gravel pits in riffles of streams producing 3000 to 6000 eggs according to weight.

[*revision*: The cutthroat trout, which spawns in spring over gravel pits in riffles of streams, produces 3000 to 6000 eggs according to the trout's weight.]

POSITIVE PARTICIPLES

Paralyzed by fear of dangling modifiers, authors sometimes simply refuse to use participles. One engineer in a large research laboratory, having for years struggled with dangling participles and deciding to do something about it, instructed her secretary simply not to type any *-ing* words in reports from her section. The result was a series of wholly unidiomatic and stilted reports. Participles are necessary. They express subordinate action, indicate simultaneity, and unify a sentence. They give a sense of a verb without the creation of a predicate and offer variety in sentence structure. But they must be kept in line. Here is a good example:

> The new mass of knowledge is still formless, incomplete, *lacking* the essential threads of connection, *displaying misleading* signals at every turn, *riddled* with blind alleys.[7] [Italics added.]

Parallelism

The series of participles in the preceding example illustrates a method of sentence construction useful to technical writers: parallelism. Scientists and engineers frequently make lists. Lists may appear within sentences or may be set off vertically in separate lines (one item per line, often numbered). Lists may consist of single words, phrases, clauses, or whole sentences. All items in a list should match logically, and no terms should overlap. Moreover, all items should be expressed in the same grammatical form. If used, an introductory term or phrase, an enumerator, sets up the logic of the list; the first item sets up the grammatical form. Expressions that meet these criteria are said to be parallel. Parallelism makes ideas stand out separately and shows their similarities and differences. The order of elements is determined either by logic (sequence in time, importance, or degree) or by rhetoric (the longest element last, unless a short one is introduced for emphasis).

Parallelism satisfies the demands of logic and appeals to the reader's sense of rhythm and balance:

> In the nineteenth century, proponents of domestic science *encouraged* proper training and education for its practitioners,

> *codified* standards of good practice, and *sought* status for professional housewives equal to that of other professionals, mostly men, in law, medicine, education, and engineering.

The italicized words here are grammatically equivalent (verbs in the third person, past tense) and make the elements they introduce parallel. In the following sentence the list consists of three nouns (italicized):

> It was not as a *surgeon*, as the *maker* of his great museum, or even as a *discoverer* in science that his greatness was revealed.

Classical rhetoricians regarded parallelism as a figure of speech, like metaphor and simile. The two sentences above demonstrate the effectiveness of parallelism as a figurative device. But to the technical writer parallelism is an important concept for the reason that he often fails to achieve it. Faulty parallelism results when a consistent grammatical form is not maintained in a list or series. The following list is not parallel:

1. Avoid overstretching.
2. Plastic wiper shoes can be used in compression-forming or radial-draw forming of aluminum alloys to avoid marring the surface.
3. Cleaning to eliminate abrasive dust particles.
4. Quality control.

To balance this list, each item could be made into an instruction beginning with an imperative:

1. Avoid overstretching.
2. Use plastic wiper shoes in compression . . . .
3. Clean to eliminate . . . .
4. Control quality.

Or each item could be made a complete statement with passive verbs:

1. Overstretching should be avoided.
2. Plastic wiper shoes should be used . . . .
3. The surface should be cleaned to . . . .
4. Quality should be controlled.

Another example:

> This overgrazing results in damage to the range, lower-quality livestock, and alters the numbers and distributions of other organisms, including small mammals. [*revision*: This overgrazing *damages* the range, *lowers* the quality of the livestock, and *alters* the numbers and distributions of other organisms, including small mammals.]

Faulty parallelism also occurs when the items in a series are not logically equal, even though they may be grammatically matched:

> Camber, twist, and bow can result from excessive rake of the shear blade, dull blades, improper blade clearance, *condition* of the work metal, or low blade speed. [All the items are of negative quality except *condition*, which is neutral; that must be changed to match. In addition, repeated elements in the series can be combined to sharpen the list. *revision*: Camber, twist, and bow can result from excessive rake, dullness, improper clearance, low speed of the shear blade, or poor condition of the work metal.]

In checking for parallelism, the writer should pay particular attention to the last item, which is often out of sequence in a draft:

> Sea water may consist of whatever type of water the ship is operating on—fresh, brackish, or sea water.

The last item in this list repeats the first one in the sentence; it is redundant because the writer is saying "sea water may consist of. . . sea water." In addition, *sea water* is not logically or grammatically parallel to *fresh* and *brackish*, which are adjectives. One assumes the last adjective should be *salt*.

To avoid faulty parallelism, the writer should make the enumerator of a list as specific as possible. For example, if the enumerator is a vague word like *things*, it is easy to violate the principle of parallelism:

> Three things may be used: matches, lighters, or by rubbing two sticks together.

Here the first two items are physical objects (expressed as nouns), whereas the third is an action (expressed in a verbal, *by rubbing*). Parallelism could be more readily attained if the enumerator were specific:

> Three devices may be used: matches, lighters, and sticks.

The technical writer frequently complains that in trying to maintain parallelism he is led to use the same words or phrases over and over and thus slips out of the grasp of faulty parallelism and into the grasp of repetition. The elements in this list are parallel, but the repetition is annoying:

> We are trying to achieve efficiency of cost, efficiency of labor, and efficiency of time.

The solution is simple:

> We are trying to achieve efficiency of cost, of labor, and of time.

Two special forms of faulty parallelism deserve mention: bastard enumeration and incomplete comparison.

BASTARD ENUMERATION

H. W. Fowler in *Modern English Usage* calls a list illegitimate when an author lines up items that cannot all follow from the "external operator" controlling the series.

> Improvements are sought in the valving to increase reliability, accessibility, maintenance, and allow application to all sizes of valves. [The external operator is *increase*; as the series stands, increase operates on reliability, accessibility, maintenance, and allow, but of course the writer means that the improvements would *decrease* maintenance. *revision*: Improvements are sought in the valving to increase reliability and accessibility, decrease maintenance, and allow application to all sizes of valves.]

> The value of this application is to prevent the entering of disease organisms, insects, and the further loss of water by evaporation. [*To prevent* is the external operator on all three items; *the entering* operates on *disease* and *insects*. An *and* would separate the elements more clearly. *revision*: This application prevents the entrance of disease organisms and insects and the further loss of water by evaporation.]

INCOMPLETE COMPARISON

The writer needs to compare like items or qualities of items. In addition, he is required, when he uses the comparative form of the adverb or adjective (*more*, *better*), to tell the reader both halves:

The rotation span of an unmanaged forest is much longer than a managed one. [*Span* can't compare with *managed one. revision*: An unmanaged forest has a much longer rotation span than a managed one.]

Often a farmer is able to plant his crops earlier in the spring because the field is dry. [Earlier than what?]

Clarity and Economy

The goal in choosing the right option in sentence construction—in linking up words and the facts and interpretations they stand for—is to be clear and economical.

CLARITY

If in his expression a writer allows any room for misunderstanding, he *will be* misunderstood. He must avoid ambiguity. The following statements are ambiguous:

A woman needs an education as well as a man.

Use this rifle and you'll never use another.

Instead of using his head, he stuck his hand in the press, chopping it off.

A writer intent on his own interpretation may not realize that his reader may respond differently. The good writer eliminates the possibility of misunderstanding.

ECONOMY

As we have seen, a writer distributes what he wants to say—his load of information—among the words and patterns of words in a sentence best able to carry it efficiently. Efficiency requires the writer to assign proper meaning: verb ideas should be carried by verbs, noun ideas by nouns. We say that a report is wordy when sentences are *underloaded*; that is, they do not say enough for the number of words they include. The words are used for their own sake, not for the sake of the material. Sentences are *overloaded*, too compressed, when they lack sufficient words to convey meaning.

Wordiness. Wordiness abounds. It abounds in both student and professional writing. But it is an easy fault to cure. Here are a few rules for being economical:

1. Use precise verbs. Don't smother verbs.
2. Keep active. Passives suck out the vigor while adding verbal fat.
3. Avoid vague, abstract nouns and jargon.
4. Eliminate needless structure words.
5. Get to the point. Eliminate most or all stretched-out sentence openers, especially expletives (*it has been found that*, *it can be shown that*, *there are cases where*). (See Section A.5 in the Handbook.)
6. Test for excessive coordination of ideas in compound and simple sentences. Delete unnecessary repetitions and insert suitable pronouns. Subordinate ideas that are secondary.
7. Avoid redundancies. The following redundant phrases crop up frequently in reports:

completely eliminate [to eliminate *means* completely]

collaborate together [how else?]

few in number [few]

estimated at about [to *estimate* means to make a close guess about]

component part [a component *is* a part]

background experience

past history [when else?]

oval in shape [how else can something *be* oval?]

hot in temperature

tensile in nature

red in color

they are both alike

adequate enough

a funding level of $100,000 in magnitude

final end

cheaper in cost

true facts

close proximity

The following sentence is wordy; its surface structure gets in the way of its basic propositions:

> It is assumed ordinarily that in computations of this character it is desirable to arrange the various elements of the problem in the form of a tabulation in order to ensure that avoidable errors are reduced to a minimum.

It means:

> Most engineers like to tabulate such data to reduce errors.

Compression. In their zeal to be concise, to save space, scientists and engineers sometimes eliminate too many words and crowd ideas too tightly in a sentence. A reader then will become annoyed at having to figure out the missing words himself. The writer is obligated to use enough words to convey his meaning. The following passage is too compressed (one of the writer's closest colleagues could not translate it):

> Every food web contains an even number of species in trophic contact (eating or eaten by or both) with an odd number. The number of species eating or eaten by an even number of species may be either even or odd. The number of species eating an odd number of species has the same oddness and evenness as the number eaten by an odd number. The number of species which eats an even number of species is similarly odd or even as the number eaten by an odd number is odd or even.

One common form of compression is the stacking of modifiers, especially other nouns, before a main noun: "a dacron-and-cotton preshrunk fabric." Such modifiers can be useful shortcuts. But they often fail to show the links among the modifiers. When they become too numerous they are like planes stacked up over an airport; they should be allowed to land—after the noun, where they belong. "Upward migrating intensity front hypothesis" would become clearer if a few more words were used: "the hypothesis that an intensity front migrates upward." "Limited particle production processes" is confusing. Does the writer mean "limited processes to produce particles" or "processes that produce particles of a limited size"? Supplying a few extra words would clarify the meaning.

Other contributors to misleading compression are excessive subordination within a sentence—too many dependent clauses and participial phrases—and strings of prepositional phrases. An overload of technical terms can also tighten prose too much, because technical terms, by definition, convey complex meanings. Lists and enumerations, which present information at high density, should not be overused.

There is no guaranteed route to a successful style. But if an author watches his words, predicates properly, emphasizes main ideas and keeps modifiers subordinate, balances all series or lists in parallel form, and strikes a middle ground between compression and wordiness, then he is well on his way. He—and the reader—will know his writing is right.

NOTES

1. This brief discussion is based on an excellent system of audience analysis developed by J. C. Mathes and Dwight W. Stevenson. See their *Designing Technical Reports: Writing for Audiences in Organizations*, Bobbs-Merrill, Indianapolis, 1976.
2. John Mitchell, "A Jargon for Technical Writers," *Technical Writing Review*, 4 (1957).
3. *Pennsylvania Gazette*, August 2, 1733.
4. For a witty discussion of the legal problems that can arise when an investigator uses the passive in his report and thus fails to assign responsibility, see C. P. Heaton, "Giacomo Ventresca, Moonshine Whiskey, and the Passive Voice," *Technical Communications*, Third Quarter, 1970, pp. 11-12.
5. Herman Struck, "Getting Active about the Passive," *The Good Writer*, 1 (1962), 1.
6. The term *smothered verb* is used by W. Earl Britton. See his perceptive article, "Efficient Writing," *The TWE Journal*, Spring, 1956. See also his "The Participle in Medical Writing," *The University of Michigan Medical Bulletin*, 25 (1959), 59-66.
7. Lewis Thomas, *The Lives of a Cell*, Viking, New York, 1974, p. 119.

EXERCISES

1. The following sentences are neither clear nor economical. Some contain errors in grammar. All can be much improved. Apply the suggestions discussed in this chapter to make these sentences right. Refer to the Handbook for specific corrections.

   1.1 The varying degrees in temperature also varies the density of the water causing it to stratify.
   1.2 By cutting off the animal's respiration, death soon follows.
   1.3 A situation such as a temperature inversion can be harmful to life and in some instances people have died.
   1.4 The use of single stub tuners is not too common in everyday use because manufacturers try to keep away from the use of tuners.
   1.5 To summarize the above results it is necessary to state that all the data points to the fact that the area already is an excellent grouse habitat.
   1.6 The reason being conventional tillage is destroying the soil's structure.
   1.7 In this paper the extent of insecticide use as dips, dusts, and sprays will be brief.

1.8 A studying of many deer wintering areas suggest that there are certain requirements of shelter that deer prefer to have.
1.9 After they had eaten the men left the building.
1.10 Rainbow trout was first introduced into Utah in 1883 where they have risen to the top game fish in the state.
1.11 These observations have concluded that between 1000 and 1500 animals spend the winter in this region.
1.12 The disadvantages of the mercury are: high cost, the necessity of operating at low temperatures, dies are expensive because only steel and cast iron can withstand the mercury, mercury is a toxic material that requires special handling.
1.13 Many forecasts of the future are made by people in the course of running a business which methods of making the forecasts are not clearly known to them.
1.14 This system demonstrates the low cost that computer-assisted programs can have and also with existing small computers you can combine them with color television.
1.15 Castings are cheap and thus very economic.
1.16 Liquid nitriding is also used, in addition to lowering the adhesion tendencies, a slight increase in surface hardness is obtained when nitrided.
1.17 Rock climbing for beginners should start with only a few essentials.
1.18 Amounts ranging 10¢, 25¢, 50¢ were asked if the visitors would be willing to pay.
1.19 The location of the plant with respect to the population centers will effect the pollution aspect of the water.
1.20 At this point there are several forces that exert themselves and try to distort the mold out of shape.
1.21 Control of distortion can be accomplished using the following ideas.
1.22 First we will visit the forest to obtain the information needed on the species present, accessibility, stocking levels, and taking soils tests.
1.23 The plots will be evaluated in three categories: turf quality by visual rating of turf density, color, and vigor; root penetration will be measured by removing soil cores after the final application and measuring the depth of the roots; water infiltration determined with infiltration rings.
1.24 Trees are in greater demand more than ever now.
1.25 This results from an insufficient number of man-hours spent in caring for the tanks and the type of filtration used.
1.26 Ideal would be a system in which only an initial effort and cost would be put forth to maintain it.
1.27 Lack of a practical storage battery that would deliver enough energy for a useful period or purpose.
1.28 This lack of complete information is present throughout the report.
1.29 Visibility is the capability of being displayed or not being seen.
1.30 The department sent their representatives to the meeting.
1.31 The effective use of these mechanisms require study.
1.32 It was found in these studies that the equipment was inadequate.
1.33 Can damage is substantially reduced, and the quality of the finished product (soup) is noticeably improved with the continuous cooker.

1.34 The material was bought from two vendors cemented together with epoxy.
1.35 When only two, my aunt took me to the circus.
1.36 Also the recovery of spent fuel is made.
1.37 A brief discussion of the periodic properties are given.
1.38 The causes were written in such a way that the question of cures for most defects were answered by simply employing a procedure opposite to that followed to produce the defects originally.
1.39 The technical report needs no dynamic start because the audience is always present.
1.40 In the case of unnecessary shrubs, poorly formed and diseased trees, chemical methods of killing will provide an economical way of disposing of these kinds of trees.
1.41 The petroleum industry is the greatest economic event ever to take place in Alaska.
1.42 The purpose of this report is to evaluate the requirements for the day care center, evaluate the building space and materials, selecting a staff, and organizing a curriculum.
1.43 The advent of family planning bringing a greater responsibility for the birth of each child and a growing realization that the number of children needs to be limited to keep the population growth level have also played a part in increasing interest in genetic counseling.
1.44 A review of our customers needs for such compounds was undertaken.
1.45 This report discusses the advantages of this pond, why the particular location was chosen, the exact dimensions, the amount and method of construction, and how to maintain the pond for years to come.
1.46 With the house close to the pond, maintenance observations will be easier to make and it may discourage some trespassers.
1.47 There are no other problems that encounter the underground filter system.
1.48 In a solar heating system the sun is used as the source of solar energy to heat the air that heats your building.
1.49 I conclude that the warm air system is more efficient than a fluid system because:
a. no possible leakage in the system.
b. its easier to maintain.
c. eliminates antifreeze needs.
d. ease in connecting to existing forced air heating systems, and
e. ease in storing heat.

2. Here are some examples of jargon. Can you translate them into sensible English? First define the particular problem (clichés, redundancies and circumlocutions, stretched-out connectors, weedy modifiers, undue abstraction, misplaced technical terms) and then strip down the sentence to say what the author probably meant.

It has been suggested by various engineering groups throughout this industry that departmental coordination could be enhanced by employing the use of additional departmental functional controls in order to facilitate familiarization with any malfunctioning in present routine.

The hope for future returns through the use of natural breeding is definitely one of the primary sparks that keep the purebreed breeder's candle glowing in hope of attaining future progress and success in the dairy industry.

This project intends to develop musicality in elementary school children through innovational instructional approaches utilizing multisensory channels through the natural elemental avenues of speech, drama, movement, rhythmics, singing, instrumental playing, and symbolization.

On the basis of personal judgment, founded in past experience conditioned by erudition and disciplined by mental intransigence, the incumbent integrates the variable factors in an evolving situation and, on the basis of simultaneous cogitation, formulates a binding decision (irreversible) relative to the priority of flow of interstate and intrastate commerce, both animate and inanimate. [from the U.S. Civil Service Commission]

Travel which is incident to travel that involves the performance of work while traveling. Simply stated, travel which is incident to travel that involves the performance of work while traveling means travel to a point at which an employee begins to perform work while traveling or travel from a point at which an employee ceased performing work while traveling. [from a Department of Justice publication titled "Travel Time Policy and Regulations"]

3. In *Politics and the English Language* (1945) George Orwell warned:

   It is clear that the decline of a language must ultimately have political and economic causes. . . .But an effect can become a cause, reinforcing the original cause and producing the same effect in an intensified form, and so on indefinitely. A man may take to drink because he feels himself to be a failure, and then fail all the more completely because he drinks. It is rather the same thing that is happening to the English language. It becomes ugly and inaccurate because our thoughts are foolish, but the slovenliness of our language makes it easier to have foolish thoughts.

   Apply the skills you have learned in this chapter, as well as the tools of analysis suggested in Chapter 3, to dissect a passage in some document you think smacks of "doublespeak," language that obscures or deliberately falsifies meaning. Politicians have frequently been accused of "doublespeak." So have military officers; one won an award from the National Council of Teachers of English for his statement to reporters in Cambodia: "You always write it's bombing, bombing, bombing. It's not bombing. It's air support." But they are not alone.

4. Make a list of the errors cited by your instructor in the reports you submit. Add to the list with each report; try to make sure that no item appears more than once—and that no additions are necessary by the end of the term.

5. As you read, keep track of the clichés that appear in the technical literature. What jargon is perhaps acceptable in conversation but not in writing?

6. Keep a list of the words you commonly misspell—and learn the right spelling.

7. Obtain a copy of a style guide published by a professional organization or journal in your field. What recommendations does it make concerning style?

CHAPTER 5

Organization

In a recent survey more than 1,000 practicing engineers were asked a simple question: "What is your biggest single problem in report writing?"[1] Twenty-eight per cent cited "organization and outlining." The next most frequently given answer was "lack of conciseness" (19 per cent), followed by ten other responses, each of which was cited by less than 10 per cent of the engineers.

The conclusion is clear: Organization is the most basic and frequent problem in the writing done by technical people. Other surveys and informal queries support this conclusion. Students faced with drawing together the threads of a research project into a final report experience the same frustrations as professionals. This chapter addresses these frustrations by showing how to organize material into finished forms, into paragraphs and whole documents.

Paragraphs

Selecting words and arranging them in logical and grammatical sentences, as discussed in Chapter 4, are the first critical steps toward clear expression. The next step is to shape individual sentences into the larger pattern of the paragraph. Some of the principles that guide sentences operate at the level of paragraph writing. But additional requirements must be met. The paragraph must satisfy the demands of typography, logic, and psychology.

Typographical requirements are the easiest to meet. In its simplest form a paragraph is a printing convention: indenting the first word of a paragraph (usually five or seven spaces in typing) makes an attractive page. Without indentions for paragraphs, a printed (or typed) page would be a black mass, unpleasing in appearance and difficult to read. Paragraphing breaks up the mass of words. Although effective paragraphs may sometimes consist of only a dozen words or so or may sometimes be as long as 400 words, most authorities advise that paragraphs be kept between 100 and 200 words. Length can vary, both to conform with the internal logic and to achieve variety in the pace of the argument and the physical appearance of the words set in type. Indeed, varying the length of paragraphs helps avoid monotony. The writer should avoid both a succession of short, choppy paragraphs and a dismal collection of long ones.

He should also strive to make the paragraph fit the format. Paragraphs that are a good length in handwriting may become too long when set in narrow double columns of type (like those used in a journal), too short in typescript or on a printed page of single-column type. The writer should visualize what his paragraph will look like to his reader.

The *logical* requirements of the paragraph are much less easy to identify and hence much harder to meet. Common sense applies. The last sentence in the paragraph should not contradict the first. A paragraph shouldn't go in the opposite direction from the one before or after it. Movement from generalization to particulars or from particulars to generalization should be consistent and uninterrupted. Parts should be fitted under the wholes to which they are related, and subparts should be clearly related to one another and to the larger wholes. We shall see more about the logic of the paragraph shortly.

Paragraphing requires attention to *psychological* considerations because the good writer is aware of his audience, its expectations, assumptions, and needs. The writer succeeds if he considers the audience and addresses it forthrightly. In paragraphing this means supplying the right kind and amount of information in an order acceptable to the audience—neither too much nor too little; neither too fast nor too slow. The needs of the audience must be borne in mind as one moves through the sentences that constitute a paragraph. The writer always asks: Am I giving the right information in the right order and at the right pace?

Recognizing the typographical, logical, and psychological factors that bear on the construction of paragraphs brings us a step closer to the difficult problem of stating exactly what a paragraph is. Here is a simple definition: A paragraph is a unit of composition centered on a single idea and its major components and arranged in a pattern that allows the point and subpoints to be easily and effectively recognized. This definition is general and abstract. Let us now see how a paragraph works. Here is an excellent example:

> (1) The line of argument in this book goes like this:
>
> (2) We can now build *machines* that will do almost everything for us from cooling a room in the heat of summer to blowing up the world. (3) We can arrange *these devices* in *technical systems* that in their operation profoundly modify and sometimes take the place of our natural environment. (4) The workings of *these systems,* if insufficiently controlled, certainly contaminate and may in time exhaust significant resources of nature. (5) *They* may well, also, create conditions that human beings, with all their powers of adaptation, cannot tolerate—at least cannot tolerate without the loss of qualities and authorities that have been assumed to be essential characteristics of human beings.* [Italics added.]

This paragraph introduces Elting Morison's *From Know-how to Nowhere: The Development of American Technology*, a work that argues coherently, and sometimes passionately, for an enlarged understanding of the effects of technology on daily life and for a national consensus on how best to use technology. The author's job in the opening paragraph is to state clearly his major argument so that he can proceed to a detailed discussion of how technology affects Americans in specific ways. His goal is to guide the reader through a wealth of information in order to make a point; he therefore must announce his point early and clearly.

The paragraph contains 117 words in five sentences. It's a good length for an opening paragraph: not so long that it will bore the reader at the outset but long enough to make a serious point and use supporting evidence to make that point persuasive. Sentence (1) introduces the subject of the paragraph (the thesis of the whole book). It tells the reader what the paragraph will do. Sentence (2) declares two facts; it is detailed, concrete, and yet relatively simple.

*From Chapter 1, "Some Introductory Remarks," in *From Know-how to Nowhere: The Development of American Technology*, by Elting E. Morison, © 1974 by Basic Books, Inc., Publishers, New York.

Sentence (3) moves out to a broader fact. Whereas sentence (2) discusses machines, sentence (3) says that *these devices* (a linking phrase) are built into *systems.* Sentence (3) also enlarges the meaning of the facts cited by leading toward a generalization or value statement (*that . . . can profoundly modify*). Sentence (4) is linked to sentence (3) through the phrase *these systems*, and it too has forward motion: we now learn that systems can *contaminate* and *exhaust* nature. The last sentence of the paragraph broadens the implications of the previously discussed facts by stating that nothing less than the loss of humanity is implied by the improper use of technological systems.

Look again at sentences (2) and (5). We have moved in a short space from two technical systems to the moral judgment that poorly used technology threatens to destroy us. That is a large movement, but it has been made effectively because the author carefully built one sentence upon another, linking each with repeated phrases. He has taken us from fact to judgment in about 100 words because he attended to the needs of both logic and psychology; facts are logically related and built into a pattern designed to convince.

THE GATHERER

One reason for the success of this paragraph is that the reader always knows what it is about. This is a simple quality often neglected by writers. To be unified, a paragraph must be controlled. The means for achieving control is called a topic sentence or a core sentence, a one-sentence statement of the point the paragraph is to make.

Robert Frost called control devices "gatherers": each assures that a single message is coming through. Some gatherer is necessary for every paragraph. The writer may state his point boldly or may be more subtle. For example, a student writing about pollution in Lake Erie might begin a paragraph with a topic sentence: "Although Lake Erie remains polluted, much progress has been made in cleaning up the lake in the past 5 years." Within the paragraph he would develop both parts of the statement—that pollution is a continuing problem and that some progress has been made in overcoming it. The same statement could be held in the writer's mind but not directly expressed in the paragraph. It would still control the selection and presentation of information, but the paragraph might begin with facts: "Five years ago the Jones Laboratory stated that the level of pollution in Lake Erie was unacceptable. Last summer the laboratory performed the same tests and found that pollution was lower but still unacceptable." The paragraph would go on to develop these points in detail. The reader would quickly see that a unifying idea—

the topic sentence given in the first example—governs the paragraph, even though it is not written out as a sentence. Written out or not, the statement serves as the "gatherer."

Beginning every paragraph with a topic sentence is repetitious and therefore boring for the reader, although it does have the advantage of helping the writer to control and unify his paragraphs and the reader to skim the document. In a first draft a writer might write a straightforward topic sentence in each paragraph and then reword the paragraph in revision to reduce the repetitiousness of form; if he does this, he must make certain that something "gathers" the paragraph together.

STASIS AND MOVEMENT

A paragraph unified on a single point and meeting the requirements of typography, logic, and psychology generally succeeds; it conveys its message to its intended audience logically and persuasively. But the more conscious one becomes of these needs, and the harder one works to meet them, the more one realizes that a good paragraph must do two apparently contradictory things at once. It must stand still and move. It stands still in that it is unified and adequately treats the essential aspects of one point. It moves in that it begins at one point and develops toward another. In the preceding Morison paragraph each sentence leads logically and convincingly to the next one, and by the end of the paragraph the reader is conveyed from a simple fact to a value judgment about the implications of that fact. This is movement. And yet the paragraph remains static because it centers consistently on one point: the thesis of the book.

In technical writing the need to keep paragraphs moving while they stand still, developing them *toward* something while they remain focused on one point, is especially acute. Examine this paragraph from Cairns's "The Cancer Problem":

> The cancers are divided into three broad groups. The carcinomas arise in the epithelia, the sheets of cells covering the surface of the body and lining the various glands. The much rarer sarcomas arise in supporting structures such as fibrous tissue and blood vessels. The leukemias and lymphomas arise in the blood-forming cells of the bone marrow and lymph nodes. These three words—carcinoma, sarcoma and leukemia—are so entrenched in everyday usage that they must be mentioned, but I do not mean to imply by their use that there are three basically different forms of carcinogenesis or that the three kinds of cancer have different prospects for prevention and cure. That kind of information can be obtained only through a finer system of classification.*

**Scientific American*, 233 (November, 1975), 64.

The gatherer for this paragraph is the initial assertion that there are three broad groups of cancer. Each of these groups is defined and illustrated. Thus the paragraph is unified. Yet by the end of the paragraph the reader knows that this form of classification is inadequate because it seems to imply three different causes that require three different kinds of treatment. The writer wishes to refute, or at least refine, that notion. Hence by the end of the paragraph he is moving toward another paragraph; the next one presents another, more refined system of classification. The paragraph both moves and stands still; it fully treats its point but leads to another one.

TRANSITIONS AMONG PARAGRAPHS

Paragraphs exhibit movement because, although they are internally unified by a single point, they must lead to other paragraphs. We call this movement *transition*. The transition is the bridge across which the reader moves from one paragraph to another. Certain mechanical devices help make transitions smooth. A paragraph can begin with the repetition of a phrase or word used at the end of the preceding paragraph: *These devices*, *Such ideas*, *The reaction thus achieved*, *But these conditions*. It may use a logical signpost to bridge the gap: *Therefore*, *On the contrary*, *Despite these statistics*, *Considering this fact*, *In addition*. Devices such as these, if used carefully rather than automatically, ease the reader from paragraph to paragraph and link the ideas expressed in these paragraphs into a coherent whole.

CLASSIFICATION OF PARAGRAPHS

Paragraphs can be classified in at least four ways:

1. By length
2. By function
   - introductory
   - supporting
   - transitional/structural
   - concluding
3. By method of development
   - restatement
   - example
   - definition
   - analogy
   - illustration

- statistics
- anecdote
- testimony

4. By order
   - natural (chronological, spatial)
   - logical (classification, general to particular, particular to general, and so on)
   - psychological

When one writes a paragraph, he is of course seldom so aware of these classifications that he consciously remarks to himself, "I will now write a short supporting paragraph using testimony and ordered from particular to general." We know what we want to do—at least we should. And we know what the content of the paragraph is to be: statistics, examples, testimony, and so on. In the revision stage we become more conscious of the paragraph types and can use them to aid in creating out of first drafts the strong, unified, purposeful paragraphs of good writing.

The following paragraph reveals the importance of such classifications:

> Winds are another factor to be dealt with in site selection. The site should be sheltered as much as possible from winter winds that come out of the northwest. The leeward sides of hills are instrumental in this protection. Wind speed is highest at the crest of a hill, whereas low velocity prevails on the leeward side in the wind "shadow." These winter winds are formed by cold air masses spreading out of the arctic. They vary greatly in speed, and tend to travel down the depression in the hollow. Conversely, the site should be open to summer breezes that tend to come from the southwest. These breezes are instrumental in cooling and ventilating.

This paragraph is moderate in length, just over 100 words. It serves as a supporting paragraph in a student architect's report on the selection of a building site. Development is through example and illustration, and the order is from general to particular. The core sentence is the first and says that winds are a factor to be dealt with, a general statement. Following sentences take up relevant particulars.

The writer of this paragraph did not say to himself, "I shall produce a moderate supporting paragraph developed through example and illustration and moving from the general to the particular." But if his paragraph had started to wander, in revising it he might well have talked to himself in this manner to determine how the paragraph could be salvaged. The following paragraph does go astray:

> This comparison between the normal typewriter and the word processor shows that the cost difference between the good and poor typists on

the electric typewriter was $0.50 per copy, where the difference was only $0.27 on the magnetic tape typewriter. The poor typist's waste of time and salary is minimized by use of the word processor. Besides increasing her productivity, the word processor creates an organizational structure that upgrades and diversifies jobs that were lacking in both prestige and advancement potential.

This is a short supporting paragraph, developed with statistics and moving from the particular (comparative costs) to the general. However, the paragraph lacks unity, and we can locate the point at which it fails by recognizing in the development plan from particular to general that the last sentence introduces a wholly new subject not appropriate to this paragraph at all. Because of its transitional nature, however, the last sentence is potentially useful as an introductory sentence for a new paragraph.

INTRODUCTORY, SUPPORTING, AND CONCLUDING PARAGRAPHS

Of special importance to the writer is the distinction made in the classification system among introductory, supporting, and concluding paragraphs. Each kind plays a different role in the report, proposal, or article. Even a memo of three paragraphs can be analyzed according to these types. The introductory paragraph should, of course, introduce. It carries the reader from his state of relative ignorance toward knowledge of what the report is about, how it will proceed, what its methods will be. The introductory paragraph interests the reader, establishes a context for the following materials, defines terms, and announces a procedure. It may be thought of as a contract made by the writer with his readers; the writer assumes the obligation to do certain things for the readers in a certain way. The introductory paragraph is usually the most general, least technical paragraph; it eases the reader into the topic and declares the writer's position.

The supporting paragraph (or, usually, paragraphs) is more technical, more detailed; in it the writer establishes specific aspects of a topic, provides concrete and detailed discussions or description, works out arguments—in short, he supports the basic thesis announced in the introduction.

The concluding paragraph ties together what has gone before. It focuses disparate details on a single point (the same one set out in the introduction), which it now directs to the reader redefined by the supporting paragraphs that have dispelled the reader's ignorance. As at the beginning, the writer at the end is especially conscious of his audience, anxious to meet its needs by bringing together his arguments and facts in a conclusion that will speak directly to the reader.

Some mechanical devices may assist in this. Phrases like *As we have seen*, *As the above proves*, *In light of these facts*, and *Because of the analysis given above* help draw together the strands of argument and summarize them in one spot for the reader. But these devices are mechanical. Overused, they irritate by seeming to make the conclusion too pat and facile.

The writer can create effective beginning, middle, and ending paragraphs if he bears in mind at all stages the reader's needs. The introductory paragraph should bridge the gap between the reader's relative ignorance about the topic and the writer's firm knowledge; the supporting paragraphs develop from that knowledge and supply the persuasive details necessary to uphold the major point; the conclusion is another bridge moving the reader from his newly acquired education about the topic toward a new position of his own, from which he can act on the information gained. At every point it is the reader's needs that govern the selection and execution of paragraph forms and types.

General Organization—A Point and a Plan

Introduction, support, and conclusion—but introduction, support, and conclusion *of what*? The types of paragraphs make sense only in the context of some larger whole, a specific proposal, memo, report, or article. Although occasionally technical writers may produce only a single paragraph (for example, a definition of a term or description of a mechanism) that someone else will fit into a larger piece of writing, on-the-job as well as class assignments usually require the technical writer to compose many paragraphs into a completed whole. To do that, the writer needs two things: a point and a plan. He must know what he wants to say, and must have a scheme for saying it.

PATTERNS OF ORGANIZATION

The writer facing the task of organizing a whole composition must finally choose from among the three basic patterns: the natural, the logical, and the psychological.

Natural order is that imposed on the material (and on the author) by the subject of the writing. Chronological (according to time) and spatial (according to space) are the two basic types of natural order. A memo reporting to one's supervisor on a trip might well follow chronological order: when I left, how I got there, what I did, how and when I returned. An architect reporting on a building that is to be restored might describe the structure from the ground up, from left to right, from east to west, from exterior to interior. Time and space dictate the ordering of details in these examples. The writing duplicates in its gross organization the subject being written about.

In *logical order* the writer imposes the pattern. He may classify the parts of the whole, distinguish cause from effect, relate particulars to generals, compare and/or contrast. A site inspection might suggest a report on a building using spatial order. But the architect might instead adopt a logical pattern in which he ignores (in the writing, not in the inspecting) the obvious spatial pattern and proceeds with his discussion according to certain imposed criteria: discussion of the elements in the building not subject to renovation and then of those that can be renovated; or discussion of the desirable features of the structure that are worthy of preservation and then of those that can be destroyed and replaced; or discussion of those parts of the building whose renovation would be inexpensive and then of those whose renovation would be expensive. These are examples of how the writer classifies, imposing his order on the subject.

Although natural and logical orders seem the most likely ones in all types of writing, in technical writing a third form, *psychological order*, is frequent—although perhaps not frequently recognized. This is true because the technical writer, more than most writers, must meet specific audience needs. He is thus critically aware of rendering his materials in an order appropriate to the audience. Psychological order is achieved when the audience's needs impose a pattern on the material.

In the case of the architect writing a report on a building, we saw that he must make an initial choice between natural and logical ordering. We can complicate his situation to illustrate psychological order. Let us suppose that the architect's study is sponsored by a local historical society. To this group the major fact about the building under study is that George Washington once slept in one of its rooms. To the architect this fact may be of the least possible consequence. What does George Washington have to do with structural qualities or architectural ornaments or façade? But knowing that his sponsors appraise the case quite differently, the architect might decide to begin his report with a description of the room in which Washington slept and a statement about the significance this lends to the building as a historical artifact. He might then proceed to describe the building according to the order of space or the order of logic. An initial statement about the Washington room will please his audience and ease them into reading the more technical parts of the report.

Another example may clarify the patterns and the principles on which a choice is made. A metallurgical engineer has been assigned to write a report about the collapse of a bridge. After studying the problem, gathering evidence, reading relevant technical literature, he sits down to compose his report. What order to follow?

He might decide to proceed chronologically. In this case he might sketch out the following plan for the report:

1. History of the bridge
2. Its failure
3. My investigation
   —site inspection
   —laboratory analysis of failed members
   —reading of other failure analyses of similar structures
4. My conclusions
   —bridge failed because of corroded chain links
   —don't use that material in the future

The report duplicates in its general pattern of organization the steps through which the engineer proceeded.

A logical order would be somewhat different:

1. General reasons for failures
   —stress
   —corrosion
   —collision
2. Description of the failed bridge
3. Aspects of this bridge that fit the general reasons in point 1
4. Conclusion about this failure
5. Recommendations to avoid future failures

In this pattern the writer has imposed an order on the events and facts of the case he is studying. He generalizes his thinking: Why do structures fail? What conditions were present in this particular bridge? What conclusions and recommendations can I draw from matching these conditions to the generalizations? Whereas in the chronologically organized report the specific bridge is discussed at the outset in two sections, in the logical organization this particular bridge is not mentioned until point 2, after a discussion of general matters.

The same material might be developed in a psychological form. Here the plan might look like this:

1. Who or what is to blame for this collapsed bridge
2. Why: use of improper material
3. Discussion of candidate materials available to initial designer, with relative advantages and disadvantages
4. Recommendation about how to avoid future failures

In this pattern, the cause is identified early, and then particulars are discussed in a logical order. The reason for assigning blame at the outset here is, we shall suppose, that the engineer has been hired by an insurance company to determine what caused the collapse and therefore who must pay for damages. The insurance company may eventually read the complete report, but its first need is to know who is responsible. The writer's awareness of this need imposes on his rendering of the information a pattern quite different from the fully chronological or fully logical.

As these examples illustrate, natural, logical, and psychological orders can effectively be mixed. But the writer must always be aware of what order he is using and why. Each has advantages and disadvantages. The choice of pattern—or the mixing of several patterns—is governed by the materials being discussed, the purpose of the discussion, and the needs, implicit or explicit, of the audience.

Whatever form of organization he selects, the writer must always have a point and a plan that makes the point clear. Different forms of technical writing demand different approaches. A proposal, for example, is more likely to use a psychologically determined plan of organization than a report for the simple reason that the proposal is a selling document that tries to persuade its specific audience. Letters are also especially subject to psychological considerations: If you are applying for a job, you want to be certain to get your reader's attention and sell him on your qualifications.

NO POINT, NO PLAN

The lack of a clear plan is apparent in the following description of a process, "The Growth of a Soybean":

> The study of plants had its start when the land-grant colleges were first being formed. Before that time there was very little science to the process of plant growth. Agronomists or plant scientists observed that a plant did actually grow better when a fish was placed with the seed at planting time.
>
> I think most of us now know that the reason for this was the nutrients

provided by the decaying fish. But do we understand the process that makes a plant grow? How about a soybean, for instance? A soybean is an agricultural plant that is being used for not only farm feeds, but for the making of synthetic fibers, plastic, and meatless food.

The seed is made of protein, oil, and carbohydrates. All of which are very important organic products. These materials are used for energy when the seed starts to grow. Inside each seed is a small part called the germ, which is actually alive. If kept away from moisture, the seed will still be capable of growing after many years.

If you place a soybean between a couple layers of damp paper towels in a warm spot, the growth process will start. The seed will absorb water, swell, and finally split open.

The soybean is a dicotyledon, or two-part seed. In between the two halves is the germ that grows. The germ obtains its energy from the cotyledons, which contain the proteins and carbohydrates. The root comes out, and directed by gravity, heads downward. When the root has found a place to support itself, the plant starts rising toward the light and unfolds. By this time, very small leaves have formed between the two cotyledons, and with the addition of sunlight, water, and nutrients from the roots, will make its own food. The cotyledons have given up all their food, and fall off. In a few weeks, the world has another plant.

This process, though complicated on a microscopic and chemical level, is physically quite simple.

The confused reader's first response to this composition is frustration: what is the point? Several rereadings reveal that the piece aims to describe how soybeans grow. A properly organized composition should not have to be read more than once to discover the basic point. This one fails to convey its message because it neglects the reader's basic right to know—early in the discussion—what it's all about. The description of the process of growth is delayed until the fifth paragraph; unintentional suspense is created as the reader is taken through a series of false starts in paragraphs about (1) the history of agricultural research, (2) a definition of soybeans and statement about their significance, (3) a discussion of the chemical composition of soybean seeds, and (4) a short course in how to germinate soybeans for the windowsill gardener. By the fifth paragraph the reader is fatally confused. The writer has succumbed to the urge to tell all he knows about soybeans, even when that knowledge is irrelevant to the purpose at hand. He blends a logical and psychological ordering in an uncertain mix that meets the needs of neither.

This description can be salvaged. The writer must first decide on the point (how soybeans grow) and then devise a plan to convey that point. He would probably wish, in revision, to eliminate most of the first and second paragraphs, place the last paragraph first, and reorder the information of the third and fifth paragraphs into several logically related paragraphs. (In a popular article he might even begin with the fourth paragraph, which attracts the reader's attention; in a technical composition for a specialized audience the fourth paragraph is irrelevant.) Effective revision must be based on an awareness of the audience's needs and a commitment to meet those needs through clear development of the basic point.

As this composition illustrates, poor organization is frequently the result of the writer's ignorance of what he wants to say. Once he has identified the message clearly, he can proceed to plan his writing so that the point clear in his mind becomes equally clear on the page.

OUTLINING

Planning the presentation of information in any piece of writing ordinarily requires *outlining*. This word has bad connotations for many people, including professional writers. No doubt, their distaste stems from days of tedious discussion of outlining they endured in some high school English class. Typically, that discussion centered on the proper use of Roman numerals, capital letters, Arabic numbers, and lower case letters. You probably learned to proceed this way:

I.
    A.
        1.
            a.

This magic formula, you were told, would produce equally magic results, bringing order to the chaos of thoughts in your mind. You might also have been lectured at some length on the difference between topic outlines and sentence outlines: the former consist of arrangements of single words or phrases representing basic points and subpoints; the latter include full sentences that eventually appear as parts of the final compositions.

What is wrong with this approach to outlining is that it focuses on the outline itself; it makes the outline an end rather than a means. This is fatal. The outline should be thought of as only a tool, a device to help the writer sketch out his plan. Properly understood, the outline serves critical needs. It allows the writer to devise, work out, and then accept or reject alternative plans for the structuring of materials. An organization that appears defective in outline form can be dropped in favor of a more effective plan *before* the text even begins to emerge. It is enormously time consuming to write out one full composition after another in search of the most efficient scheme of organization. The outline can be reviewed and tested, modified, refined, scrapped, redone; as much time as this takes, it is bound to be less than that required to write a whole report in draft form to represent each different organizational approach.

Another advantage of outlining is that it imposes control on the writer. The author of "The Growth of a Soybean" lived with the danger of total freedom. He refused to limit himself. An outline is a limiting device. It continually admonishes the writer to keep on the track, to avoid telling more than is necessary, to discipline his expression, to follow a predetermined sequence. Free play of the imagination is crucial in research, but once the research is complete and the results are ready to be conveyed to someone else, a check on total freedom becomes essential. With a strong outline beside him as he composes, the writer can resist the urge to wander off into unprofitable (although perhaps appealing) side streets and maintain firm control over the material that he must effectively organize toward the communication of his points. This of course does not mean that the outline is inflexible; like a blueprint that can be changed during the building process, an outline is always subject to modification. But in its general form it does serve to limit the writer and to structure his work.

To avoid false starts, and thus save time, and to discipline himself during the writing stage, the technical writer is therefore strongly advised to adopt some form of outlining. But I-A-1-a? Topical or sentence? The form really doesn't matter. What matters is that the writer devise a form adequate to meet his needs, something he feels comfortable with. This section of the textbook on general organization emerged from the writer's mind in the form of the following sketchy plan:

1. Intro: the need to have a point; then a plan
2. Logic and psychology
   —patterns of development
3. Outlining

As you are aware, that plan was modified to read something like this:

1. Intro: the need to have a point; then a plan
   —logic and psychology
2. Patterns of development
   —natural

—logical
—psychological

3. A negative example: growth of a soybean

4. Outlining

The second plan represents both refinement (moving original point 2 to a subpoint under point 1) and addition (the specific types of development listed under point 2 and the new point 3). Thus the original scheme was drastically revised.

In this informal method of outlining, major points are listed, qualifications or explanations are added after colons, and subpoints are included underneath main points and set off with dashes. Abbreviations are freely used. Fine points of grammar and style are ignored.

You may have been told by an English teacher that an outline should be so complete and clear that someone else could pick it up and, with the help of supporting note cards, write out the draft that the outline represents. The outlines of this section presented herein fail that test miserably. No one but the writer could convert the sketchy outline into prose. And that is the point: The outline rarely serves for "someone else"; it's for the writer—it's his code, his unique plan.

The technical writer is sometimes asked to prepare an outline of a report or proposal to which many members of a company will eventually make contributions. In such a case the writer must, of course, create a polished and comprehensive outline easily understood by those who will add to it or will follow parts of it in preparing individual paragraphs or sections of the final composition. Only in such cases is the outline for "someone else." In most instances, especially in class assignments, it is the writer's private tool, and within his privacy he may use any form he wishes.

Because outlines are private tools, pragmatically judged according to the success of the documents they produce, a student may properly resent any advice about how to design an outlining system. We'll risk that. Here are some suggestions.

1. Cultivate the habit of "outlining in your head." Some people call this activity "brainstorming." Take time to think out the organization of a piece of writing you're assigned to complete. In the shower, driving to work, stirring your coffee, let the major points of your project swim around in your head until they achieve some form, however loose. In this way you can identify the major point or points you will need to make, the subpoints that must be subordinated to them, and the general scheme you will follow when you finally produce your working outline.

2. Jot down the ideas generated in this procedure. You're not concerned with logic or the niceties of language; just list, as they occur to you, the major and minor points, the chief details, the relevant facts. Order is not important. The aim is to get it all down on paper. One engineer calls this her "data dump."

3. Impose some tentative order on the jumble of ideas you've brainstormed. Sketch out your ideas in a form understandable to you. An increasingly popular form of outlining is called "nonlinear" because it is not confined to point-by-point deployment of facts and ideas. You can take a large pad of unlined paper and fill it with bits and pieces. Major points might go in boxes, minor points in circles. Arrows might show the movement from one box or circle to another. Introductory material can be kept at the top of the sheet, supporting material in the middle, ideas about conclusions at the bottom. (Or, if you like, reverse that scheme; it's your outline.) You can construct pyramids, butterflies, or any geometrical shapes you like. The goal of this nonlinear form of outlining is to encourage free thought. At some point you will probably want to convert this form of material into a linear outline you can follow at the typewriter, but the freedom it gives you is useful in making the transition from thoughts in your head to thoughts on paper.

4. If the composition you are planning is long and complex, devise an outlining system that can be efficiently coordinated with the information you have accumulated. If you have note cards (see Chapter 3) on which important details are recorded, you will find it helpful to arrange a linear outline that will serve as an index to the notes. All notes that belong with point 1 (or I or A or a) can be arranged in a stack. You can even label the notes in the upper left corner with the number corresponding to the point in the outline where that note will be used. An outline set up in this manner will help you sort the notes and gain control over the material you want to present.

5. Regard your outline as tentative. At some point you simply have to stop playing with the outline and start writing. But the more attention you give to the outline—the more time you spend checking it over, thinking through its logic, shuffling parts—the more time you will save when you finally begin to put words on paper. Even in the middle of writing you may discover that a particular point should be moved to a new position. Move it. Keep the outline strong enough to govern your writing yet loose enough to allow you to revise and refine to avoid problems in presentation and to save time.

6. Above all, consider the outline as your personal guide. Don't worry about how it will look to someone else. Develop a system of

outlining that will help you write the organized, reader-oriented composition that is the outline's only reason for being.

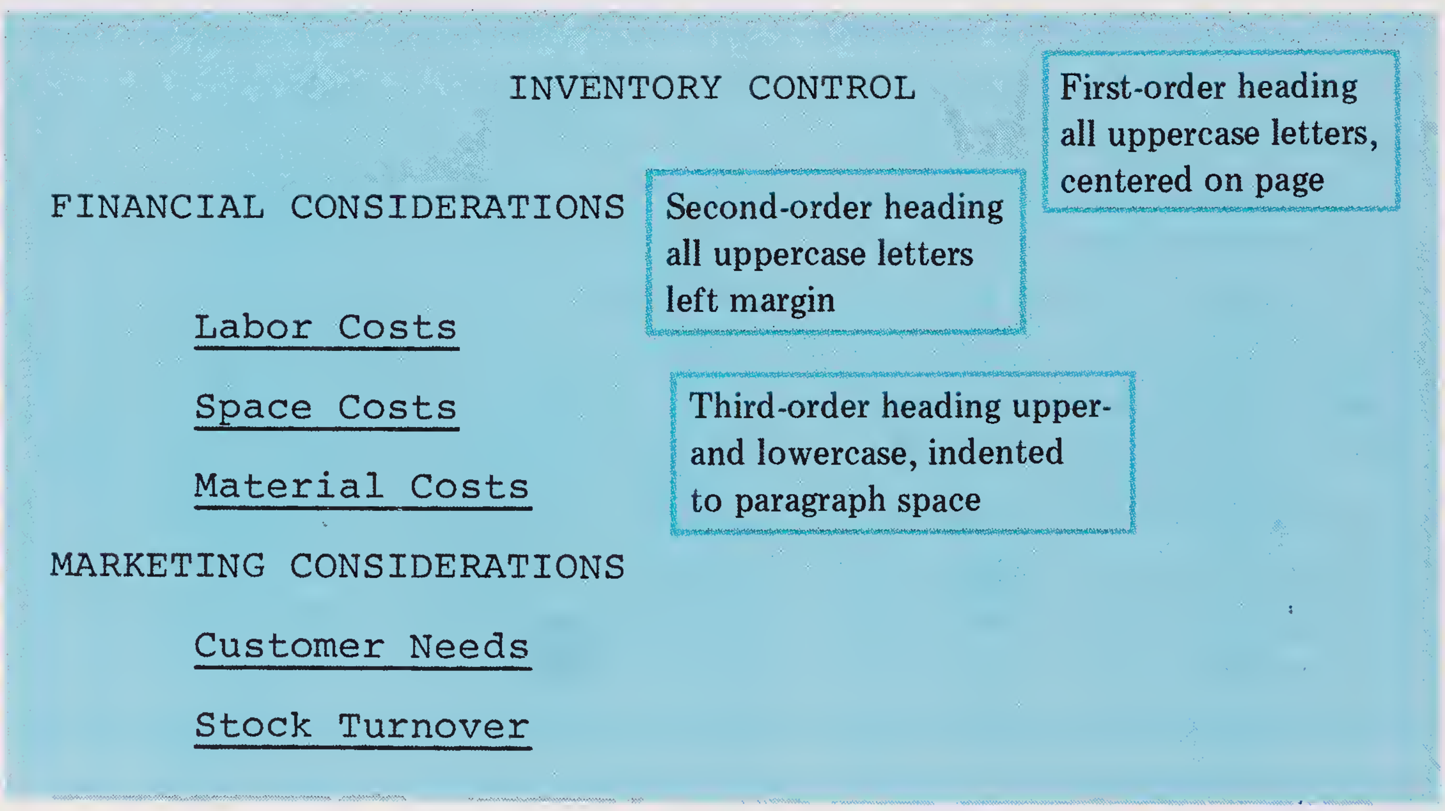
HEADINGS

An additional advantage of outlining is that it makes easier the job of using headings, which are common devices in technical writing. Like paragraphs, headings break up the page and make it more attractive and easier to read. They also provide directional signals to the reader, explicit statements that the writer is moving from one topic to another or from one aspect of a single topic to another aspect. The headings in this chapter, for example, separate the three major sections ("Paragraphs," "General Organization—A Point and a Plan," "Distribution") and the subsections within them.

Although headings are common and necessary in technical writing, the student must not rely on them as a crutch. He must not use them as a means of avoiding the obligation to make the prose itself flow smoothly and to make paragraphs and sections fit together coherently. Headings are visual aids to good organization, not substitutes for control of material and easy transition among parts.

Two forms of headings are common in technical writing. One is the use of typography (uppercase, lowercase, underlining, and combinations of these) and spacing. The second is the use of numbers with substantive titles.

Practice varies, but a convenient form of typographical headings is this:



The use of numbers is more standardized:

```
1.0 INTRODUCTION
    1.1 Critical Problems
    1.2 Past Work
        1.2.1 Biological Research
        1.2.2 Computer Models
        1.2.3 Financial Analyses
    1.3 Political Constraints
2.0 ADVANTAGES OF DDT
    2.1 Control of Pests
    2.2 Ease of Application
    2.3 Low Cost
3.0 DISADVANTAGES OF DDT
```

As these examples make clear, headings should not exceed one line of type; usually two or three words are sufficient. Descriptive headings ("Introduction," "Discussion," "Conclusion") are useful for general sections, but wherever possible informative ones are preferred. These are headings that indicate directly the content of the section ("Labor Costs," "Customer Needs," "Control of Pests"). All similar groups of material should be provided with headings of similar rank, and no part should be without a heading.

The writer should adopt the style for headings specified by the person or institution he is addressing or should follow the form established by his employer. Whatever form he uses, he must always be consistent (never mixing two or more forms within one document). And he must be sure that the writing itself is well organized and that the headings are employed only to show explicitly the divisions that exist.

In constructing sentences the writer's job, as we have seen, is to distribute the elements into appropriate grammatical parts. Distribution is equally critical in organization, both in the paragraph and in the whole composition. The writer must distribute parts of his argument in a pattern and at a pace that meet the needs of his audience and do justice to his subject. He puts into an introductory section those aspects of his report that introduce the subject and involve the reader. In supporting sections he places the details that buttress the main point and develop it through subpoints. At the end he draws together his argument. Improper distribution occurs when the writer introduces new evidence in the conclusion, leaps into a technical discussion in the introduction, or introduces new subjects in supporting paragraphs. The writer must control his material, probably through some outline, and distribute it according to the functions it serves in the particular composition.

Moreover, the reader's needs require that the writer make the principles of distribution explicit. He must alert the reader to what he is doing and why. A venerable piece of advice about writing holds that you should tell the reader what you're going to say, say it, and then tell him what you have said. Followed rigorously, this overstatement would lead to repetitive, stiff, artificial prose; but the intention of the advice is admirable. The writer does need to guide his reader.

An opening statement revealing the plan of a report is one guide. Within individual sections of the report the writer may also erect directional signposts: "Having considered the disadvantages of this computer program, we will now turn to its advantages"; "these statistics must be explained"; "such a choice of materials requires elaboration." Statements like these are structural or transitional; they contribute nothing directly to the content of the report but do help the reader understand the presentation—what has gone before and what will come next. In long, complex compositions the writer may even employ whole paragraphs serving only structural or transitional purposes. Like the individual clauses or sentences at the end and beginning of paragraphs, structural and transitional paragraphs provide direction for the reader.

The value of structural devices is illustrated in the following paragraphs, which form the "Introduction" to a professional paper titled "Simulating a Jet Gas Turbine with an Analog Computer." The selection is a good model of effective organization in its control, development, and use of transitional devices.

Thesis sentence for paragraph

During the past decade the electronic analog computer has proven to be an invaluable tool for the solution of engineering problems. It adapts itself particularly well to problems when complexity precludes analysis "by hand," when experimental costs are too great for risk of failure, or when danger exists to human life. These problems can first be modeled on the computer and the validity of proposed physical configurations tested. Not only is time saved in the initial solution of the problem, but the system parameters can be changed with ease, often with the quick setting of a dial. In case of failure, the cause can be determined and corrective measures applied with relative ease.

[Typical of the problems amenable to analog computer analysis is one recently investigated at Battelle.] The project, sponsored by the Cooper-Bessemer Corporation of Mount Vernon, Ohio, included a computer simulation of a jet gas-turbine-driven generator system. The Cooper-Bessemer concept of packaged industrial power, employing a slightly modified aircraft turbojet engine which supplies hot gas to a turbine, has gained acceptance within a short time as the result of a number of successful field applications. For the most part, these applications have employed the jet gas turbine as a prime mover for a centrifugal compressor in pipeline booster service or industrial process operations. A step to expand the field of possible application was to adapt the jet gas turbine to an alternating-current generator for both peaking and base-loads service. In extending this particular prime mover to electrical power generation, two

Repetition of key term and pronoun

Internal transition through structural device

Internal transition through structural device

Internal transition through structural device

Supporting details further defining "problems"

Transition (movement from general to particular application) questions were immediately raised: (1) Could the jet gas turbine meet the stricter requirements for speed control and recovery from load disturbances with available control equipment? And (2) Which of the many possible combinations of engines, controls, governors, and other equipment would give stable operation with good dynamic response?

Transition → To investigate these questions prior to actual equipment testing, Cooper-Bessemer requested Battelle to simulate two specific combinations of equipment on the analog computer and from these simulations to prepare a general analog computer program for future studies of other combinations.*

Statement of purpose for project

NOTE

1. Terry C. Smith, "What Bugs People Most About Report Writing," *Technical Communication*, Fourth Quarter, 1976, pp. 2-6.

EXERCISES

1. The following paragraph, written by a student, uses the technique of comparison and contrast to discuss the advantages and disadvantages of earthfill construction of dams. Although it centers on a single point, the paragraph is confused—and confusing—because it does not show clear movement. This

*Donald R. Ahlbeck, "Simulating a Jet Gas Turbine with an Analog Computer," reprinted by permission from the September 1966 issue of *Simulation*; © 1966 The Society for Computer Simulation.

is probably because the writer was unsure about his purpose. Reorganize the paragraph to fit each of the following three purposes:

- To discuss objectively the advantages and disadvantages of earthfill dams
- To emphasize the advantages
- To emphasize the disadvantages

You may eliminate any sentences that you find irrelevant to the purpose, and you may add sentences consistent with your intention.

> (1) Earthfill dams are the most common type of dam. (2) This is primarily because its construction generally involves readily available materials used with a minimum amount of processing. (3) There are other advantages to earthfill dams. (4) The construction material is generally available. (5) Another advantage is that earth is easily handled. (6) Also earth dams are often suited to sites where other dams are too heavy. (7) Earth structures are somewhat flexible and can conform to small movements of the foundation. (8) The earth dam is designed with a large base width and this distributes the horizontal load of the water pressure over a wide area. (9) This design reduces the danger of sliding on a weak foundation. (10) Earthfill dams are also economically favorable. (11) The cost of concrete on a recent dam project was \$15 per cubic yard concrete in place. (12) The cost of compacted earth on comparable jobs has been 50¢ per cubic yard. (13) There are some disadvantages to earthfill construction. (14) First, there are some sites where nearby material is not suitable. (15) Second, greater maintenance is required for earthfill dams. (16) Third, the earthfill dam cannot be used as a spillway due to erosion characteristics of the dam, therefore the dam requires a supplementary spillway structure.

2. Identify the "gatherer" in the following paragraph and reorganize the sentences around it to achieve a coherent unit that exhibits both stasis (writing around a clear point) and movement (from point to point). One clue: underline "Hauser Lake Dam" each time it appears and trace the development of information about it through the paragraph.

> (1) Around 1900 an attempt was made to use steel as the major construction element in three large dams. (2) However, after the failure of the Hauser Lake Dam, the idea was generally abandoned. (3) Today steel dams are used only as temporary cofferdams needed for construction of permanent dams. (4) Basically a framework covered with riveted steel plate is used for the steel dam. (5) A masonry abutment is used to anchor the steel work into the reservoir. (6) A typical design is shown in Figure 19. (7) The Hauser Lake Dam in Montana failed on April 14, 1908. (8) Steel dams decreased in popularity after this. (9) There were only three major steel dams made. (10) These were the aforementioned Hauser Lake Dam, the Red Ridge Dam in Michigan, and the Ash Fork dam in Arizona. (11) The basic design of these dams can be seen in Figure 20. (12) The small number of these dams that were built made stability design a matter of calculation rather than experience. (13) The Hauser Lake Dam failed due to overturning.

3. The paragraph below exhibits neither stasis nor movement. Yet the writer seems to have some purpose in mind. Try to discover that purpose and then rewrite the paragraph to develop the point clearly.

(1) Roller coating from a consumption of organic coating is undoubtedly one of the largest application techniques. (2) Canning of food and beer has mushroomed in the past 10 years to a gigantic industry. (3) Beer cans are an excellent case study of roller coating. (4) Vinyl resins are used exclusively for beer cans because of their freedom of flavor and flexibility during fabrication. (5) Vinyl resins do not stand up to soldering of the side seams so they are roll-coated externally and sprayed internally. (6) Phenolics with 20% epikotes are slowly entering the canning industry because of their high chemical resistance, fabrication strength, and soldering resistance. (7) Phenolics can be used exclusively with roller coating, thus eliminating costly secondary operations. (8) The resin mixtures used in roller coating are usually very complex. (9) Gold lacquers must be used as a primer for internal protection against the attack of sulfur in vegetables and acids in fruits.

4. Identify the *method of development* (facts, illustration, anecdote, testimony, and so on) and the *order* (natural, logical, psychological) of the following two paragraphs.

Body-centered cubic and face-centered cubic are common crystal structures. Both structures have an atom at each corner of the cube with additional atoms inside the cube. The body-centered cubic has an atom in the center of the cube, and the face-centered cubic has atoms on each face of the cube but no atom in the center. Examples of body-centered cubic structures are chromium, iron, and tungsten. Examples of face-centered cubic structures are aluminum, copper, and lead. [quoted in John Wallace, *Effective Technical Writing*, Battelle Memorial Institute, Columbus, Ohio, 1972, L4, p. 2]

Newton's third law of motion states that for every action there is an equal and opposite reaction. This law is demonstrated in many everyday happenings. When we row a boat the oars exert a force against the water, and the water exerts an opposite force against the oars. Air reacts against the propellers of an airplane so that the propellers pull the airplane through the air. Water reacts against the nozzle of a garden hose and drives it back if it is not restrained. [Wallace, L4, p. 3]

5. The following items might be included under the general topic of diet for football players. Organize them for the introduction to a report for a professional society of nutrition experts who want a general review of the topic.

(1) Steak is high in protein.
(2) A survey of Big Ten football coaches shows that 50 per cent encourage their players to eat steak just before a game.
(3) Your research indicates that the protein from steak is less quickly broken down into usable form than the protein in lobster.
(4) Joe Slopehead, star fullback for Dismal State University, eats three 1-pound steaks before each game; last year he averaged three touchdowns

in the first quarter of each game.

(5) The retail cost of steak is $2.17 a pound.

(6) The retail cost of lobster is $5.95 a pound.

(7) The American Association for the Study of Pregame Nutrition recommends that football players eat a heavy starch diet just before a game.

(8) Studies show that athletes need three times more protein than file clerks do.

6. Using the same points listed under exercise 5, organize the introduction to a report to a football coach recommending that players be fed steak just before games.

7. Using the same points listed under exercise 5, organize the introduction to a story for the sports page of your local newspaper on the controversy among coaches about what to feed players before the game.

8. The following 21 points are to be covered in a report "Trends in Watershed Problems and Control." Construct an outline (linear or nonlinear) to show how you would distribute the points and order them into a report. Use all the points; do not add new ones.

(1) Forestation and other planned planting
(2) Increase in per capita use of water
(3) Upper Missouri Basin
(4) State efforts
(5) Watershed control methods
(6) Supervision of industrial use
(7) Loss of timber
(8) The current problems
(9) Private efforts
(10) Long-range projects
(11) Cooperation of all agencies
(12) Storage in reservoirs
(13) Successful experiments in watershed control
(14) Federal programs
(15) TVA
(16) Silting
(17) Local planning
(18) Lowering of the water table
(19) Contamination
(20) Reduction in the supply of water
(21) Pollution

9. Using the outline you made in exercise 8, write the first paragraph of the introductory section of the report on "Trends in Watershed Problems and Control." (You can make up data to fit the points.) Name different audiences who might be interested in the report, and adjust the introduction to fit each.

10. Using the outline you made in exercise 8, write the final paragraph of the concluding section of the report on "Trends in Watershed Problems and Control."

CHAPTER 6

Techniques of Presentation: Verbal

In Molière's play *Le Bourgeois Gentilhomme* (The Would-be Gentleman) M. Jourdain discusses poetry and prose with his philosophy master. He is surprised and delighted to learn that he has been speaking prose all of his life. "Well, I'll be hanged. For more than forty years, I've been talking prose without any idea of it." Students know without surprise that they have been using prose, usually in the form of exposition, most of their lives. They will also recognize that they have been using, without identifying them as such, the techniques of writing to be discussed in this chapter. It is important to distinguish different techniques so that appropriate ones can be chosen. Should I use exposition, analysis, narration, description, or argument? Or should I use a combination of these?

Traditionally, the art of rhetoric, and hence that of composition, is divided into four categories: *exposition*, *narration*, *description*, and *argument*. We shall add a fifth, *analysis*. Analysis is often considered a subcategory of exposition; we shall consider it as a technique in its own right because it underlies almost all technical writing.

Although any one of the techniques of presentation may be used in any section of a report—introduction, body, or conclusion—their major function is to assist the writer in the organization, development, and clarification of ideas presented in the body of the report.

Exposition

Technical writing depends to a great extent on exposition. Exposition explains to the reader what something is, how it works, and how it is related to other things. It is probably the broadest of all categories because the expository writer employs a great number of rhetorical devices such as comparisons and contrasts, examples, and analogies as well as narration and description. Furthermore, exposition quite often spills over into argument. If well done, exposition becomes a nicely balanced discourse made up of generalizations and details. Unfortunately, many expository writers rely on generalizations without including supporting details or using clarifying techniques. Conversely, they sometimes drown the reader in details without demonstrating their significance. Lewis Thomas is a master of exposition and analysis, as illustrated in the following excerpt from his excellent book *The Lives of a Cell*:

> We continue to share with our remotest ancestors the most tangled and evasive attitudes about death, despite the great distance we have come in understanding some of the profound aspects of biology. We have as much distaste for talking about personal death as for thinking about it; it is an indelicacy, like talking in a mixed company about venereal disease or abortion in the old days. Death on a grand scale does not bother us in the same special way: we can sit around a dinner table and discuss war, involving 60 million volatilized human deaths, as though we were talking about bad weather; we can watch abrupt bloody death every day, in color, on films and television, without blinking back a tear. It is when the numbers of dead are very small, and very close, that we begin to think in scurrying circles. At the very center of the problem is the naked cold deadness of one's own self, the only reality in nature of which we can have absolute certainty, and it is unmentionable, unthinkable. We may be even less willing to face the issue at first hand than our predecessors because of a secret new hope that maybe it will go away. We like to think, hiding the thought, that with all the marvelous ways in which we seem now to lead nature around by the nose, perhaps we can avoid the central problem if we just become, next year, say, a bit smarter.
>
> "The long habit of living," said Thomas Browne, "indisposeth us to dying." These days the habit has become an addiction: we are hooked on living; the tenacity of its grip on us, and ours on it, grows in intensity. We cannot think of giving it up, even when living loses its zest—even when we have lost the zest for zest.*

If the expository writer uses a logical plan for developing his presentation, he can easily determine what divisions are needed and what order is most appropriate, as discussed in Chapter 5. Moreover, such a plan will suggest techniques and clarifying devices that should be incorporated.

*__The Lives of a Cell__, Viking Press, New York, 1974, pp. 47-48.

Analysis

Analysis is the process of studying any concept, object, or organization by (1) isolating individual components or features and (2) examining how the components fit together.

Analysis can be considered in two ways: (1) in a broad sense and (2) in a limited sense.

BROAD SENSE

Without analysis of a subject, it is impossible to construct a plan of presentation. Analysis is the writer's thought process that initially develops order out of chaos. It orders miscellaneous material into logical and understandable divisions.

Analysis is an everyday process. If a student decides how to budget his finances, plans a study schedule, or determines which girl to ask out, he conducts an analysis. The process allows doctors to diagnose trouble by examination of X-ray plates. The Internal Revenue Service busies itself checking thousands of tax returns in order to determine which should be audited. To discover a soft landing place on Mars for Viking 1, scientists studied hundreds of photographs before electing Chryse Planitia, and they did the same for Viking 2 before choosing Utopia Planitia.

In a report on "The Medicaid Mess" (a questionable title; see discussion of titles in Chapter 11), any reader would expect a full analysis of the causes of the problems as well as an analysis of possible solutions. Or if a decision is to be made on where to locate a new restaurant the audience would expect an analysis of the advantages and disadvantages of the new location: codes and regulations, traffic patterns, accessibility and convenience to prospective customers, competition, cost, and so on. (Such an example illustrates how dependent different techniques are on each other because the analysis would be finally presented in the form of comparison and contrast.)

LIMITED SENSE

Analysis considered in a limited sense can be divided into classification and partition.

Classification. Classification used in formal analysis is a systematic grouping of objects or procedures into categories based on similar characteristics or traits. It is natural for people to classify things to better understand them: planets, stars, animals, insects, chemical substances, ideas. Paragraphs are classified in Chapter 5; each classification has a common denominator: length, function, development, or order.

In classification a unifying principle or a common denominator is necessary. One cannot, for instance, classify mammals with insects. They have little in common except that some of them live in the same habitat. But one can classify objects, species, and ideas if they have a common denominator.

After choosing the unifying principle, the writer must stick to it until he has completed his classification. According to the *Encyclopaedia Britannica*, bridges can be classified by their purpose or function, their material, their form or types, or their interspan relations. But once a writer has chosen the basis for classification he cannot logically switch from one basis to another. That is, if he is discussing building materials he should not allow another construction feature to interfere with his developing classification. Of course, once he has exhausted his classification of materials, he can turn to another category.

In order to classify one must have a plural subject, although this may be a single subject that is understood in a plural sense, such as fish, fox, mail, or blood. Mail, for instance, could be classified into letters, post cards, advertisements, and magazines; blood into types O, A, B, and AB. One must have a subject that can be divided into smaller classes. Shoes can be classified by widths A, B, C, D, E. They can also be classified by material: canvas, leather, plastic, straw, wood, and rubber. The broader the subject, the more difficult it is to classify. Tools, for example, would call for a great many divisions, but limiting the subject to antique tools or garden tools would provide better control for classification.

Partition. Analysis of a single unit takes the form of partition; that is, the unit is divided into its parts. Operas could be classified as dramatic, comic, and tragic, but one opera, *Carmen*, must be divided into its parts—acts, scenes, and characters. Chemical elements can be classified, but sulfuric acid would be partitioned into hydrogen, sulfur, and oxygen. Almost any mechanical device can be partitioned because it is made up of different parts. Classification and partition are often combined, as shown in this example from the naturalist Charles Darwin:

> The diversity of the breeds [pigeons] is something astonishing. Compare the English carrier and the short-faced tumbler, and see the wonderful difference in their beaks, entailing corresponding differences in their skulls. The carrier, more especially the male bird, is also remarkable from

the wonderful development of the carunculated skin about the head; and this is accompanied by greatly elongated eyelids, very large external orifices to the nostrils, and a wide gape of mouth. The short-faced tumbler has a beak in outline almost like that of a finch; and the common tumbler has the singular inherited habit of flying at a great height in a compact flock, and tumbling in the air head over heels. The runt is a bird of great size, with long massive beak and large feet; some of the sub-breeds of runts have very long necks, others very long wings and tails, others singularly short tails. The barb is allied to the carrier, but, instead of a long beak has a very short and broad one. The pouter has a much elongated body, wings, and legs; and its enormously developed crop, which it glories in inflating, may well excite astonishment and even laughter. The turbit has a short and conical beak, with a line of reversed feathers down the breast; and it has the habit of continually expanding slightly the upper part of the esophagus. The Jacobin has the feathers so much reversed along the back of the neck that they form a hood; and it has, proportionately to its size, elongated wing and tail feathers. The trumpeter and laugher, as their names express, utter a very different coo from the other breeds. The fantail has thirty or even forty tailfeathers, instead of twelve or fourteen—the normal number in all the members of the great pigeon family: these feathers are kept expanded, and are carried so erect, that in good birds the head and tail touch: the oil-gland is quite aborted. Several other less distinct breeds might be specified.[1]

Narration

Students may feel that the word *narration* refers to a story with a plot and thereby conclude that narration in no way concerns technical writers. In "imaginative" literature the term *does* usually pertain to a novel or a poem; however, narration can also be considered as the movement of events showing relationships generally organized chronologically or spatially. In this sense technical writers often employ narration, although rarely uncombined with other techniques such as description. The example of the layout of a plant in Chapter 11 combines description with narration. Description of an experiment or a process becomes narration as it moves sequentially from one process to another. A student will find that narration, when possible, makes the task of organization easier and usually results in greater clarity.

Very rarely, however, does a whole report depend entirely on narration. Narration often appears at the beginning of a report. It is used to acquaint the reader with background material needed for a later discussion of problems and solutions.

The following passage precedes an argument for protecting our national parks; narration is combined with description:

Among our parks, the Grand Canyon National Park in northern Arizona seems to be as unchanging as any of [the National Parks]. However, even a place like the Grand Canyon itself, which to the casual eye appears unchanging even over a long lifetime, is actually undergoing constant change—change caused by nature and change caused by Man himself. Let's look at some of the past changes and those now underway in our "unchanging" Grand Canyon of the Colorado River.

The horizontal layering of rocks in the Grand Canyon vicinity reveals the area was a flat plain for several hundred million years before the beginnings of the Grand Canyon itself. At various times the area was below sea level, a fact recorded today by the presence of fossilized marine organisms in the sedimentary rock. Much of the time the land was above sea level and received deposits of mud and sand from ancient rivers; a great thickness of sediments of varying color and composition was accumulated over those millions of years. The deposited layers were transformed by heat and pressure into rock. Tracks of reptiles and amphibians are preserved in the layered rocks, along with impressions of the primitive plants that also flourished in long-past times. As the land was slowly raised by great forces within the earth, the Colorado River, in its passage to the sea, began to carve into the layered rocks. Slowly—ever so slowly over millions upon millions of years—the land rose and the great river scoured its ever-deepening channel at approximately the same rate as the rising of the land. The rims of the great chasm are now approximately a mile and a half above the level of the sea; today, the upper walls of the Grand Canyon tower a mile or so over the river whose unceasing energy has carved it and changed it—indeed, which it continues to do to this day.*

In this next excerpt, combining narration with examples, the author is eventually concerned with defending expenditure for medical research:

In 1895 two events took place that would have a profound effect on the progress of American medicine: 1) the discovery of a "new kind of rays" by Roentgen, which led to the development of a diagnostic radiology and X-ray therapy; and 2) the development of psychoanalytic psychiatry through the studies of Sigmund Freud. In the same way, the accurate diagnosis of many diseases was virtually impossible before the advent of two major technologies in the early part of the 20th century: 1) the chemistry of blood and bodily fluids, which made easier the study of the body's organ systems; and 2) the use of the X-ray machine and progressive development of such radiopaque substances as barium and iodine compounds to visualize organ systems. These two advances together with the expansion of surgery after the introduction of anaesthesia and antiseptic techniques, transformed the hospital. From a passive receptacle for the sick poor, it became a house of hope and an active diagnostic and curative

*William J. Breed, "Our Unchanging Canyon," *Arizona Highways*, 52 (1976), 12-13. Permission to reprint granted by *Arizona Highways.*

institution for all classes. The use of blood transfusions hastened the transformation.

The new sciences of bacteriology, biostatistics and epidemiology led to the development and extensive use of vaccines, pasteurization of milk and measures for the control of disease. These advances led to a marked improvement in public health. So did the development of urban sewage-disposal and water-purification systems, the rapid transportation of food and its storage in refrigeration, state food-control acts and the new concern for woman and child labor, as well as for industrial working conditions. By 1910 average life expectancy at birth had increased to 50 years.*

Description

Description, the process of telling what something looks like or how it works, can be divided into two types:

1. Description of objects
   —general
   —specific
2. Description of processes
   —general
   —specific
   —directive

Both types of descriptions are especially dependent upon rhetorical devices such as various kinds of definitions, comparisons, and contrasts. Both objects and processes are described either through words or through visuals. To be most effective the two methods are combined. Words are accompanied by drawings, photographs, figures, or graphs that help the reader understand and visualize an object or process. No matter how skillful the writer or how imaginative the reader, it is almost impossible to portray completely objects using only words because words cannot be expected to produce identical pictures in the minds of different persons (see Chapter 7).

DESCRIPTIONS OF OBJECTS

Unlike the writer of imaginative prose, who often paints an impressionistic picture, the technical writer must present a "photo-

*John H. Knowles, M. D., "The Struggle to Stay Healthy," *Time*, August 9, 1976, p. 61. Reprinted by permission from TIME, The Weekly Newsmagazine; Copyright Time Inc.

graph"—objectively and as true to the form as possible. As in photography, the picture is presented from a particular angle. If a writer is asked to describe a common mousetrap, he must reveal whether he is looking at it from front, top, or side. It is possible to move into different positions, but the audience must understand the changes in position. In the following selection from Henry Adams on "The Merveille," Chapter 3 in *Mont-Saint-Michel and Chartres*, the author takes his reader along with him in order to describe the outside of the building from a certain angle:

> A conscientious student has yet to climb down the many steps, on the outside, and look up at the Merveille from below. Few buildings in France are better worth the trouble. The horizontal line at the roof measures two hundred and thirty-five feet. The vertical line of the buttresses measures in round numbers one hundred feet. To make walls to that height and length stand up at all was no easy matter, as Robert de Torigny had shown; and so the architect buttressed them from bottom to top with twelve long buttresses against the thrust of the interior arches, and three more, bearing against the interior walls. Between these lines of buttresses the windows tell their story; the seven long windows of the refectory on one side; the seven rounded windows of the hall on the other. Even the corner tower with the charter-house becomes as simple as the rest.[2]

Except on unusual occasions a technical writer does not include description for its sake alone. Rather, it is used to complement some other purpose. Even though Adams used description as the core of his work, his ultimate purpose was to show the spiritual unity of the philosophy, art, and vision of the Middle Ages.

The following description of a condor is important only as a prelude to a report on an endangered species with an argument for its protection:

> Andean condors, unchanged little by evolution, are magnificent birds. They are giants among the species. Because of their physiology and weight, they have difficulty in launching their flights. Consequently, leaping from cliffs or crags, they depend on updrafts to propel them into the air. Once airborne, they can soar at 35 miles an hour with a minimum flapping of wings. They often attain heights of 3 miles as they scan the earth for carrion upon which they feed.

They are magnificent, but not beautiful. They have beady red eyes (the male's paler than the female's) and hooked beaks. The female is distinguished by her white ruff and the male by his crinkled crest.

Once plentiful on the coasts and in the mountains from Colombia to Tierra del Fuego, they are rapidly disappearing as humans encroach on their wild domain.

Many reports require detailed description of a complex system or mechanism to familiarize the reader with its various components and their relationships for a better understanding of how it works. Such descriptions may introduce a newly developed device in order to evaluate it. They may precede suggestions for changes or alternatives when a company is considering the purchase of some new equipment, or they may be included sometimes when cautions or safety measures are proposed.

Descriptions of mechanisms or systems usually follow a common pattern, although some of the elements can be reordered.

Pattern for a Description of a Mechanism

1. Introduction
   a. Definition
   b. Purpose
   c. Generalized description
   d. Division of the device into its components

2. Principle or theory of operation
   a. Divisions—what the part is, its purpose, and its appearance
   b. Division into subparts
      (1) Purpose
      (2) Appearance—often through visuals
      (3) Details—shape, size, relationship to other parts, connections, material

3. The operation of the system
   a. Ways in which each division achieves its purpose
   b. Causes and effects of the device in operation

Following is a detailed description of a cooling system. Parts and their functions are described.

COOLING SYSTEMS

The engine cooling system [Fig. 1] is designed to regulate operating temperatures and prevent overheating. *About one-third of the total heat energy contained in the fuel must be carried away by the cooling system.* By regulating the operating temperature, the cooling system keeps the engine at the best heat level for each operation. During starting, the engine should be allowed to warm up quickly, while it must be cooled when operating under heavy loads.

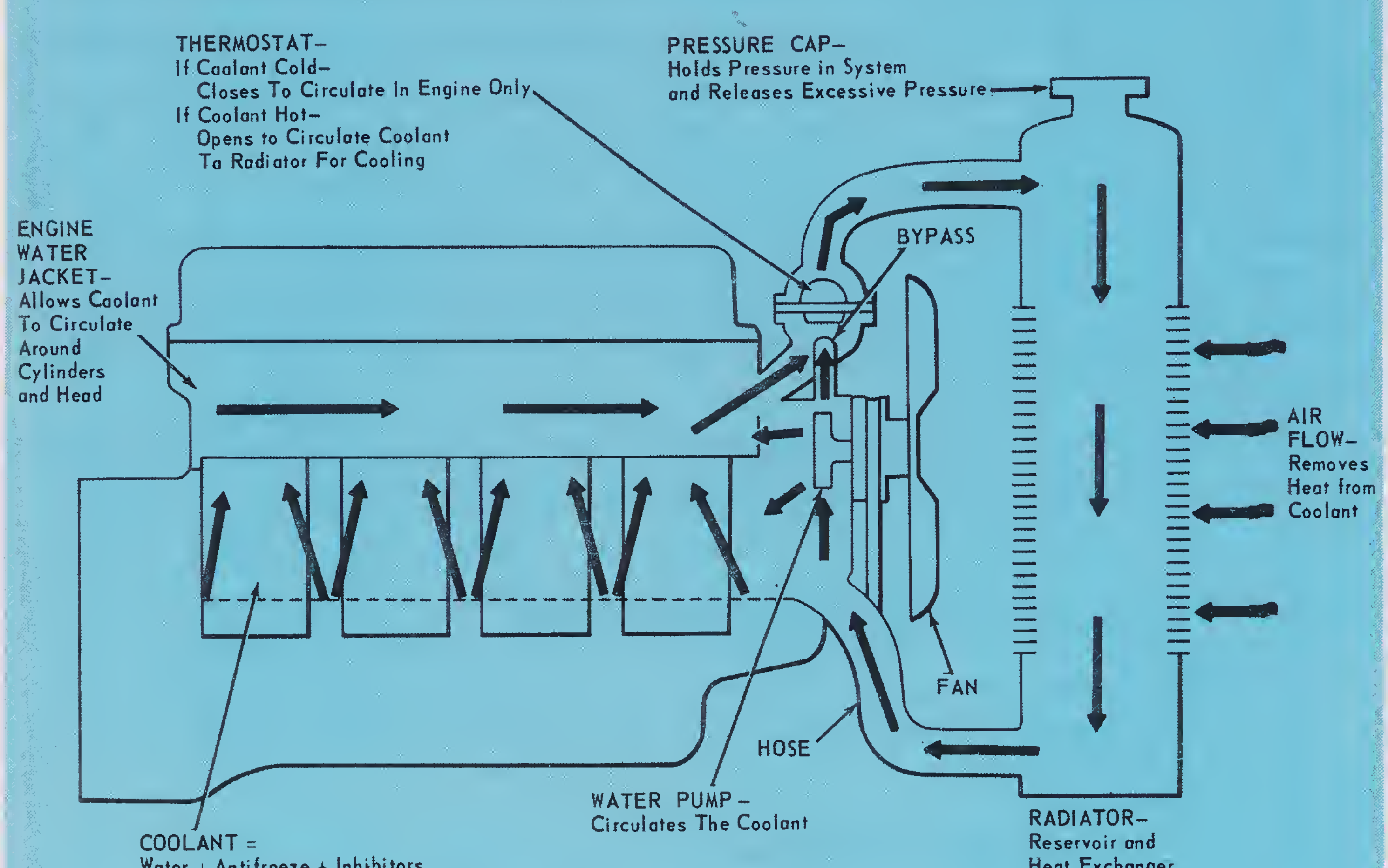


Fig. 1. Typical cooling system

By regulating operating temperatures, the cooling system keeps the engine from running too cold. Running the engine too cold can cause unnecessary wear, poor fuel economy, and an accumulation of water and sludge in the crankcase.

By cooling the engine and preventing overheating, the cooling system guards against pre-ignition, detonation, engine knock, burned pistons and valves, and lubrication failure.

Fig. 2. Tube-and-fin type radiator

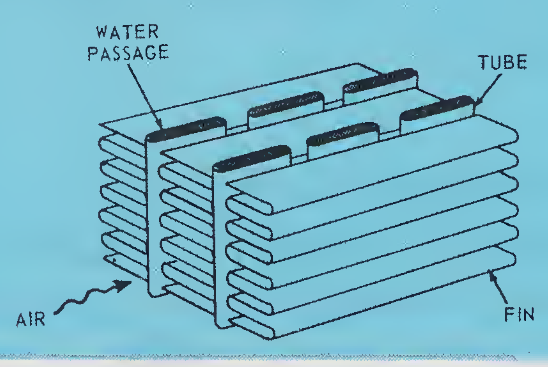


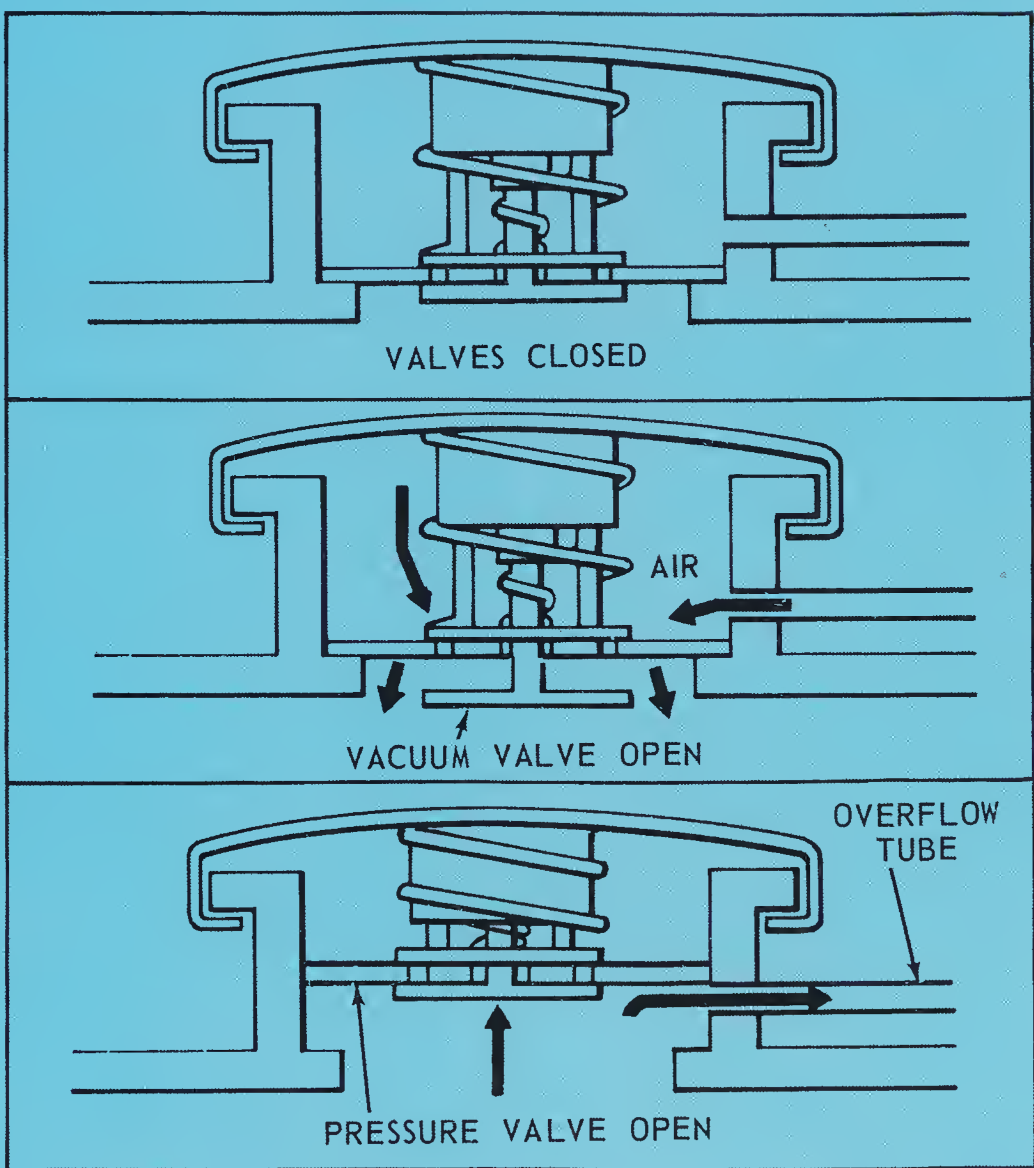
Figure 6-1. Description of a Process, Integrating Verbal and Visual Techniques of Presentation. (From *FMO*: *Tractors*, John Deere Company, 1974, pp. 56-61. Reprinted by permission of Deere & Company.)

COMPONENTS

The cooling system consists of:

- Radiator and pressure cap
- Fan and fan belt
- Water pump
- Engine water jacket
- Thermostat
- Connecting hoses
- Liquid or coolant

Fig. 3. Pressure control radiator cap



The RADIATOR, one of the major components of the cooling system, transfers the heat in the coolant to the atmosphere. It also provides a reservoir for the liquid needed to operate the cooling system efficiently.

The FAN forces cooling air through the radiator core to help dissipate the heat carried by the coolant in the radiator.

The WATER PUMP circulates the coolant through the system. The pump draws hot coolant from the engine block and forces it through the radiator.

The ENGINE WATER JACKET surrounds the internal engine parts.

Coolant flows through the jacket, and takes heat away from the engine to the radiator.

The CONNECTING HOSES are the flexible connections between the engine and other parts of the cooling system.

The THERMOSTAT is a heat-operated valve. It controls the flow of coolant to the radiator to maintain the correct operating temperature.

The FAN BELT transmits power from the engine crankshaft to the fan and the water pump.

COOLANT is the liquid that circulates through the system and carries away heat.

Radiator

Radiators are equipped with a series of small tubes surrounded by fins and air passages [Fig. 2]. The radiator receives the hot coolant at the top. The coolant then moves down through the tubes and is cooled by air flowing through the radiator fins. By the time the coolant reaches the bottom of the radiator, its temperature has been reduced, and it is once again pulled through the water jacket to cool the engine.

The radiator is usually equipped with a pressure cap [Fig. 3]. The pressure cap, by increasing the pressure of the coolant in the system, increases the coolant's boiling point. An increase in pressure of one psi raises the boiling point of pure water about 3°F.

The radiator cap on modern cooling systems has two functions:

1. *Allows atmospheric pressure to enter the cooling system.*
2. *Prevents coolant escape at normal pressures.*

A pressure valve [Fig. 3] in the cap permits the escape of coolant or steam when the pressure exceeds a preset value.

A *vacuum valve* [Fig. 3] in the cap opens to admit air when the system cools, thus preventing a vacuum in the cooling system.

Fan and Fan Belts

The cooling system fan is usually located between the radiator and engine, mounted on the front of the engine block. The fan is generally driven by a V-belt from the crankshaft.

The fan can be either a *suction* type or a *blower* type [Fig. 4]. The suction type is similar to the arrangement used on automobiles. The fan pulls the air through the radiator, and discharges it around the engine.

In some applications, the fan is arranged as a blower or "pusher" type. Here, the direction of airflow is in the opposite direction. This arrangement is usually limited to use on slow moving equipment, used in a dusty or dirty environment. The "reversed" air flow avoids blowing air from the engine rearward, reducing operator discomfort.

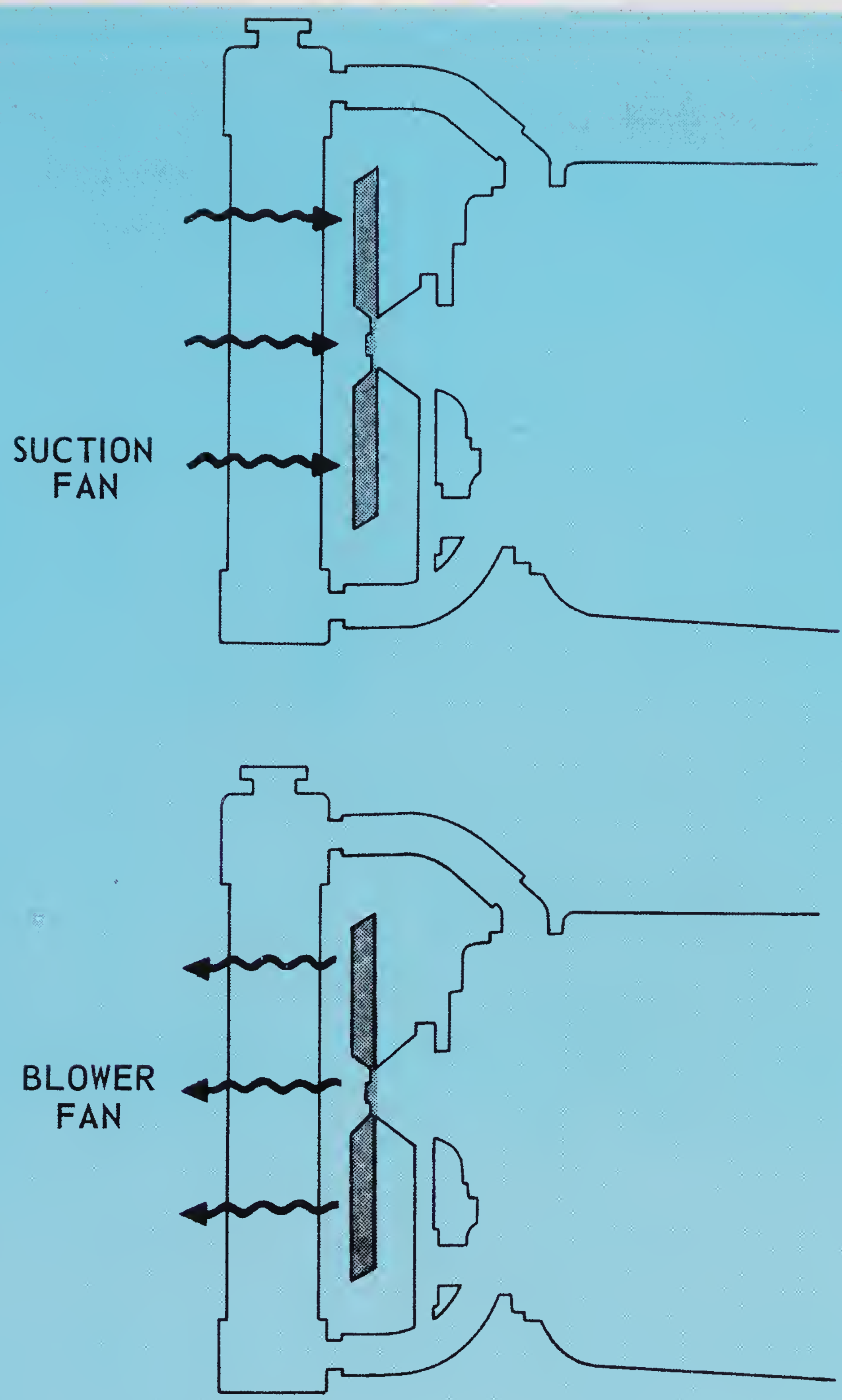
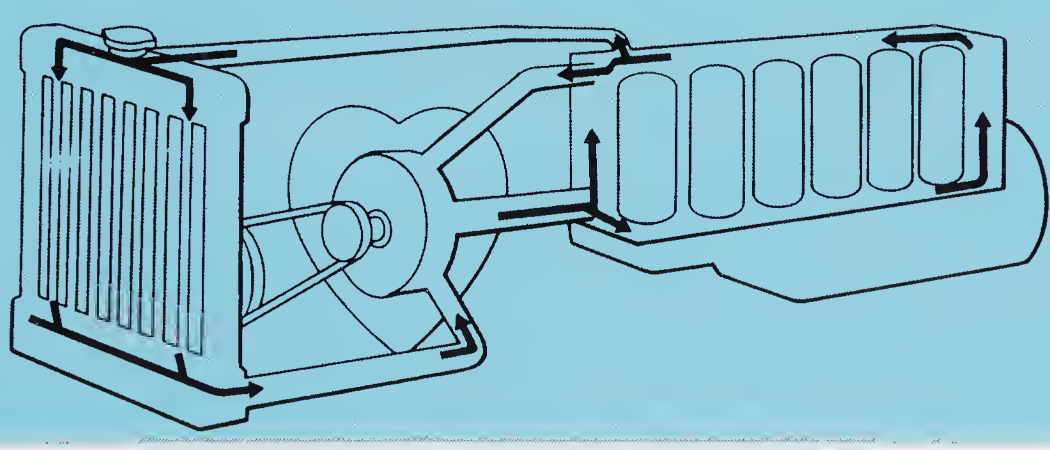


Fig. 4. Two types of fans

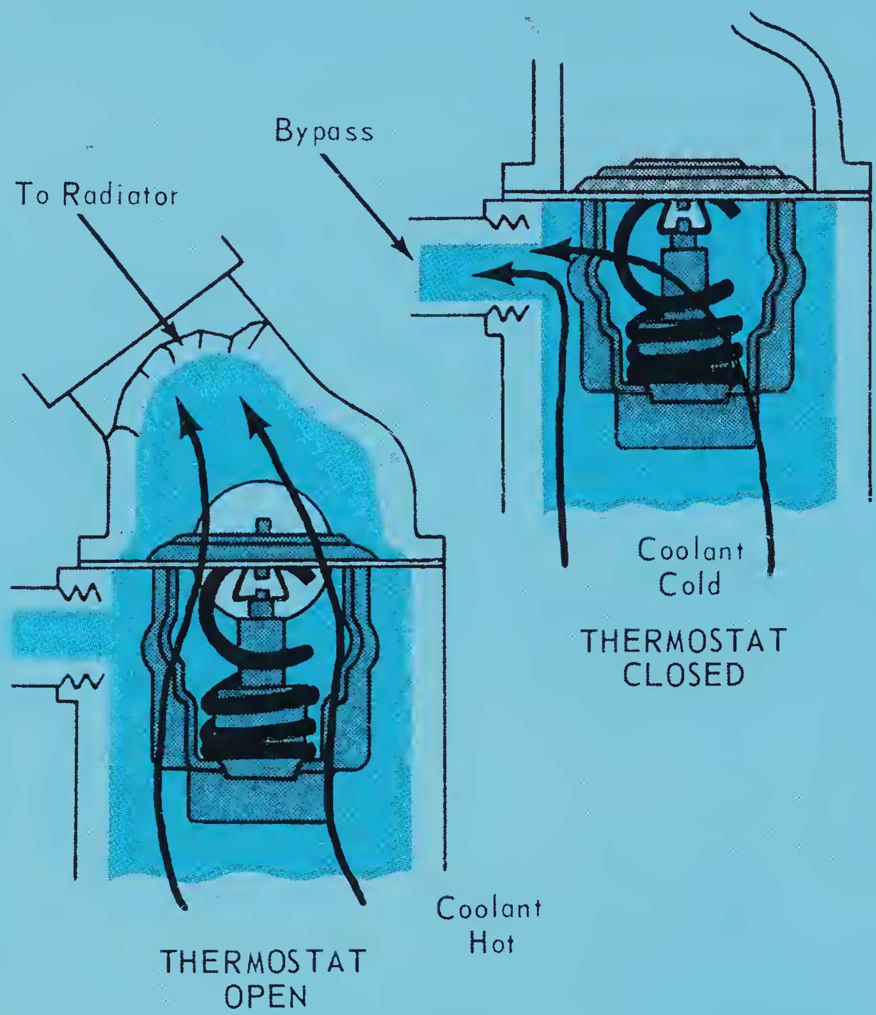
Fig. 5. The water pump is the heart of the cooling system



Water Pump

The water pump is normally a centrifugal-type pump [Fig. 5]. Some pumps turn as fast as 4000 rpm and pump as much as 125 gallons of coolant per minute. The pump is equipped with an impeller that turns at high speed. The impeller vanes push the water through the system.

Fig. 6. Cooling-system thermostat



Thermostats

The thermostat provides automatic control of engine temperature at the correct level by controlling the flow of coolant through the system [Fig. 6]. During warm-up, the thermostat remains closed [Fig. 6]. The water pump circulates coolant through the engine water jacket only by way of the bypass.

The engine quickly warms up to its operating temperature before the thermostat opens.

When the thermostat opens, hot coolant flows from the engine to the radiator and back.

There are two types of thermostats:

- Bellows-type
- Bimetallic-type

The BELLOWS-TYPE consists of a short length of circular corrugated tubing closed at both ends and filled with a liquid having a low boiling point (ether) [Fig. 7].

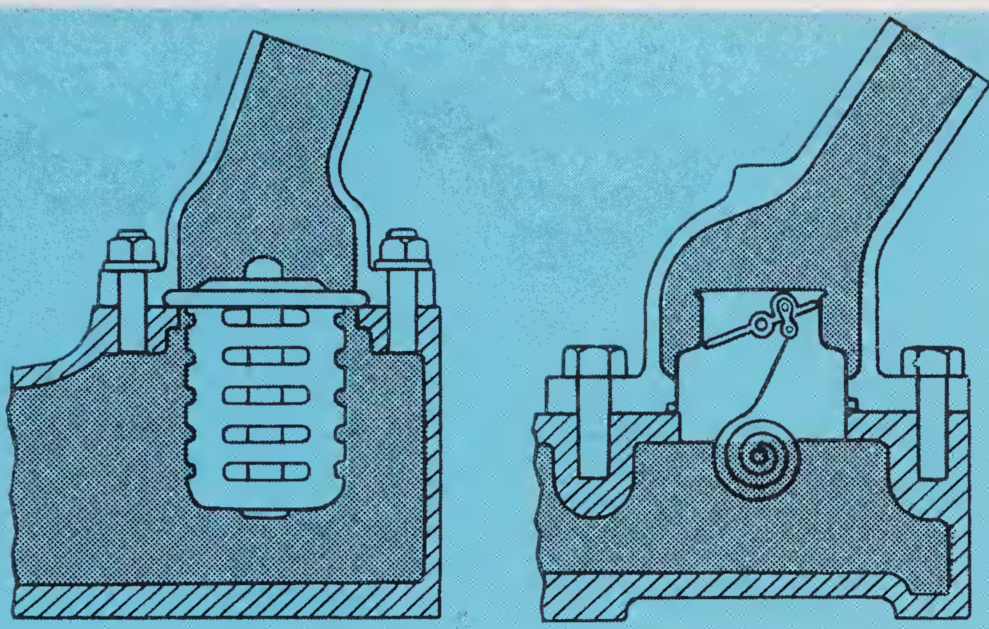


Fig. 7. Types of thermostats

The *thermostatic valve* is located directly above the bellows. The elasticity of the bellows holds the valve closed when the water is cold. The water pump does not create enough pressure to force the valve open.

The BIMETALLIC-TYPE of thermostat consists of a spiral of a bimetallic strip [Fig. 7]. This is a strip of steel welded to a strip of bronze. Bronze expands more when heated than steel does, and as the temperature of the water surrounding the spiral rises, the spiral uncoils and opens the valve.

Hoses

Flexible hoses are used in connecting cooling system components because they stand up under vibration better than rigid pipes. The hoses can rot and crack, however, and should be checked regularly.

Coolant

Water is a good coolant because:

1. *It is plentiful and readily available*
2. *It absorbs heat well*
3. *It circulates freely at all temperatures between its freezing and boiling points (32° to 212°F).*

But water has the following disadvantages:

1. *It freezes readily when cold*
2. *It boils and evaporates when hot*
3. *It may corrode metal parts*
4. *It may cause deposits in water jackets*

Modern pressurized systems overcome the low boiling temperature of water, and *additives* can offset many of its harmful properties.

ANTIFREEZE is used to reduce the high freezing point of water. Modern engines usually operate at a temperature above the boiling point of alcohol so the permanent type (ethylene glycol) is recommended by most engine manufacturers.

The term "permanent antifreeze" means only that the solution will not boil away at normal engine operating temperatures and does not mean that it is good for use for more than one season.

Coolant Heater

In cold weather situations, many farmers use a heater to aid in starting the engine. There are a variety of types available. Electrically powered heating elements may be installed in the coolant passages in the engine block, or in the hoses connecting the engine to the radiator. The heating elements may also be immersed in the engine oil. Still another arrangement connects the cooling system and burns engine fuel to keep the coolant warm.

DESCRIPTIONS OF PROCESSES

The description of the appearance of an object is static, whereas the description of a process is dynamic, that is, involves development and change. Concerned with movement, it is usually organized chronologically. Descriptions of processes can be divided into two types: those that explain a process to give the reader a general understanding of it and those that present in detail steps in a process that would allow the reader to repeat the process.

General Descriptions. The two following examples from *Smithsonian* illustrate the general description of processes. The first is from an article titled "Perfume Is Social Dynamite in an Expensive Package":

Today, as a rule, a perfume is a union of oils, gums, spices, herbs, fixatives and synthetics. The real art and skill of the perfumer lie in blending these materials and producing a pleasing fragrance.

There are five methods of producing natural oils.

Distillation

Plant cells are broken down and oils released. Vaporization and condensation take place simultaneously. The oil floats to the top; the water sinks. This is a simple, inexpensive method, excellent for woods and leaves, too rough for delicate flowers.

Enfleurage

Fresh flowers are brought to factories and within a few hours the petals are picked and placed by hand on glass covered with oil-absorbing fat. After one day the petals are removed and replaced by new ones. This is repeated until the fat is saturated with pure oil. The fat is then dissolved by alcohol and is drained off, and the natural oil is the residue. This time-consuming, centuries-old process is still practiced—but mainly for the benefit of tourists.

Maceration

Flowers, or flower parts, are immersed in fats softened or liquified by heat. The natural oils are thus "digested." This system is fast (and speed is not without importance because some flowers wither quickly and decaying odors taint the final product). Both maceration and enfleurage yield high quality oils but in very small quantities—and at great cost.

Extraction

A solvent—ether, benzine, alcohol—is used to extract the oils from plant material. When the solvent is removed, a concentrated oil is left. This is further treated by purification. According to many experts this method produces the truest possible essence of the natural flower.*

Such a description aids the reader in understanding the processes, but without further information he would be unable to produce perfume by any of the methods.

The second example describes a major process in lifting the island of Philae to a dry and safe setting:

An Egyptian construction organization undertook the protection of the island of Philae by the coffer dam. The first step was to pump a sludge of water and sand from a pit on the mainland through five miles of huge pipes to form a base into which to drive the 3,115 steel planks, each one-and-a-half tons and 56 feet long, that form the sheathing. They were put down in two roughly concentric circles, about 30 feet apart and 2,600 feet in circumference, and girded with a steel belt. More than 1 million cubic yards of sand was needed for the base and the fill between the two circles of piling. All this was done while Philae was under water, submerged as it was soon after the High Dam was finished. Then the water

*Charles Oppenheimer, 3rd, "Perfume Is Social Dynamite in an Expensive Package," *Smithsonian*, February 1976, pp. 73-74. Copyright Smithsonian Institution, 1976; from SMITHSONIAN Magazine, February 1976.

inside the coffer dam was pumped out and Philae reemerged, below the level of the lake.*

Both examples are general descriptions. They simply give the reader an overview of a process for a better understanding of it. They are not designed to allow the process to be repeated. Such descriptions are often sufficient, depending on the purpose of the report. At times, however, the author's purpose calls for more specifics. Just as in the description of a mechanism, a detailed and complete description of a process usually follows a common pattern.

Specific Descriptions.

Description of a Process.

1. Introduction
   a. General information as to why, where, when, by whom, and in what way the process is performed or occurs
   b. List of main steps
   c. List of components involved
2. Description of the steps or analysis of the action
   a. First main step (or sequence of events)
      (1) Definition
      (2) Special materials
   b. Division into substeps
3. Conclusion (summary statement about the purpose, operation, and evaluation of the whole process)

The following examples illustrate division 2 in the outline. The first example is a description of extrusion in processing plastics:†

> Extrusion molding is the method employed to form thermoplastic materials into continuous sheeting film, tubes, rods, profile shapes, filaments, and to coat wire, cable and cord.
>
> In extrusion, dry plastic material is first loaded into a hopper, then fed into a long heating chamber through which it is moved by the action of a continuously revolving screw [Fig. 1] At the end of the heating chamber the molten plastic is forced out through a small opening or die with the

*Alfred Friendly, "Philae, 'the Pearl of Egypt,' is Being Lifted to a Dry and Safe Setting," *Smithsonian*, February 1976, p. 48. Copyright Smithsonian Institution, 1976; from SMITHSONIAN Magazine, February 1976.

†Don Mason ed., *The Story of the Plastics Industry*, Public Relations Committee for the Society of the Plastics Industry, 1970, p. 35. Reprinted by permission.

shape desired in the finished product. As the plastic extrusion comes from the die, it is fed onto a conveyor belt where it is cooled, most frequently by blowers or by immersion in water.

In the case of wire and cable coating, the thermoplastic is extruded around a continuing length of wire or cable which, like the plastic, passes through the extruder die. The coated wire is wound on drums after cooling.

For wide film or sheeting, the plastic is extruded in the form of a tube. This tube may be split as it comes from the die and then stretched and thinned to dimensions desired in the finished film. In a different process, the extruded tubing is inflated as it comes from the die, the degree of inflation of the tubing regulating the thickness of the final film.

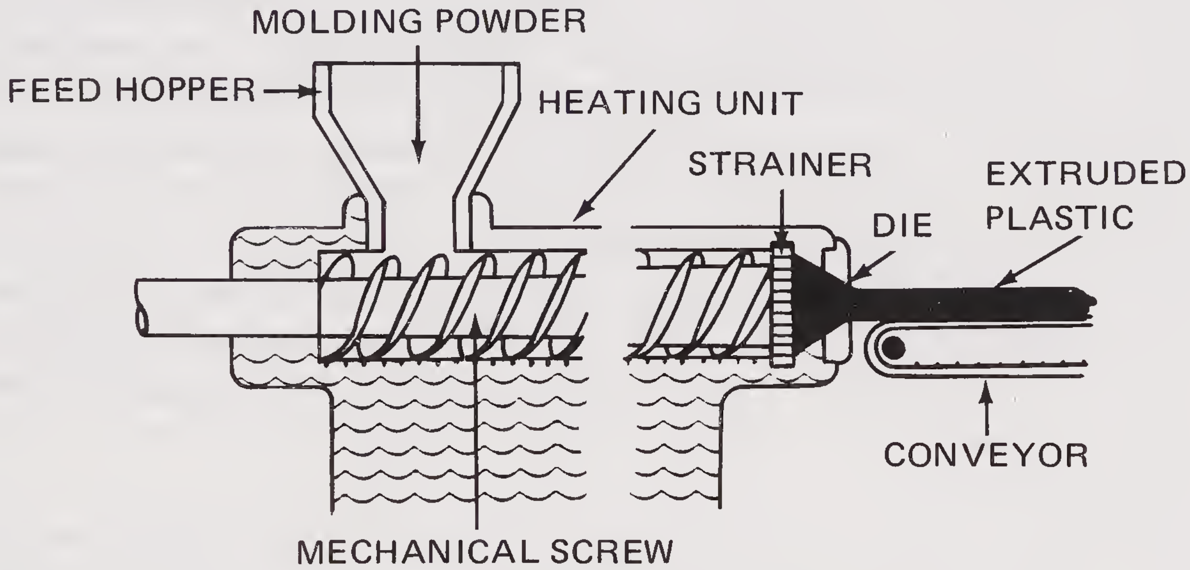


Figure 1. Extrusion Molding

At times, the steps in a process are listed and numbered as in the following example:[3]

Microbial Procedure for Surfaces of Porcelain and Plastics

1. The 2- X 2-inch squares of test materials (ABS, polystyrene, polycarbonate, and porcelain) were sterilized by immersing in alcohol. They were then placed in sterile glass petri dishes and allowed to dry. Unabraded and abraded squares were used.
2. Cultures used in the study were obtained from The Ohio State University culture collection. They were *Pseudomonas fragi*, *Mucor*, and *Salmonella oranienberg*.
3. The cultures were inoculated into nutrient broth and incubated for 24 hours. These broth cultures were diluted 1:100 in sterile 0.1 per cent peptone for the inoculation of the test squares.
4. One-half milliliter of a diluted culture was pipetted onto the surface of each sample of material. The liquid was allowed to dry, after which the petri dish containing the inoculated sample was placed in the refrigerator at 4°C. This procedure was replicated three times. A total

of eight test squares was inoculated with each organism for each replication. Duplicate plates were run at each test period (1, 7, 14, and 28 days).

5. The original number of organisms inoculated was determined by diluting the culture in peptone water, plating with plate count agar, and incubating the plates of *Pseudomonas* and *Mucor* at room temperature (21-23°C) for 48 hours and *Salmonella* at 37°C for 24 hours. To obtain the number of organisms inoculated, the count of microorganisms per milliliter of culture was divided by 2, since only ½ ml was used as the inoculum for the test materials.

6. To determine the number of survivors on the test squares during storage, two procedures were followed.

   a. With counts in excess of 300 organisms, the test squares were aseptically transferred to sterile pint jars and 100 ml of sterile peptone water was added. The jars were then shaken so that adhering organisms would be removed from the surfaces of the test materials. When needed, further dilutions were made in sterile peptone water. The resultant diluents were plated in duplicate, using plate count agar. After incubation, the number of colonies was counted with the aid of a Quebec colony counter.

   b. With counts of 300 or less, plate count agar was added to the petri dish containing the test squares and this was incubated. This allowed all potentially viable cells remaining on the plastic or porcelain surfaces to grow and multiply. Colony counts were made after incubation.

7. Incubation of *Salmonella* was at 37°C for 24 hours, *Pseudomonas* at room temperature for 48 hours, and *Mucor* mold at room temperature for 24 hours. Room temperature varied from 21 to 23°C.

8. Uninoculated controls were tested using procedure 6b. No organisms were ever observed on the control samples.

The following example is a short report that includes the description of both a mechanism and its operation:*

A WIRE STRIPPER WITH RAPID GAUGE ADJUSTMENT CAPABILITY

Abstract

This paper discusses the design of a wire stripper that is exceptionally versatile, easy to operate, and very suitable for laboratory use.

Introduction

The need for a way to conveniently strip wires of different size without requiring blade change resulted in the development of a bench-mountable stripper that is excellent for laboratory scale fabrication. Its main features are the capability to rapid-dial wire size to be stripped and semipowered stripping, which aids the operator in obtaining fast, uniform stripping without nicking the conductor.

*Howard M. Dyke, "A Wire Stripper with Rapid Gauge Adjustment Capacity," unpublished manuscript, 1971. Reprinted by permission of Howard M. Dyke.

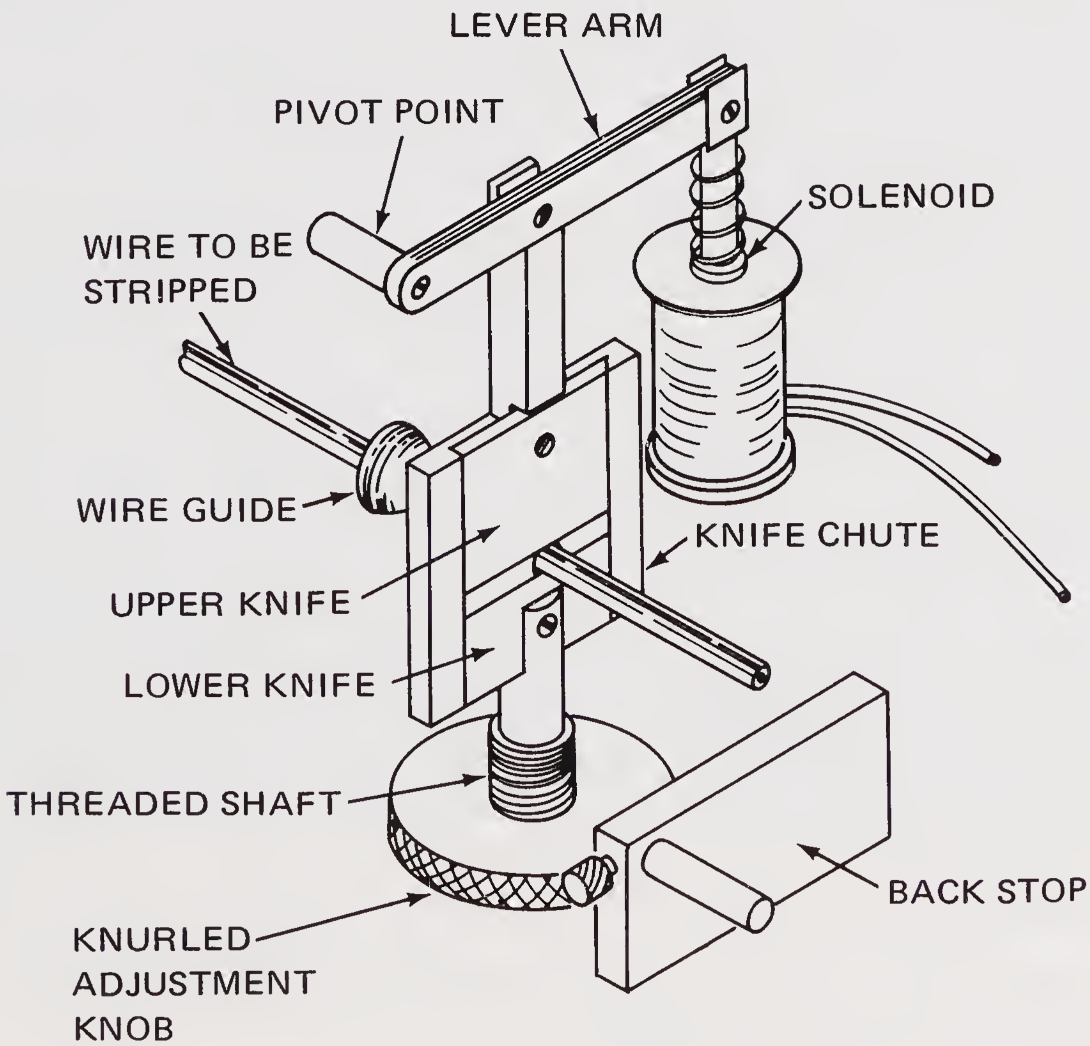
Description

The stripper basically consists of two parallel knives (refer to Figure 1). The upper knife is connected to a solenoid by a lever. The lower knife is attached to a threaded shaft. The threaded shaft fits into a threaded knurled knob. In front of the knives is a tapered wire guide for ease in positioning the wire between the knives. Behind the knives is an adjustable backstop for setting desired stripping length.

Principle of Operation

The upper blade is normally held in the up position by spring action. When the solenoid is energized, the blade moves downward a fixed distance. The lower blade is adjustable and may be moved up or down by rotating the knurled knob clockwise or counterclockwise. Therefore, separation between the blades (with the solenoid actuated) may be adjusted to correspond with the diameter of the conductor. In order to strip insulation from a wire, the wire is inserted through the wire guide and between the knives until it reaches the adjustable backstop (refer to Figure 1). The wire is now in position for stripping. A foot pedal is used to energize the solenoid, causing the knives to close. The knives cut through the insulation but stop short of cutting or nicking the conductor (see Figure 2). Finally, the operator pulls the wire in the reverse direction of insertion and the insulation remains behind. The stripping action is thus complete.

Figure 1. The Wire Stripper



Capability

The stripper is ideal for use with wire ranging in size from #30 to #18 and having vinyl, PVC, Kynar, or rubber insulation.

Summary

The wire stripper is presently in use in the Electronics Laboratory of The Physics Department of The Ohio State University. It has proven to be a very useful tool in providing fast, high-quality stripping for wire-wrapping applications.

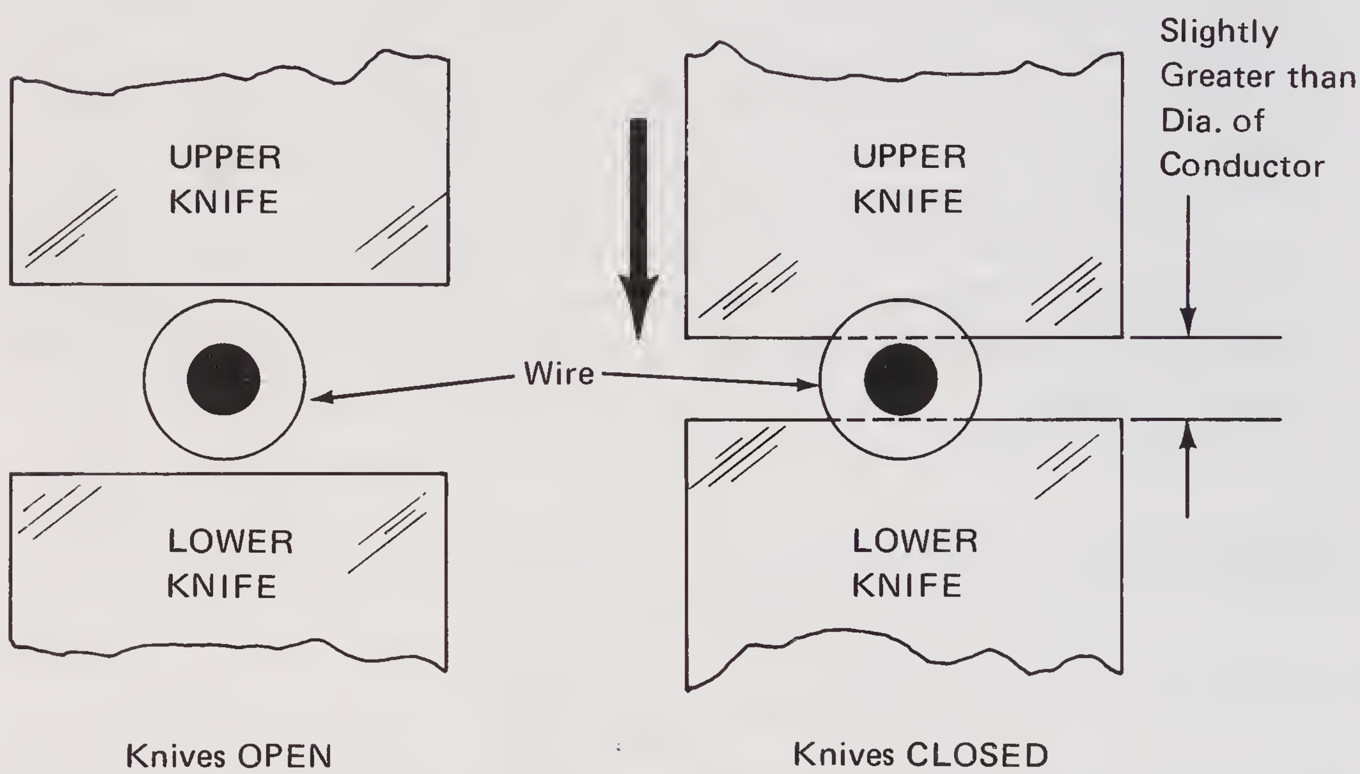


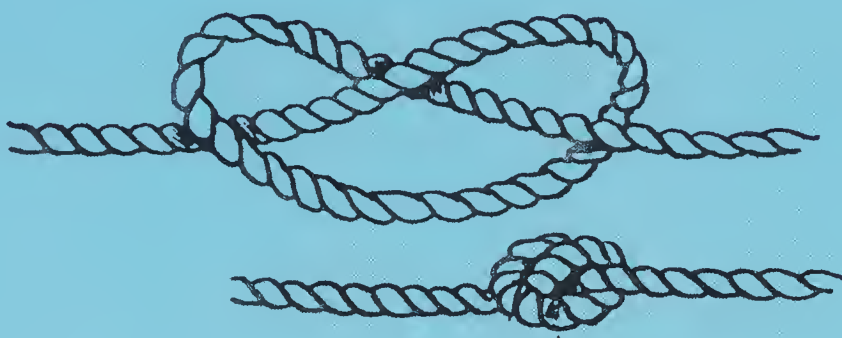
Figure 2. Insulation Cleavage

Directives. Although, technically, a directive is not classed as a description of a process, it can be viewed so because it instructs the reader on how to carry out an activity. The steps are given in sequence; none can be omitted; each step must be complete, and precautions are often included. Unlike a description of a process, the directive is presented in second person. Anyone familiar with how-to-do-it kits or operation and maintenance manuals will recognize this type of writing. Included here is a short example of a directive on tying several types of knots. Directives often begin with a definition, as does the following example.

USEFUL KNOTS AND HOW TO TIE THEM

A knot is an interlacement of parts of one or more flexible bodies, forming a lump or knot—any tie or fastening formed with cord, rope, or line including bends, hitches, and splices.

Use Stopper Knots to keep rope ends from slipping through the opening.



The Overhand Knot

This is the simplest and smallest of all knots. In general, use it only on small cord and twine, since it jams and is hard to untie, often injuring the fiber.

To Tie: Make a loop near the end of the rope and pass the end under and up thru the loop. Draw up tight.

The Figure Eight Knot

This is much easier to untie than the overhand knot—is larger, stronger, and does not injure rope fibers. It is the best knot to use to keep the end of a rope from running out of tackle or pulley.

To Tie: Make an underhand loop. Bring end around and over the standing part. Pass the end under and then up through the loop. Draw up tight.

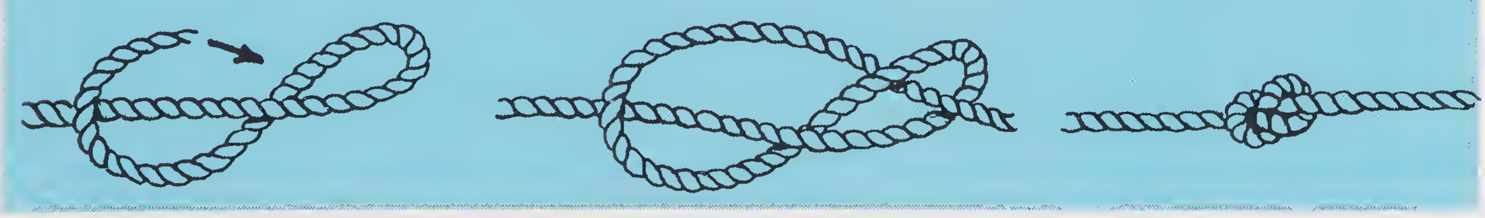


Figure 6-2. Directions, Integrating Verbal and Visual Techniques of Presentation. (From *4-H Member Manual* E.C. 7-01-67, Cooperative Extension Service, University of Nebraska, 1967. Reprinted by permission of Cooperative Extension Service, University of Nebraska.)

The Square Knot

The square knot is used to tie two cords together and is referred to as the universal package knot.

To Tie: Pass the left end over and under the right end. Curve what is now the left end towards the right. Cross what is now the right end over and under the left. Draw up tight.

Don't tie the weak granny knot. Remember that the Square Knot presents two ends lying under one loop and over the opposite loop—while the granny presents one end under and one over on both loops.

To ensure that each step is followed in sequence, a writer usually lists and numbers the steps. Thus the example on "Microbial Procedure" could have been shifted to the second person and listed by steps:

1. Sterilize by immersing in alcohol 2 X 2-inch squares (abraded and unabraded) of test materials.

2. Place in a sterile glass petri dish.

3. Allow to dry.

   And so on.

DEFINITION

Definitions state the meaning of a word or phrase; they often appear at the beginning of a long or complex description. A term is placed in a category and then how it differs from other things in that category is shown.

Definitions establish the limits of terms by inclusion and exclusion. Because language is made up of symbols standing for objects, actions, and ideas, it is important that the symbol used convey to the reader the meaning that the writer intends (Chapter 4). Although, of course, it is unnecessary to define every term, the question should always be asked, "Will my reader understand the term in the context in which I am using it?" The decision about whether to include a definition depends on the audience. To a crane operator, the term *malkiel float* (pads) might be familiar and need no definition. If one is unfamiliar with cranes, the term would have to be defined: "a *malkiel float* is an assembly for equalizing the crane weight over a broad area to reduce dock/site loading." The definition might even be expanded to describe the mechanism: "the assembly consists of eight large floats (pads), four per side, connected by equalizer beams to a transfer beam. The transfer beam is attached to the outer rigger beams, allowing the malkiel floats to be lifted and the crane to travel with the floats in one place." This example illustrates two types of definition: formal and expanded.

Actually, five types of definitions are used by technical writers: (1) formal, (2) informal, (3) stipulative, (4) operational, and (5) expanded.

Formal Definition. The formal definition is made up of the term or symbol; the genus, the family to which the term belongs; and the differentia that distinguish the term from other members of the family—color, size, material, function, shape, and so on (see Table 6-1).

Table 6-1: Parts of Formal Definitions

Term	*Genus*	*Differentia*
X-ray radiography	A nondestructive testing technique	Uses X-rays as penetrating radiation
A rain gauge	A cylindrical tube open at one end and closed at the other	Of aluminum, plastic, or glass about 5 inches long marked with a scale to measure rainfall
Turquoise	A valuable mineral	When processed becomes a brilliant blue and is used for decorative purposes: necklaces, belts, and rings

Even facetious definitions often use the formal pattern, as illustrated by a sign over the entrance of a university faculty club:

> A committee is a group of the unwilling, appointed by the unfit to do the unnecessary.

In an effort to make the following statistics meaningful to the lay reader, formal definitions of two terms—*revenue passenger mile* and *cargo ton mile*—are offered in the following newspaper item:

> Western Airlines said that June passenger mile traffic rose 9.3% to 682 million from a year earlier. That brought the year-to-date total to 3.79 from 3.26 billion in 1975's first half. *A revenue passenger mile is one paid passenger carried one mile.* Cargo tons rose 35.1% in June to 11.6% million, from the year earlier's 8.6 million, up 33.1% from 47.6 million a year ago. *A cargo ton mile is one ton of freight flown one mile.*[4]

The principal verb of a formal definition is usually some form of the verb *to be*; other verbs, however, are possible: *can be thought of as*, *stands for*, *represents*, *refers to*, and *occurs when*.

Informal Definition. Informal definitions can be used when a synonym will suffice and the author does not wish to interrupt a long explanation. A child asks, "What is an escalator?" and is answered, "It's a moving stairs." "What is a beetle?" "It's a bug." *Roof pitch* means the slope of the roof. A technical writer can use this type of definition whenever he thinks it will satisfy his reader.

Stipulative Definition. When Humpty Dumpty told Alice that "glory" meant a "nice knockdown argument," he was using a stipulative definition and defended his term to mean "what I choose it to mean—neither more nor less." Most technical writers are not quite so arbitrary as Humpty Dumpty, but they often use a stipulative definition when they wish to attribute a limited or special meaning to a term used in a particular report so that the writer and the reader will be on the same wavelength.

An author writes, "The term *pollution* as used in this report refers to the presence in the atmosphere of noxious substances, such as lead, sulfur, and carbon compounds, discharged from gasoline-propelled vehicles." With such a definition the author sets limits on his subject and ensures that the audience will not be thinking of water or soil pollution.

Operational Definition. The operational definition approaches the description of a process, although it is not presented in such detail. In this type of definition the author states his term and then explains how the term operates. A child might say rather ungrammatically, "Happiness is when you have a friend to play jacks with." A publisher or a printer uses an operational definition when he defines a four-color printing or photographic process as follows: "a method for reproducing illustrations in full color with a wide range of graduated tones and colors. When the original is photographed through color filters, the colors are separated so they can be printed from four plates with four inks: black, yellow, blue, and red. They are transferred from four different plates to a surface. In successive runs through the press the four colors, one for each plate, are combined to produce a range of tones like that of the original."

Operational definitions are popular with technical writers because they often clarify terms more satisfactorily than formal definitions do.

The dictionary, for instance, offers the following formal definition of *plaster of Paris:* "any group of gypsum cements, essentially hemihydrated calcium sulfate, $CaSO_4 \cdot ½ H_2O$, a white powder that forms a paste when mixed with water and hardens into a solid. . . ." Although the last phrase is operational, it still does not give the reader a definite idea of the process. An operational definition would be as follows: "*plaster of Paris* is the cementlike product that results when $CaSO_4 \cdot ½ H_2O$, a white powder, is added to a container partially filled with water and stirred until it forms a slurry that eventually solidifies through chemical reaction."

Operational definitions are particularly effective when a specialist is writing for an audience of nonspecialists.

Expanded Definition. At times, terms defy a short, complete definition and must be expanded for clarification. Several methods or their combinations can be used to expand a definition: word derivation, comparison and contrast, analogy, and example, along with visuals.

derivation: The prefix in the term *ecology* comes from the Greek *oikos*, house or place to live, but science has broadened the term *ecology* to include the science of relationships between organisms and their environment. Early ecology involved the study of food sources and ways to obtain food, but today ecology is the study of whole organisms that comprise an ecosystem—a system that includes the interrelationships of organisms, population, communities, and biospheres.

comparison and contrast: A diesel is similar in design to a conventional engine except that it is more heavily constructed.

It needs to be stronger to withstand extremely high compression ratios—22:1 versus 9:1 for a conventional engine. The diesel uses this high compression to ignite its fuel mixture by heat and pressure, thus eliminating the need for an ignition system. Also, the high compression allows the diesel to operate on a much cheaper grade of fuel than that necessary for the conventional engine. The extremely high heat and pressure result in much more efficient combustion, producing very low emission as compared to the conventional engine.

Comparisons are valuable in almost any type of expository writing to clarify definitions or points to be made. Harlow Shapley in *Beyond the Observatory* compares the earth with Venus:

> We assume that the earth and Venus are of the same age and of the same parentage. Their orbits are much alike. Yet Venus is severely cloud-bound; the earth nearly clear of clouds. Our planet's atmosphere is mostly nitrogen and oxygen; Venus's mostly nitrogen and carbon dioxide. The earth has a temperature variation and an agreeable climate that permit over most of its surface a remarkable protoplasmic adventure (life). Venus, on the other hand, is not agreeable. It has a surface temperature that according to recent radio telescope measures is above 800 degrees Fahrenheit. Such temperature should make the space traveler hesitate about landing; he might find, as did Icarus before him, that near approaches to such hot spots as the sun would surely unglue him.*

analogy: An ecosystem is similar to a computer or any mechanical device that has many intricate and related parts. If even the smallest component breaks down, ceases to work, or is damaged, the machine will not function properly. So also, the ecosystem is damaged by problems caused by man, who has upset the delicate balance of nature. Ecology has become the study of environmental mistakes and their effects on the ecosystem.

An analogy cannot be offered as proof. An analogy is nevertheless helpful because it makes use of the familiar. In trying to explain to his patient what a spinal disc is, the doctor compares it to a grape with a tough outer skin, plus a pulpy interior that provides fluid cushioning as a person moves or when tensions cause the person to set the back muscles. The process is like cocking a gun: with the muscles preset, even a minor twist or strain can trigger a painful spasm in the back.

The following expanded definition depends on several devices:

**Beyond the Observatory*, Charles Scribner's Sons, New York, 1967, pp. 84-85. Reprinted by permission of Charles Scribner's Sons.

Informal def- inition

The word *symbiosis* is sometimes restricted to intimate reciprocal relationships. But sometimes—and more properly—it is used in a very broad sense to cover all close relationships between two different kinds of organisms. The word essentially means "living together."

Inverted stipulative def- inition

An orchid growing on a branch of a tree is living in close association with the tree. As far as we can tell, the tree gets neither benefit nor harm from the orchid, but the orchid definitely gets the benefit of a place to grow, a perch. This sort of relationship—benefit to one partner and neither benefit nor harm to the other—is often called *commensalism*. Barnacles growing on a whale would be another example—the barnacles get transportation. Cockroaches in the kitchen could be regarded as commensal, since it is difficult to demonstrate that they cause either harm or benefit to the housewife though the cockroaches get the benefit of a warm place to live and easily available food scraps. But cockroaches may annoy the housewife and there is a nice gradation between the annoyance of cockroaches for the housewife and the annoyance of fleas for a dog. The alleged benefit dogs get from fleas is very questionable, and they clearly are living directly at his expense, so we call this relation *parasitism*. But where both partners easily benefit, as with fungus and the alga in the lichen, we call the relationship *mutualism*.*

Operational def- inition

Expanded definition

Examples

Besides being an integral part of the description of objects and processes, definitions can appear elsewhere in a report: in glossaries (usually formal), in introductions (usually stipulative), and in footnotes.

Argument

It might appear that argument has no place in an objective report, but argument means not only a more or less violent dispute between two or more contenders but also a course of reasoning intended to prove or disprove a hypothesis by presenting evidence to support it. Students will recognize that it is this type of argument that becomes part of a persuasive report. Such reports are designed to get a reader to accept the validity of information, follow a course of action, or accept the expediency of a change.

Constructing an effective argument poses the problem of how to present reasoning—induction, deduction, and causal relation—that will enable the report to accomplish what it is supposed to: to get someone to think or act in a way that the author believes is best. Practically all proposals and decision-making reports employ argument. (See Chapters 9 and 11.)

*Marston Bates, *The Forest and the Sea*, Random House, New York, 1960, pp. 151-52. Copyright Random House, Inc.; reprinted by permission.

A number of logical reasoning processes are used in argument. All discourse, whether spoken or written, that attempts to reason uses (or misuses) certain principles of logic.

Universally recognized are two types of reasoning: deduction and induction. Both have the same goal—to prove something. But they differ in their methods of accomplishing their purposes. Reasoning deductively we start with an accepted fact: all men are mortal; Socrates was a man; therefore, he was mortal. It is an argument from the general to the specific or a particular. With induction, however, we set out to prove the statement that all men are mortal by citing a long list of men who have died and the fact that there appears to be no record of an exception. Induction is an argument from the specific to the general. Both types of reasoning have hidden traps, fallacious arguments in deduction (as discussed in Chapter 3), and incomplete or inaccurate general statements in induction.

DEDUCTIVE REASONING

Anyone who is addicted to reading mystery or detective stories is familiar with deduction. The murder or crime is known (generalization) and the plot consists of the process of discovering why it was committed and by whom. It is also the type of reasoning generally used in applied science and mathematics (inductive reasoning is commonly used in pure science). Deduction is based on a syllogism, that is, a statement of a generalization—a universal—and its application to a particular. Thus one moves from a general truth or assumption to a particular conclusion. We can say:

All number six screws belong in bin X.

This is a number six screw.

Therefore it belongs in bin X.

Although this type of reasoning is used daily, it is rarely set up in the form of a syllogism. In our conversations we do not include all the elements of a syllogism. We look at a wet road and say, "This road must be slippery." Clearly, we have bypassed "All wet roads are slippery." However, skipping too many steps in reasoning will puzzle the listener or reader. One student who received a failing grade insisted that unless the grade was changed his father would go into bankruptcy. Only after he supplied the missing steps did the announcement make any sort of sense: If he failed, he would have to attend summer school; his father would have to hire additional help on his farm; this would cost a considerable amount of money and so his father would be forced into bankruptcy.

The construction of a syllogism has been greatly simplified in this text. It is actually a complicated process, the subject of a number of books entirely devoted to logic.

INDUCTIVE REASONING

Induction is the reasoning used to discover universal truths, theories, laws, and principles—by examining a number of particulars or establishing recurring patterns. It is a process used in our daily lives. A nurse may discover through constant use that Dove keeps her hands softer than do other soaps. A driver may decide that the use of high-octane gas takes the knock out of his automobile engine.

Often laymen do not realize that they are using inductive reasoning, although scientists are quite aware of the process. Sufficient amounts of DDT will kill off certain species of birds. The Surgeon General has determined that cigarette smoking is dangerous to your health. Based on induction, doctors declare that an increased risk of thromboembolic disease (blood clots) results from use of the birth control pill. This type of reasoning relies on evidence—sufficient evidence to justify the final claim.

Some generalizations are the product of personal judgment or prejudice, not scientific reasoning: Cadillacs are the best cars on the market. Advertisers are very likely to state a generalization without including sufficient evidence to prove their statement. The manufacturers of the Mercedes Benz state that their car is "engineered as no other car on earth," a blatant generalization and in reality an ambiguous statement. To prove this contention, all cars on earth would have to be compared for their engineering.

The inductive arrangement of a report is useful when the writer anticipates that the reader will resist the conclusions. From a psychological standpoint such a reader needs to be acquainted with the facts before he is presented with the conclusion.

CAUSAL RELATIONSHIPS

Both induction and deduction are employed in reasoning from cause to effect and from effect to cause.

Cause to Effect. When one reasons from cause to effect, he predicts what effect the cause or causes will have, that is, that certain causes will result in certain effects. If we combine two parts of hydrogen with one part oxygen, we obtain water. Ingestion of too much of an alcoholic beverage results in a hangover. We observe lightning streaking across the sky and we listen for the thunder; we expect thunder because the pattern has occurred over and over.

Working from cause to effect is often complicated because we deal first with a necessary cause; that is, if a condition precedes a situation and the situation could not occur unless that condition existed, we have a necessary cause. But the necessary cause may be accompanied by any number of contributory causes. Low wages may result in low morale, but low morale may be attributed to other causes as well: lack of safety precautions, inadequate health protection, and the absence of fringe benefits. Another example is the statement that sodium chloride causes potholes in highways. Because concrete is porous, the salt penetrates the concrete until it reaches the reinforcing steel beneath. When the salt reaches the steel, the steel rusts and the rust occupies a larger volume of space than the steel from which it came. The expanding rust then cracks out the concrete, forming potholes. And, of course, potholes can result from other causes as well.

Effect to Cause. Reasoning from effect to cause is almost a daily exercise. There is a certain effect. What caused it? An airplane plummets to the ground, killing all its passengers. Immediately investigators rush to the scene to try to ascertain the cause, no easy task because of the many possibilities. A car stalls on the highway. Why? Lack of gas, faulty ignition, or some other cause? Instead of reasoning forward as in cause to effect, we reason backward from effect to cause.

Marston Bates, in *The Forest and the Sea*, is reasoning from effect to cause when he writes:

> The green of the landscapes is due to the chemical nature of chlorophyl just as the red of blood is due to the chemical nature of hemoglobin. The colors are incidental or accidental consequences of the chemical structure of the molecules of substances that play important parts in the chemistry of living. A variety of colors may thus be an incidental consequence when chemical processes alone have free sway. Ordinarily the free play of colors resulting from these chemical processes is masked and controlled by biological processes. The green of the chlorophyl is chemical, and chlorophyl, the basic substance through which plants build up starch from carbon dioxide by capturing energy from the sun, dominates the living world on land. The seed plants, with sporadic exceptions, have not masked this green of chlorophyl with other pigments. Insects, birds, lizards, a host of animals living among foliage, then also become green—not as a consequence of their chemistry, but because green serves a biological purpose, to make them inconspicuous either to their enemies or their prey.*

**The Forest and the Sea*, Random House, New York, 1960, pp. 64-65. Copyright Random House, Inc.; reprinted by permission.

In the discussion of causes the author should make clear his purpose and intentions: to predict a certain effect or to establish the causes for the effect.

NOTES

1. *The Origin of Species*, Modern Library, New York, 1936, p. 24.
2. *Mont-Saint-Michel and Chartres*, Riverside, Cambridge, 1936, p. 44. ,
3. Fern H. Hunt, Harriet Harris, Clarissa Bloom, "Performance of Selected Materials Used in Liners and Drawers of Regrigerators," *Ohio Agricultural Research Bulletin 1058*, pp. 15-16.
4. Columbus (Ohio) *Citizen-Journal*, August 10, 1976.

EXERCISES

1. What techniques discussed in this chapter *dominate* the following selections?

   If the craters were excavated by artesian waters welling up from underground, those waters must have had a means of escape on the surface. In other words, there should have been outlet channels leading from the craters, and those channels should still be visible where spring waters are still flowing or where they ceased to flow so recently that the channels have not yet been buried by drifting sand or other deposits.

   —Aaron Seyvetz

   X-radiography is a nondestructive testing technique that uses X-rays as penetrating radiation. Neutron radiography is a nondestructive technique that uses neutrons as penetrating radiation. The image obtained in an X-ray is dependent on the densities of the materials being examined. The image obtained in a neutron radiograph is dependent on the neutron cross-sections of the materials being examined.

   —Kevin Kok

   Although mathematical proof is necessarily deductive, the creative process practically never is. To foresee what to prove or what chain of deductive arguments will establish a possible result, the mathematician uses observation, measurement, intuition, imagination, induction, or even sheer trial and error. The process of discovery in mathematics is not confined to one pattern or method.

   —Morris Kline

   The geologist deals with the rocks; the biologist with conditions and phenomena of life; the astronomer with stellar masses and motions; the mathematician with the relations of space and number; the chemist pursues his atoms; while the physical investigator has his own large field in optical, thermal, electrical, acoustical, and other phenomena.

   —John Tyndale

The medical profession and laity, too, have learned the painful truth that tranquilizers are not an unmixed blessing. Side effects such as unpredictable periods of drowsiness, confused mental states, and even suicidal tendencies are an extravagant price to pay for temporary peace of mind. The possibilities of these and other side effects are not known well enough by many doctors and still more patients. Communication of the facts has been inadequate.

—Joseph F. Montague

Plastics are man-made materials, in contrast to nature's materials like wood and metal. They are any one of a large and varied group of materials consisting wholly or in part of combinations of carbon, hydrogen, nitrogen, and other organic and inorganic elements that, although solid in the finished state, at some stage in their manufacture are made liquid, and thus capable of being formed into various shapes, most usually through the application, either singly or together, of heat and pressure.

—*The Story of the Plastics Industry*

As recently as 80 years ago, no reliable pyrometer existed that was capable of measuring the temperature used in ceramic kilns. The "thermocouple and galvanometer" method did not come into general use until after the turn of this century.

Photocomposition means that the text is set not with metal type but on a film negative—the same that is used in a Brownie camera. The negative emerges from the typesetting machine as a positive print. The photocomposition process, computer driven, permits the reporter to type his story, and then place it into an optical scanner device that reads his story and through electrical impulses activates the typesetting film machine.

The Detroit Civic Center Commission has done a commendable job in establishing the Cobo Hall-Convention arena, which is the largest convention and exhibit facility in the world, including 2.3 million square feet of floor area and costing $110 million. The rooftop parking of 1300 cars on Cobo Hall is also the world's largest of such facilities thus far constructed. Located on the Detroit River directly across from Windsor, Canada, this Civic Center Complex fills 27 acres of land in the 75-acre Civic Center area and is magnificent by any standard of comparison.

Insecticides have an excellent safety record. Never hesitate to use insecticides; just be sure to use them properly and safely:

1. Read the label.
2. Observe and follow all regulations.
3. Store pesticides away from children, animals, and irresponsible people.
4. Always keep chemicals in original and labeled containers.
5. Dispose of empty containers safely.

2. Description of a process: Which terms could be classified and which partitioned?

a. scissors
b. sheep
c. books
d. smoke detector
e. transportation
f. pollution
g. an alarm clock
h. student organizations
i. television shows

Beginning with a formal definition, supply an operational definition of each term.

3. Furnish a directive on how to operate a simple device.

4. Believing that an expanded definition is necessary for the reader's understanding, choose a term and expand it.

5. Give a general description of an object or a piece of equipment. Next describe it specifically and include the components, their relationship to each other and to the whole.

6. Describe in words a simple mechanism or an uncomplicated object. Do not identify it. Exchange your description with another student and ask him or her to provide a drawing or sketch to accompany the description.

7. Provide a sketch or a drawing for another student and ask him or her to supply the necessary words to accompany the sketch.

8. Write a short introduction in which you stipulate the meaning you attribute to a term used throughout the report.

9. Analyze the following statistics:

   By grade eight, 20 per cent of all U. S. children have dropped out of school. At the end of grade 12, it is 45 per cent. At the end of college's sophomore year, 89 per cent are not in school. At college graduation time, only 10 per cent are left of the millions of boys and girls who began school at the age of 5 or 6.

CHAPTER 7

Techniques of Presentation: Visual

As important as words are, few technical writers rely on words alone. There is nothing surprising in this. When an engineer or scientist is asked to explain something—an object or a process—his first instinct is to pick up a pencil and sketch a picture. He is well aware of the value of visual devices; indeed, he often thinks visually. Thus in almost any presentation he depends not only on words but also on the visual techniques available to him: tables and figures.

Tables arrange related items—usually numbers, sometimes words—in rows and columns. An effective table organizes, classifies, and condenses material. It establishes meaningful relationships.

Figures, sometimes called illustrations, are graphic displays of information: graphs (curves), diagrams, charts, pictograms, photographs, maps, and drawings. Illustrations speak a universal language; they display material that is difficult to convey in words.

Technical writers handle these visuals in one of two ways. Before writing their reports, scientists and engineers often analyze their raw data and then use graphic devices to arrange and interpret their findings. These graphics become the basis for the report. On the other hand, a technical writer may write his report first and add visuals where needed to assist the reader in understanding.

The purpose of tables and figures is to tell a story more completely, more clearly, more forcibly in less time and less space than prose description can. For the author they require fewer words (not less time), they furnish a means of condensing material, and they emphasize a particular point.

For an audience they enhance readability. A reader's first impression of a document is greatly influenced by tables and figures; he is attracted to the document if the graphics are clear and effectively presented. He remembers a concept better if he associates it with a picture. Tables and figures tend to vary the pace of a document by presenting information at high density and breaking up the text with white space. They contribute a dramatic effect, complement the text, and epitomize or emphasize important data. They serve as a springboard for a textual discussion that follows or as a summary that recapitulates a preceding discussion.

This chapter by no means treats the subject of tables and figures completely, but it suggests guidelines for selecting the appropriate method of presentation and integrating graphics with the text. A list of books that discuss these techniques in detail is included in Appendix B.

Principles of Use

The four guidelines that follow apply to both tables and figures; specific advice for each form is given later.

1. Match the form of presentation to the purpose of the report, the material, and the audience. Know the audience's ability to understand graphics as well as its capacity for understanding technical terms. For instance, technically trained audiences can understand graphs that plot logarithmic functions. General audiences may not be able to comprehend these but may be appealed to with photographs, maps, uncomplicated diagrams, drawings—even cartoons. A clever drawing can add humor to a report as well as make a pertinent point. Know the capabilities of each graphic device.

2. Make the table or figure readable. Simplify the material as much as possible. Select data carefully. Avoid irrelevant details and don't clutter the table or figure with too much information. Construct graphics to a scale large enough that they can be read accurately and without undue effort. Surround them with plenty of white space to avoid a crowded appearance.

3. Construct the table or figure so that it is self-sufficient. Each table or figure requires a title or caption that says briefly—but completely—what it is about. Subtitles may be necessary to keep the main title from becoming too long. Tables and figures should be numbered in reports and technical articles. The number allows the author to refer easily to a graphic that is integral to the development of the text. In tables the title and number are placed at the top. In figures they appear generally at the bottom (although practice varies). Whatever information the reader needs to interpret the data should be included in the table or figure itself. Delete from tables and figures any internal codes or identifications that are meaningless to the reader, for example, "run #11," "alloy 60," or the date of the run.

4. *Integrate each table or figure with the text.* A graphic device used in a report functions as part of the text. Its relationship to the text must be made clear. Left to their own devices, readers may interpret graphics in different ways. To make sure the reader sees the table or figure right, the author discusses it. The amount of discussion needed depends on the audience's sophistication and the relative importance of the graphic. The author may use the textual discussion to tell the reader how to read the table or figure—what he should see—or to highlight the main points. He may make the graphic the subject of a full sentence of introduction. If so, he should be specific:

poor: Figure 2 gives a typical waveform.

better: As shown in Figure 2, the beginning of each heartbeat is detected as a large, positive spike in the differentiated pressure waveform.

Or the reference to the graphic may be contained in parentheses:

The beginning of each heartbeat is detected as a large, positive spike in the differentiated pressure waveform (Figure 2).

Determining How Many Graphics to Use

Two general questions remain to be answered concerning tables and figures: how many and where.

The answer to "how many" is somewhat like Lincoln's reply when asked how long a person's legs should be: "Long enough to touch the ground." The writer should use as many graphics as are meaningful and necessary. One major responsibility of the writer in planning his report is to assign material to either the verbal or visual form and to decide whether a figure or a table is more appropriate. The text can generalize and explain; the visual can give the details and facilitate correlations, especially among numerical values. The information in the following passage is not particularly clear:

TEMPERATURE AND SNOW REPORT, WEEK OF JANUARY 9-15

Monday's high temperature was 30°. Tuesday's high was 25°. Wednesday's high was 28°, followed by 32° on Thursday, 35° on Friday, 37° on Saturday, and 30° on Sunday. The average high temperature for the week was 31°.

The snowfall for the week totaled 14 inches. It did not snow on Wednesday, Friday, or Saturday. It snowed 4 inches on Monday and 7 inches on Tuesday, a total of 11 inches for the first 2 days. Average snowfall was 2 inches a day for the week.

However, this information presented in a table is much easier to grasp:

Table 1. Temperature and Snow Report, Week of January 9–15

Day	*High Temperature (°F)*	*Snow (inches)*
Monday	30	4
Tuesday	25	7
Wednesday	28	0
Thursday	32	1
Friday	35	0
Saturday	37	0
Sunday	30	2
	average high, 31	Total snow, 14 Average daily snow, 2

Students sometimes see graphics as stuffing to fill the gap between the 10-page report they have written and the 25-page report they were required to write. This is obviously a faulty use. So is the use of graphics for mere showmanship. The writer has to assess his audience's needs, as with any kind of presentation, and then fit the graphics to those needs—and to his own skill at using graphics. In some instances the number of graphics, especially those in color, is limited by their expense.

Placing Graphics in the Text

Graphics can be placed almost anywhere that is convenient. Some are placed in wide margins left for the purpose on the nonbound side of a page (see, for example, *The American Heritage Dictionary*). Most often they are placed within the text itself in space left between the lines or on separate pages inserted either before or after the discussion to which they are relevant. They can also be included in an appendix, especially when they pertain to the whole report rather than to one section or when they are merely supplemental. For example, tables placed in a report as a matter of record and not essential to the text can rest comfortably in an appendix. But an appendix can become an unused attic unless the writer selects carefully what he allows to be stored there and refers in the text to the figures or tables.

Tables

The information best suited to expression in a table is information that can be grouped into categories, especially statistics. A fully developed table records data concisely and facilitates rapid comparisons and interpretations. It collects statistics that would lose emphasis if spread out in sentences and supplies information for ready reference and comparison.

Two types of tables are commonly recognized: informal (tabulations) and formal. Informal tables are slightly expanded lists. They are placed in the text after an introductory sentence (usually stopping at a colon before the table.) They have no title or number and are referred to only once. Most have fewer than five lines. Figure 7-1 is an example of an informal table.

Formal tables, on the other hand, adhere to a more complete set of conventions of presentation. The title (and subtitles, if necessary) is *always* at the *top* of the table, never below. Each column also has a heading that identifies both the items mentioned in the column and the units in which the quantities are reported. (Put units of measurement in the headings rather than after each entry.) The items are listed within the columns in sequence: chronological, alphabetical, quantitative, or geographical. Information in the table may be referenced by footnotes appearing below the table. Superscript letters (^{a}, ^{b}, and so on) or signs (*, †, and so on) may be used to key the data to their source. Figure 7-2 shows a table with its parts identified.

Figure 7-1. An informal table, integrated with the text of a report.

The bank buildings we'll visit are described briefly below (all are on Chestnut St):

Address	Name	Date of Construction	Architect
ne cor 2nd	Corn Exchange	1901	Newman, Woodman and Harris
ne cor 3rd	Borie Counting House	1896	Wilson Eyre, Jr.
420	2nd Bank of U. S.	1818-24	William Strickland
315	First N. B. of Phila.	1865	John McArthur, Jr.
323	Philadelphia N. B.	1898	Theophilus Chandler

Although the table in Figure 7-2 reads vertically (that is, it is set broadside on the page), a table is of course set upright when it fits within the width of the page. Two factors influence whether the data *within* a table should be placed in columns (vertical) or rows (horizontal): (1) numbers can be compared more easily in columns than in rows; (2) the length of rows is limited by the width of the page, whereas columns can be carried onto another page. If a table is set broadside like that in Figure 7-2, it should begin on a right-hand page, with the top toward the inner margin. Usually when tables are included within the text they are set off by several typing spaces from the surrounding prose. A line may be drawn beneath the title and below the entire table. The table may also be boxed. Vertical lines are not drawn between columns unless they are necessary, as in very long tables (they are expensive to set into type); usually, the groupings can be adequately expressed by appropriate spacing within the table.

Most important, the table should be unified. Like a sentence or a paragraph, it should display one subject with distinctness and not trail off into unnecessary details. It should be clear, accurate, and economical. Table *A* in Figure 7-3 is badly designed; Table *B* is a better version.

Figures

The term *figure* or *illustration* refers to a wide variety of graphic devices. These devices can be dramatic as well as informative—like the photograph of the earth from the moon or a sharply rising line on a graph of profits. They are often understandable at a glance and readily interpreted. They invigorate a presentation.

Before including a figure in a document the writer should ask himself certain questions. Is the figure really needed? Does it convey information or reveal significant features more effectively than a full prose discussion or a table? Is it in the medium best suited to the purpose? And, if relevant, will it take the necessary reduction for publication or can it be folded to fit the 8½ × 11 inch format? The drawing of figures requires good scientific sense as well as a draftsman's hand and an artist's eye.

GRAPHS

Like tables, graphs are used to display data. They are mathematical tools (now often drawn directly by computers). In a line graph the data points are plotted on coordinate paper and are joined by a continuous line to form a curve or straight line. Such a graph is useful in indicating trends, rates of change, points of inflection, and interpolated or extrapolated values. A graph may not be so detailed or accurate as a long table, but it is easier to comprehend quickly.

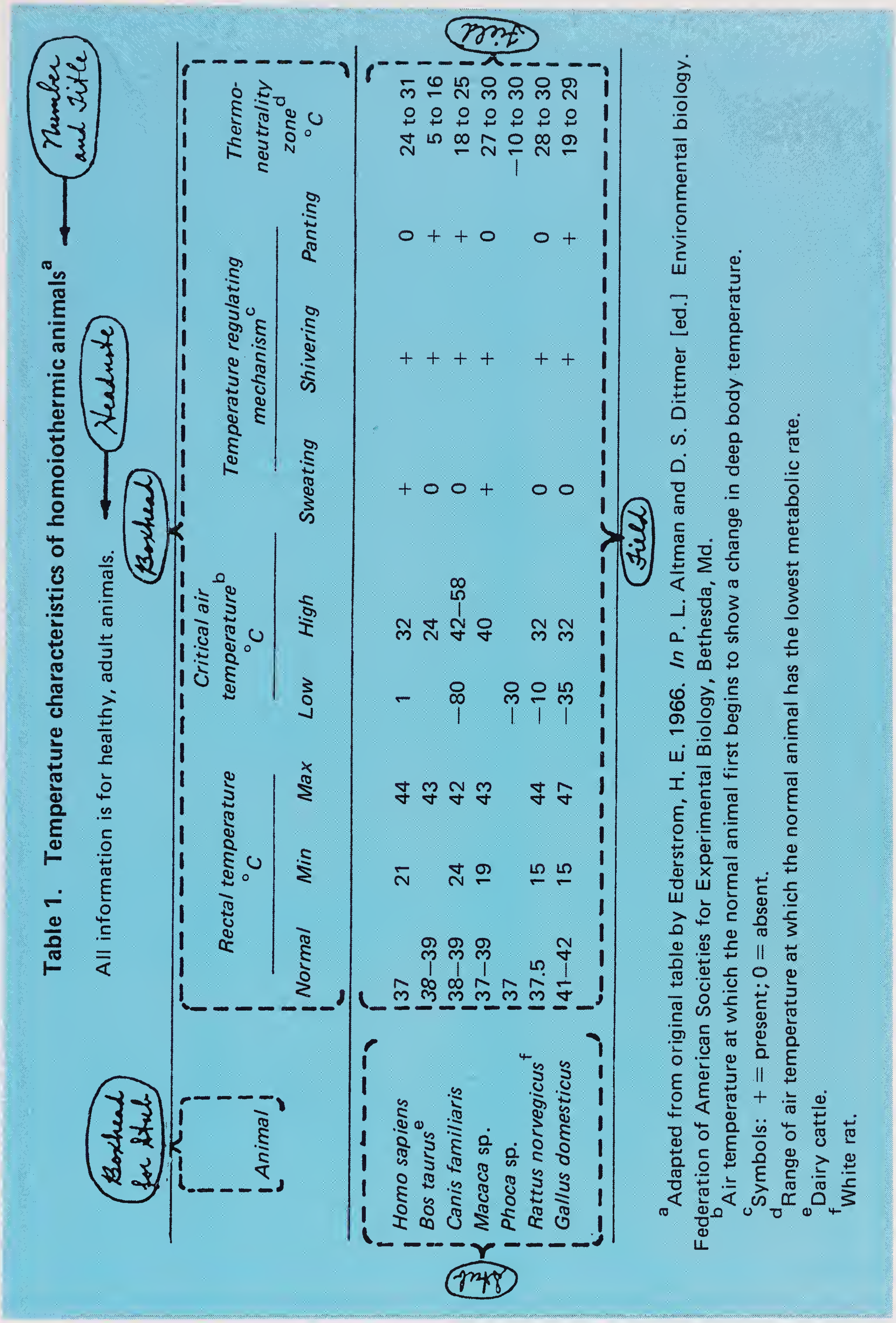


Table 1. Temperature characteristics of homoiothermic animals[a]

All information is for healthy, adult animals.

Animal	Rectal temperature °C			Critical air temperature[b] °C		Temperature regulating mechanism[c]			Thermo-neutrality zone[d] °C
	Normal	Min	Max	Low	High	Sweating	Shivering	Panting	
Homo sapiens	37	21	44	1	32	+	+	0	24 to 31
Bos taurus[e]	38–39		43		24	0	+	+	5 to 16
Canis familiaris	38–39	24	42	−80	42–58	0	+	+	18 to 25
Macaca sp.	37–39	19	43		40	+	+	0	27 to 30
Phoca sp.	37			−30					−10 to 30
Rattus norvegicus[f]	37.5	15	44	−10	32	0	+	0	28 to 30
Gallus domesticus	41–42	15	47	−35	32	0	+	+	19 to 29

[a]Adapted from original table by Ederstrom, H. E. 1966. *In* P. L. Altman and D. S. Dittmer [ed.] Environmental biology. Federation of American Societies for Experimental Biology, Bethesda, Md.

[b]Air temperature at which the normal animal first begins to show a change in deep body temperature.

[c]Symbols: + = present; 0 = absent.

[d]Range of air temperature at which the normal animal has the lowest metabolic rate.

[e]Dairy cattle.

[f]White rat.

Figure 7-2. A formal table set broadside on the page. (From Committee on Form and Style of the Council of Biology Editors, *CBE Style Manual*, 3rd ed., American Institute of Biological Sciences, Washington, D.C., 1972, p. 138. Used by permission.)

Table A: Comparison of Results

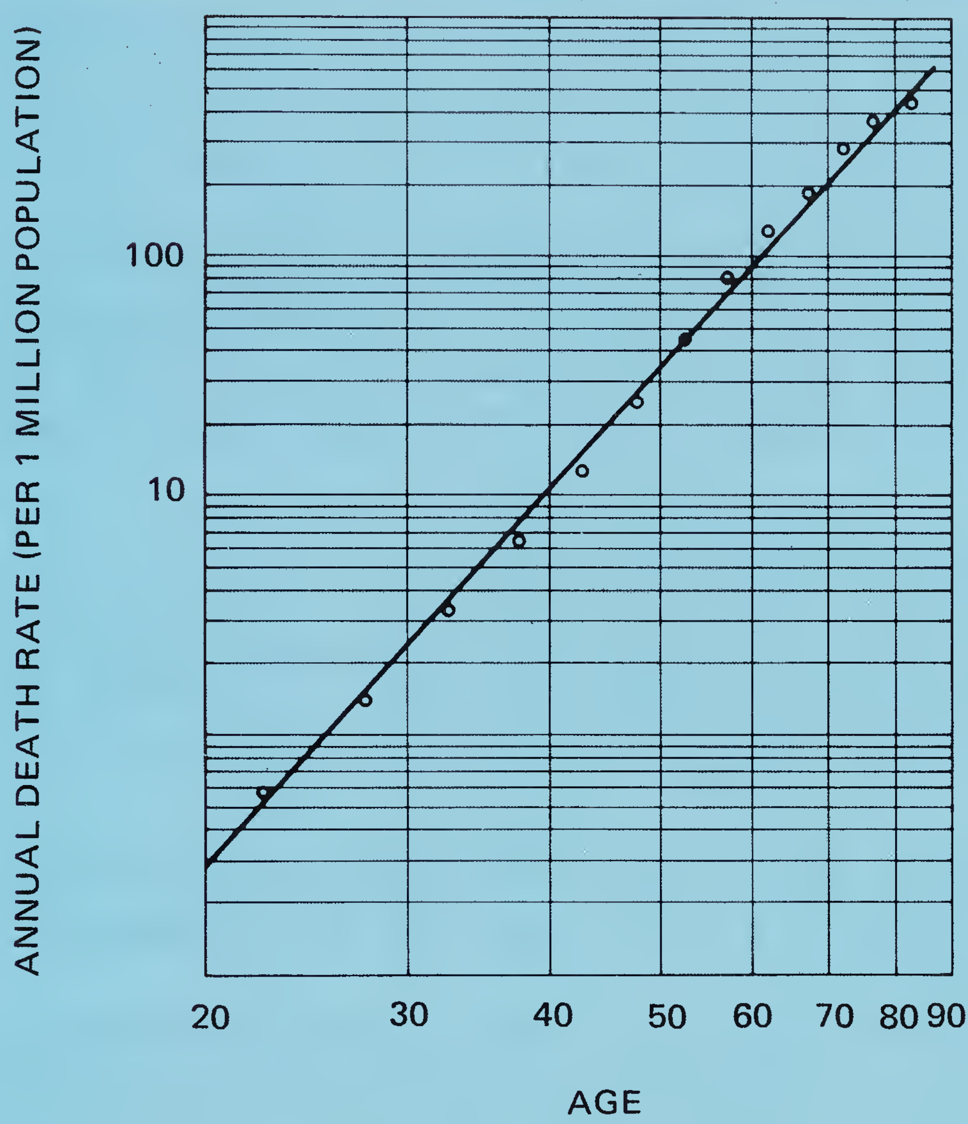
Sample Number	Description	A (lb)	B (lb)	C (lb)	Average (lb)
367	XXXXXXX	5.1	5.2	5.2	5.2
384	XXXXXXX	5.4	5.8	6.8	6.0
506	XXXXXXX	5.6	5.6	6.2	5.8
732	XXXXXXX	8.2	8.7	9.2	8.7
847	XXXXXXX	5.2	5.4	5.7	5.4
963	XXXXXXX	5.1	5.8	6.1	5.7

Table B: Comparison of Results Reported by Universities in Three Countries

Description	England (lb)	France (lb)	USA (lb)	Average (lb)
XXXXXXX	8.2	8.7	9.2	8.7
XXXXXXXX	5.4	5.8	6.8	6.0
XXXXXXX	5.6	5.6	6.2	5.8
XXXXXXX	5.1	5.8	6.1	5.7
XXXXXXX	5.2	5.4	5.7	5.4
XXXXXXX	5.1	5.2	5.2	5.2

Figure 7-3. Table arrangement. (Used by permission of Dolores Landreman, Battelle-Columbus Laboratories.) Table A is defective in important respects: (1) the headings are not adequate, (2) the column of sample numbers is not necessary and appears to establish a trend that is actually meaningless, and (3) natural trends are not revealed. Table B is superior in all three respects.

Figure 7-4. A line graph. (From "The Cancer Problem" by John Cairns.



OLD PEOPLE compose the subpopulation that is most conspicuously at risk in the development of cancer. The incidence of almost all forms of cancer increases dramatically with advancing age. Here the U.S. death rate from a representative cancer, that of the large intestine, is plotted against age. It can be seen that the logarithm of the death rate is linearly related to the logarithm of age. The relation can be explained by the hypothesis that several mutations are required to generate a cancer, and that the probability of each mutation is proportional to age. The slope of the line suggests that the number of mutations required is five.

Figure 7-4 is a graph from *Scientific American* that plots the U.S. death rate from cancer of the large intestine with respect to age. It follows certain conventions of graphs. The two axes (sides) are labeled; generally, as here, the horizontal axis (the abscissa) plots the independent variable, the vertical axis (the ordinate), the dependent variable. Units of measurement are indicated on each axis.

This figure is accompanied by a fifteen-line caption that explains the graph at some length. The caption is useful to the reader who wants to understand the graph without reading the text. In more technical publications and reports, figures usually have only a number and a brief title. The title may appear either above or below the figure, and usually it is outside the rectangle enclosing the grid. A figure number may appear either above the title on a separate line or run in with the title. The title should be informative:

poor: Figure 2. Pressure waveform.

better: Figure 2. Differentiated pressure waveform showing beginning of each heartbeat.

Where possible, the title should not merely restate what the labels on the axes say but should rather be an interpretation of what the graph means.

To facilitate comparisons, more than one curve may be plotted on the same set of coordinates. The curves can be differentiated by being drawn in various ways (different combinations of dots and dashes) or in different colors. Sometimes, when a graph contains several curves, labeling each curve directly may be difficult or may clutter the graph. Then a key and legend are necessary. They may be boxed within the grid or below it. The graph itself should be kept as free as possible of supplementary data (Figure 7-5).

There is a limit to how much can be shown on one plot. Often a series of sequential plots is effective. The curve or line should record the information as the original instruments did; if the recording was continuous, no data points should be shown. An appropriate scale or scales should also be chosen. Sometimes a plot of the total behavior of a parameter or measured quantity can be supplemented with an insert that details an important segment in magnified scale. For example, a plot of weight change over a 2-day period might include an insert showing the behavior over the first few hours. The scale should neither underemphasize nor overemphasize the importance of the changes shown. It is very easy to mislead readers by manipulation of the scales on a graph.

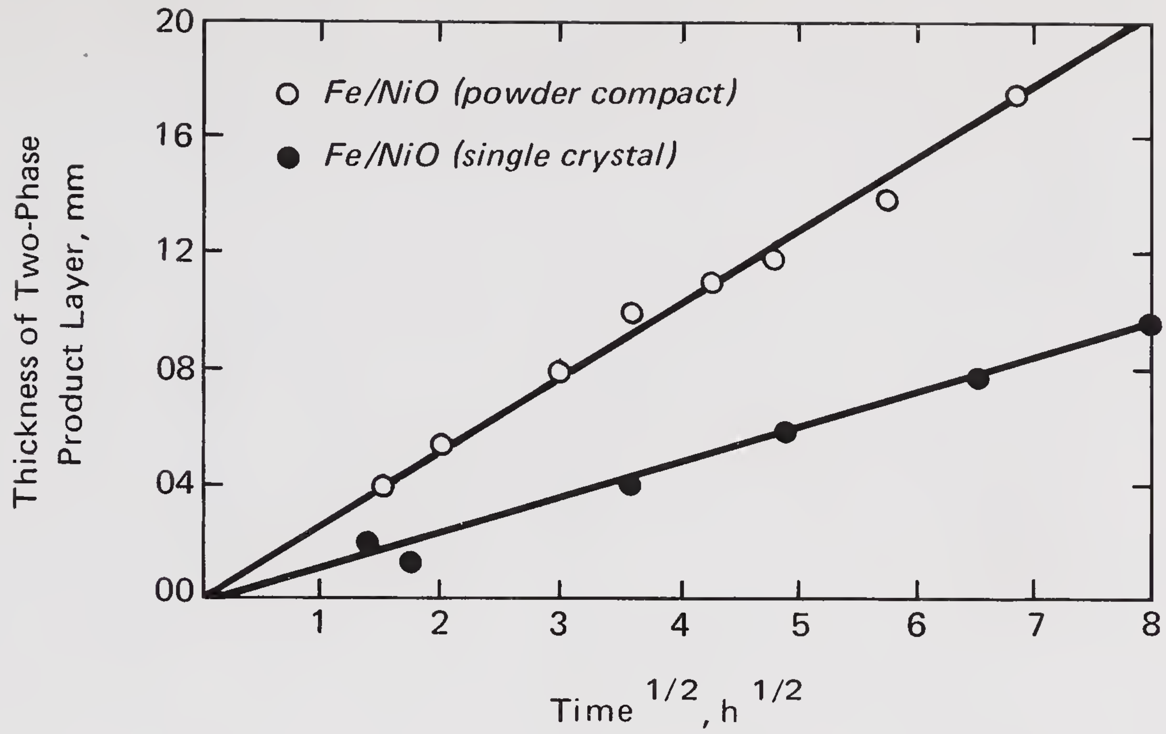


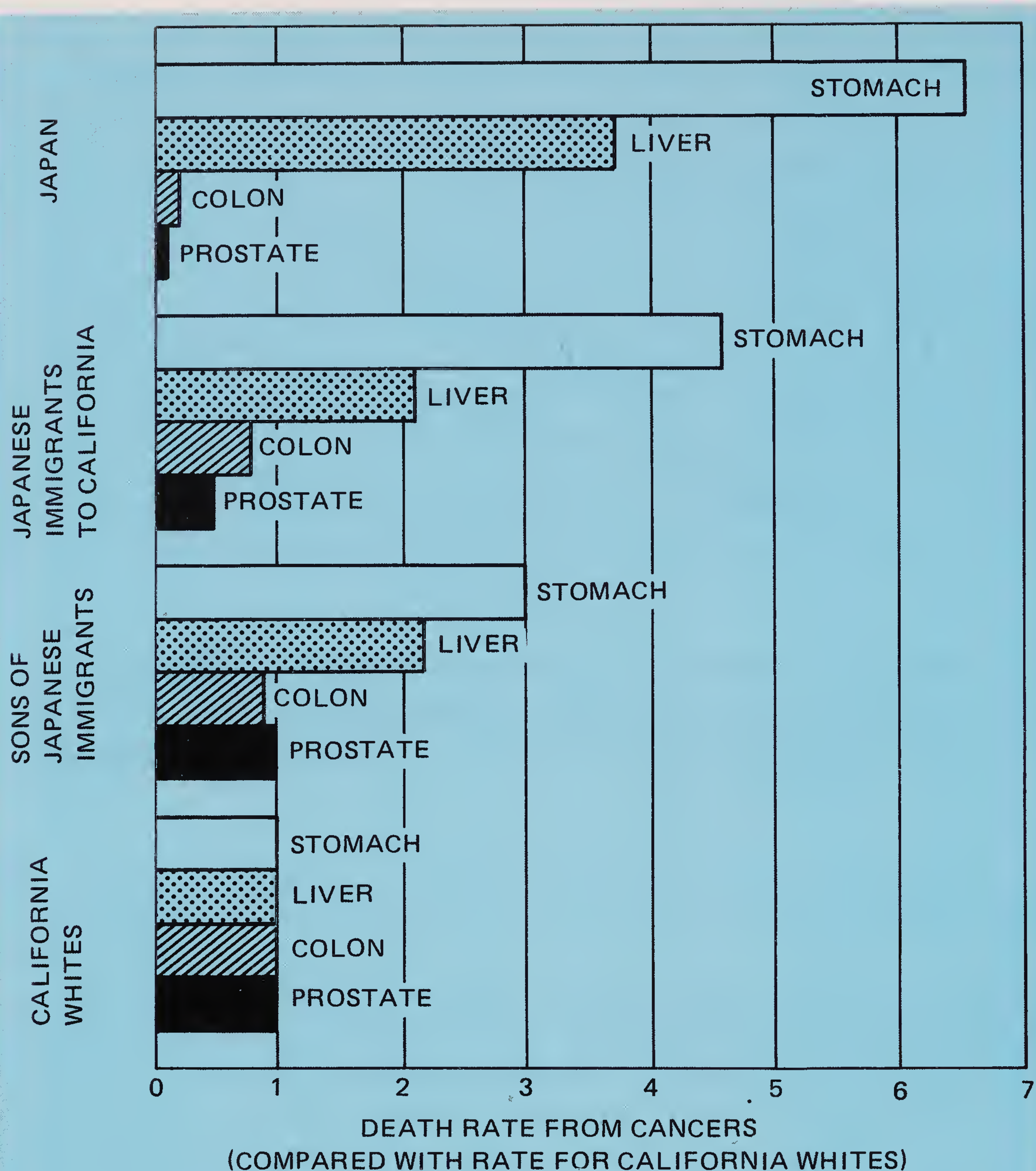
Figure 7-5. A graph with key and legend. [From Robert A. Rapp, Andre Ezis, and Gregory J. Yurek, "Displacement Reactions in the Solid State," *Metallurgical Transactions,* 4 (1973), 1291. © American Society for Metals, 1973.]

BAR CHARTS

Bar charts show graphically (1) differences in the size or amounts of similar products, (2) incidences of diseases and the like at different times, (3) the relative size or amounts of several items at the same time, or (4) parts of a whole. Bars are arranged along a scale and are variously hatched or colored. They are often ordered in increasing or decreasing lengths. Figure 7-6 is an example of a horizontal bar chart; vertical bar charts are also common.

FLOW DIAGRAMS AND ORGANIZATIONAL CHARTS

Flow diagrams and organizational charts represent schematically the steps in a process or the relationships in an administration. Figure 7-7 shows a circular-flow model of a market economy. In flow diagrams symbols or drawings are linked by arrows to show the direction or directions of a process. In organizational charts blocks show the line of authority in a company or program. Such charts are often included in proposals. The top administrator is at the top of the chart. Equal functions read from left to right; subordinate from top to bottom (Figure 7-8).



CHANGE IN INCIDENCE of various cancers with migration from Japan to the U.S. provides evidence that the cancers are caused by components of the environment that differ in the two countries. The incidence of each kind of cancer is expressed as the ratio of the death rate in the population being considered to that in a hypothetical population of California's whites with the same age distribution; the death rates for whites are thus defined as 1. The death rates among immigrants and immigrants' sons tend consistently toward California norms, but the change requires more than a generation, suggesting that causative agents are factors influenced by culture rather than hazards to which all are exposed equally.

Figure 7-6. A horizontal bar chart. (From "The Cancer Problem" by John Cairns.)

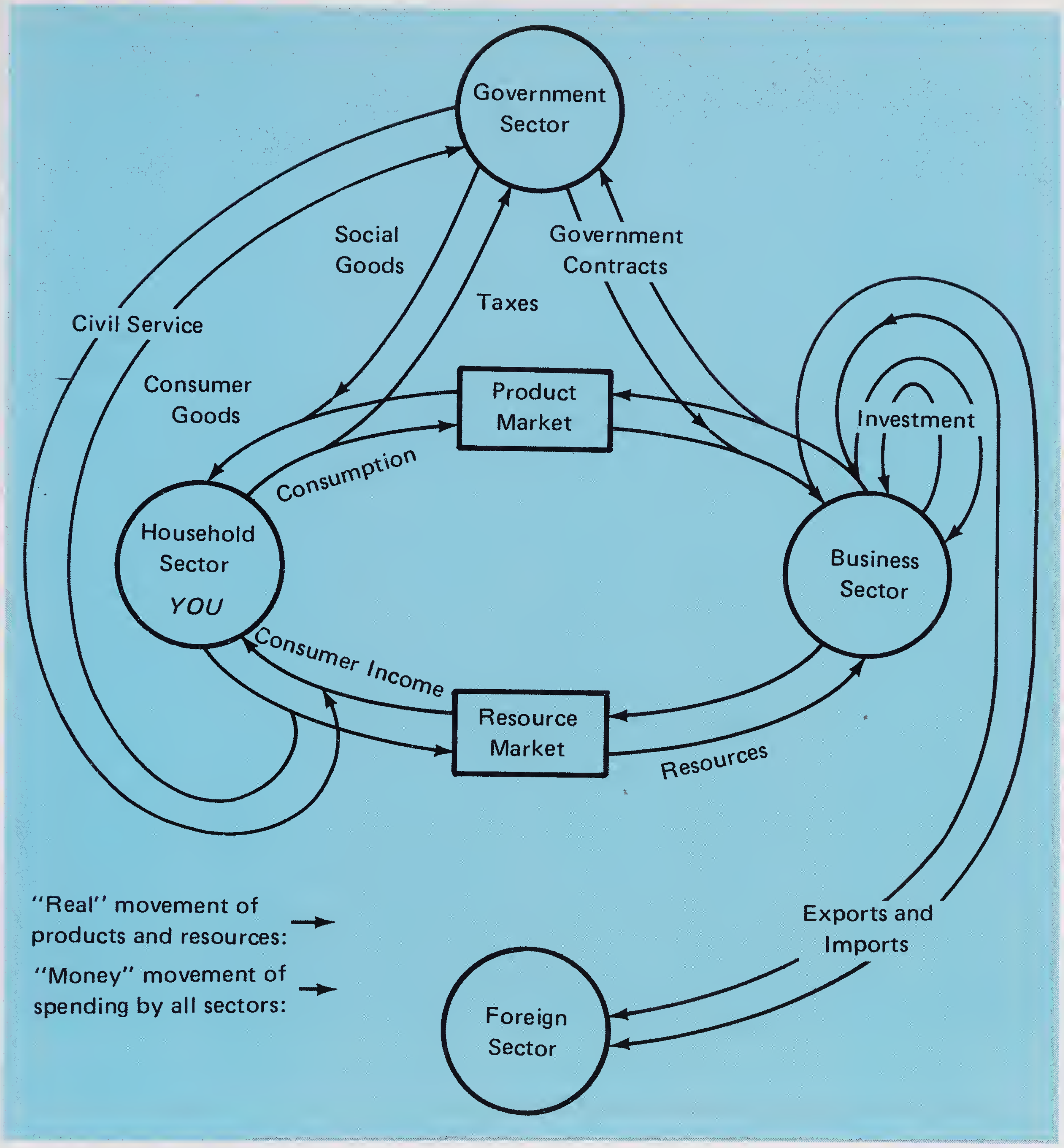


Figure 7-7. Flow diagram of circular-flow model of market economy. (From James Phillips and C. Pearl, *Elements of Economics,* Macmillan, New York, 1973, p. 14 © 1973. Reprinted by permission of the publisher.)

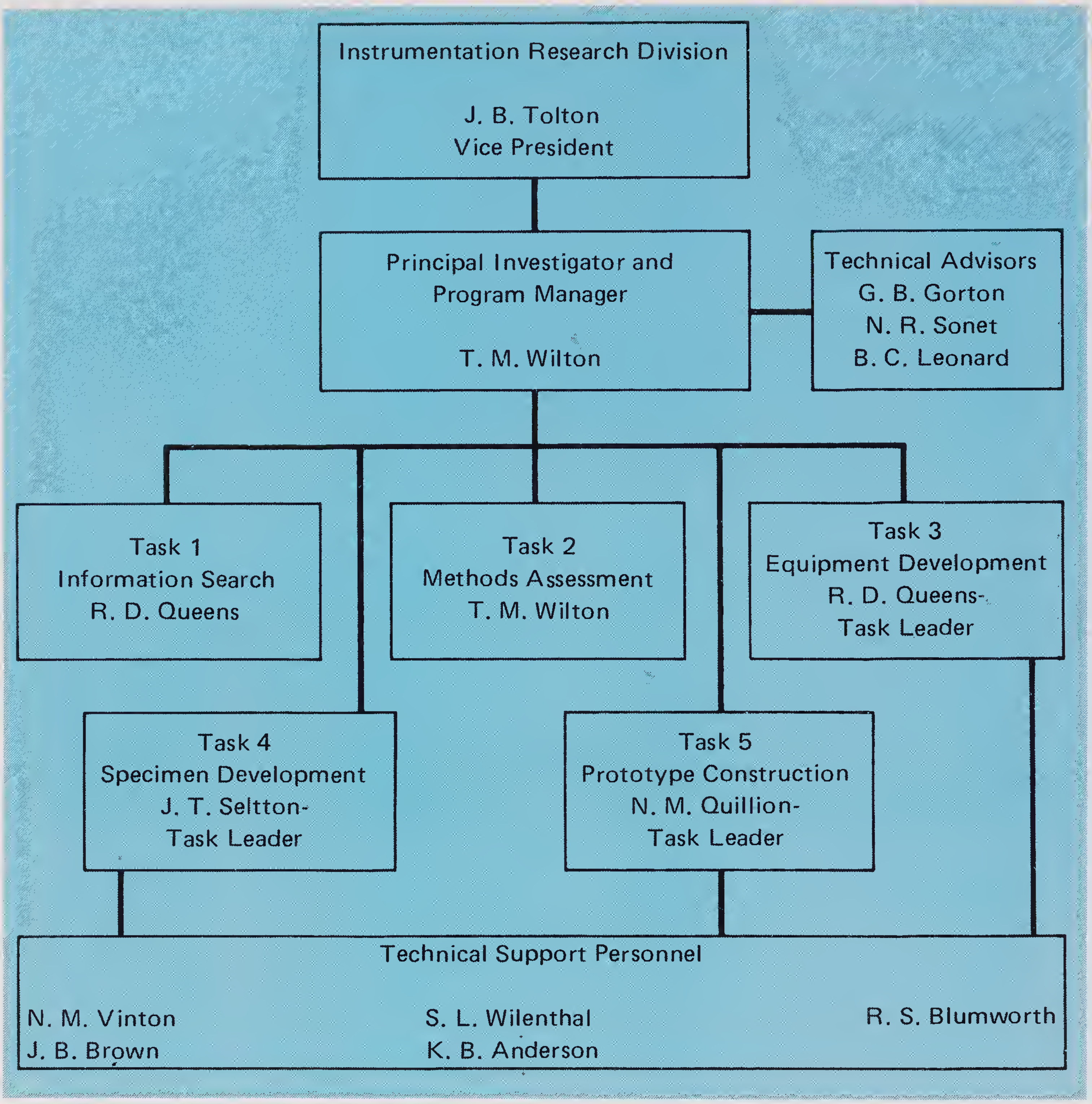
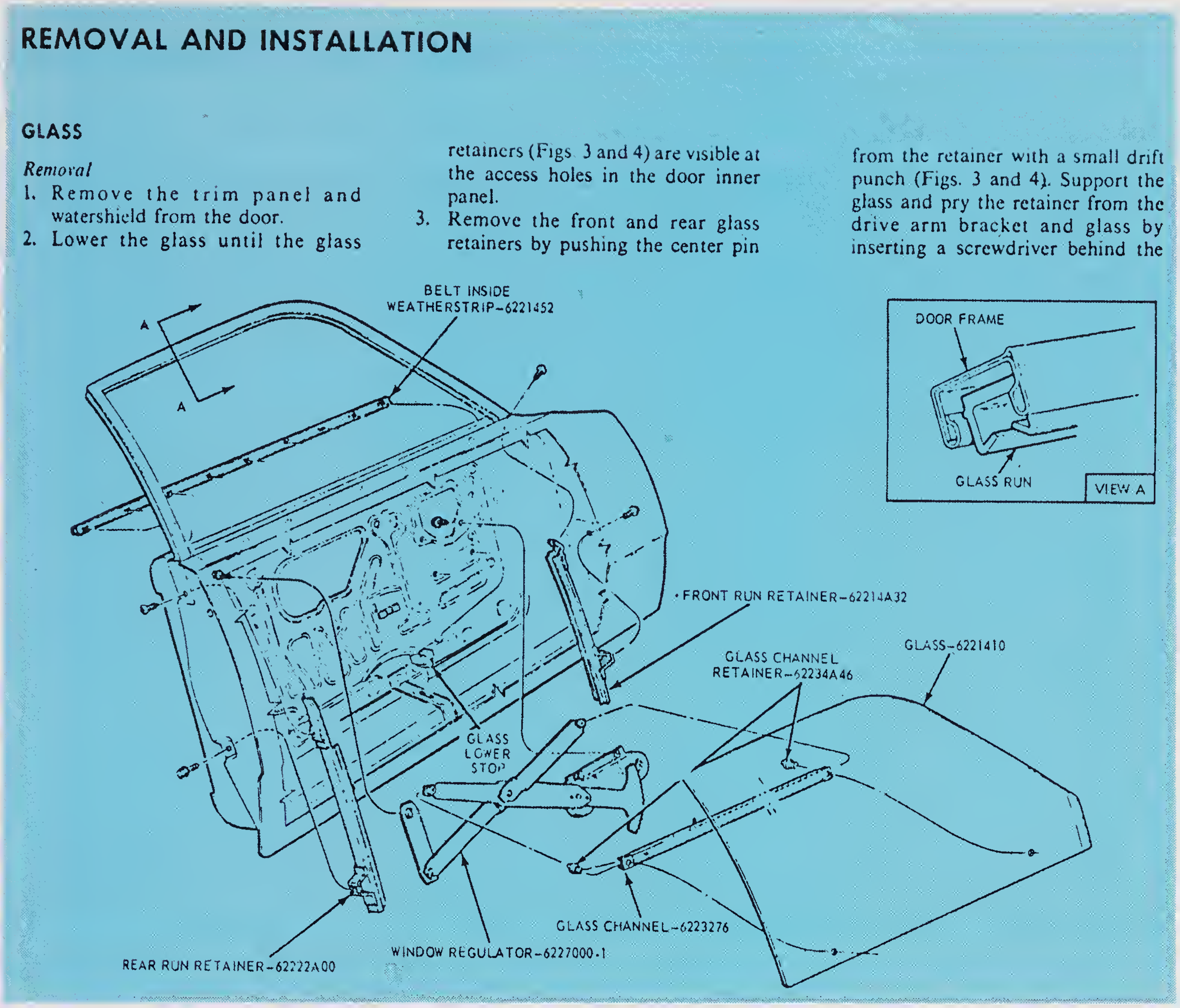


Figure 7-8. Organizational flow chart. (Used by permission of Dolores Landreman, Battelle-Columbus Laboratories.)

PHOTOGRAPHS AND DRAWINGS

Physical objects and places—project sites, buildings, equipment, laboratory or shop setups—are best described through photographs and drawings. These are valuable in engineering and architecture as well as in the descriptive sciences.

Photographs have certain advantages. They are accurate. They are often dramatic. As attention getters, full-color photographs function well, especially in popular science accounts. Their purpose may be as much to impress the reader as to convey information. They are also realistic; through a photograph, a would-be researcher can examine a laboratory setup that he might want to duplicate. A photograph can also show what materials were used to construct an object.



REMOVAL AND INSTALLATION

GLASS

Removal

1. Remove the trim panel and watershield from the door.
2. Lower the glass until the glass retainers (Figs. 3 and 4) are visible at the access holes in the door inner panel.
3. Remove the front and rear glass retainers by pushing the center pin from the retainer with a small drift punch (Figs. 3 and 4). Support the glass and pry the retainer from the drive arm bracket and glass by inserting a screwdriver behind the

Figure 7-9. An exploded view of a car door. (From Ford Marketing Corporation, Ford Customer Service Division, Service Technical Communications Department, *1973 Car Shop Manual*. Permission granted by Ford Motor Company.)

Special cameras attached to microscopes produce pictures called photomicrographs that show extremely small structures of an organism or other material.

Drawings also have their advantages. They are useful in indicating the structural or engineering aspects of, for example, a building or a piece of equipment. An "exploded" view or "cutaway" drawing gives a clear view of both the surface and what is beneath it. A serviceman who has a car door in front of him can refer to the drawing in the repair manual to see what components are there and how to deal with them. The drawing shows only one section at a time and avoids confusing details. Note how the drawing in Figure 7-9 is integrated with the surrounding instructions.

Architectural drawings show structures from different perspectives (see figures in Chapter 11). They can delineate projected structures in concrete detail—and are used by contractors to make the design a reality. The greeting card in Figure 7-10 shows five different architectural views of Santa Claus.

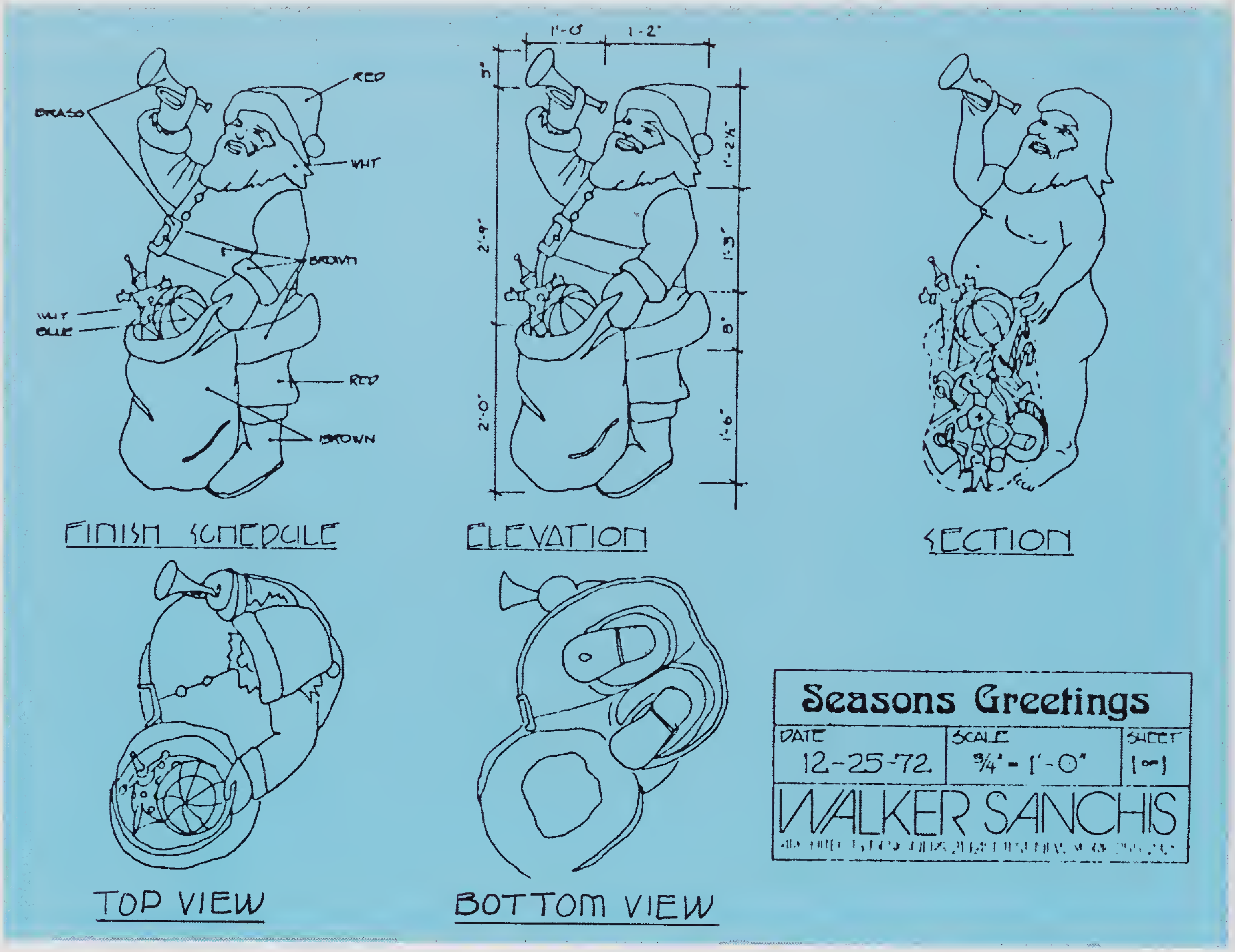


Figure 7-10. Five views of Santa Claus. (Used by permission of Frank E. Sanchis.)

Computer-plotted figures are becoming more popular. Frequently, experimental data are directly recorded onto magnetic tape from which the results can be plotted directly by an *X-Y* recorder. The computer can also find the best fit of some mathematical function to such a plot, so that the researcher can request the experimental values for any desired parameter. He can also ask the computer to draw alternate plots as he changes various system parameters.

Like any other figures, photographs and drawings need labels that explain what the reader should see in them. The title can be written directly (in white or black ink) on the surface of a full-page glossy photograph to be submitted with a report. When included in the text, drawings or photographs may be labeled at the top or bottom. Arrows to labels that point out important features should be as short as possible, and all identifying terms should read in the same direction. The terms should also be brief. Long explanations belong in the body of the report or article.

Final Checks

In going over the draft of his report the writer should examine carefully his tables and figures with the following pointers in mind:

1. Avoid unnecessary redundancy between a figure and a table or between a photograph and a schematic diagram. The same data may be included in different forms in one document for emphasis, but the reason for doing so must be clear or the redundancy will suggest oversight rather than intention.
2. Make the data in the table or figure agree exactly with those in the text. The capacitor that costs 25¢ in a table ought not to cost $1.00 in the text. A given symbol should not have two different uses, and a given parameter should be associated with only one symbol. Terms and abbreviations should also be consistent. The graphics and the text may have been prepared at different times. They must be forced into conformity.
3. Follow the conventions of presentation of each form. Label axes or columns. Give each graphic a title (and number, if required). Eliminate any bizarre symbols. Number figures and tables consecutively (but separately) through a chapter or whole report. Every table and figure must be mentioned in the text; none may enter unannounced.
4. Indicate clearly the source of all information not directly observed or derived. There are several ways to show source; one method should be used consistently throughout a report. A reference or footnote number may be placed at the end of the title (see Appendix A). A source line may be typed at the bottom of the table or figure. Or the source may be named (with full bibliographic information) in parentheses after the table title or figure caption.
5. Set up all tables or figures that are part of a series in the same form. The rules of parallelism that apply to language apply also to graphics. Before-and-after comparisons belong on the same page.
6. Check the arithmetic. Make sure, for example, that columns in a percentage table do add up to 100% if they ought to, and clearly differentiate between actual numbers and percentages.

The good design of a report—its attractive physical appearance—is much aided by well-constructed and well-placed figures and tables. The author who deals imaginatively with his material and effectively integrates techniques of prose, of visuals, and of overall design to fit his purpose and audience will find that he not only clarifies his writing but also adds interest and vigor to his report.

1. Examine the visuals in five annual reports. They may be 5 years of reports from the same company or the reports from five different companies. Is their purpose primarily to convey information or to serve as decoration? What do they say about the company? How are they integrated with the text?
2. Compare an aerial photograph, a topographic map, and a highway map of the same area. What differences are there in the three visuals? How might each contribute to a report?
3. Try to find two articles on roughly the same subject, one in a technical journal and the other in a semitechnical or popular account (see Chapter 13). What visuals does each author use to appeal to his audience? How much background in mathematics or graphic interpretation does the audience need to understand the visuals?
4. Draw a flow chart of the tasks involved in preparing a formal report.
5. Revise the following table from a progress report on a management plan for a 50-acre forest. Give it a title and adjust as you can the columns and column headings.

Period: September 1–November 1

Item	*Time (days)*	*Labor (hours)*	*Expenditures*	*Period of Time*
Soil sampling	21	27	$ 251.00	Oct. 3–Oct. 24
Soil drainage	26	128	$ 1436.00	Oct. 8–Oct. 31
Fertilizer	8	48	$ 3330.00	Oct. 26–Nov. 1
Wages	—	834	$ 4300.00	Oct. 1–Nov. 1
Machinery	—	—	$126,000.00	Sept. 1–Sept. 30
Miscellaneous	2.3	57	$ 536.00	Oct. 1–Oct. 30

6. Arrange the following information about a proposed course in the feeding habits of wildlife into an informal table:

   The lecture schedule is based on the 10-week quarter. Lecture will be taught 3 hours a week. The material is divided according to species. The first 2 weeks will concentrate on deer. Weeks three and four will be devoted to rabbits. The next 2 weeks, five and six, will cover the three squirrel species found in the northeastern United States. One week each will be assigned to the pheasant, quail, and ruffed grouse. The last week of lecture will cover the wild turkey. Diets of adults, immatures, and reproducing females will be studied for all species.

SECTION III

FORMS

CHAPTER 8

Abstracts

Convenient Tools

An abstract is a short summary of the contents of a document. It is written for reports, proposals, articles, dissertations, and papers to be presented orally.

An abstract usually precedes the introduction of the original document. In addition, abstracts of papers may be collected and printed in a booklet circulated before or during a meeting. Abstracts of articles are collected in such abstracting journals as *Biological Abstracts* and *Chemical Abstracts* (see Chapter 2). Abstracts of reports are sometimes printed on 3 X 5 inch file cards. Several of these cards may be bound with the report, to be detached by interested readers who send them to alert others to the report. The cards may also be stored in a library's index file or in an automated information retrieval system.

An abstract serves several purposes. The abstract of a report is generally read by everyone who sees the report, including managers who might not read the technical discussion, accountants interested in a general overview of the project, and cataloging librarians. The abstract of an article is used by indexers to select the appropriate categories in which to list the article; by readers of abstracting journals who can find out from the abstract the breadth of work in a field and whether they should consult the original; by readers of a particular journal to decide whether to read an article. Abstracts included on notices of colloquia or in the bulletins of meetings help participants to decide which sessions to attend and to formulate questions they wish to ask of the speakers. When printed after the meeting in a professional journal or in a proceedings, the abstracts remind those who attended of what they heard and alert those who could not attend to what they missed.

With the explosion in the amount of printed material that engineers and scientists produce and must read, abstracts have become critical. Professional abstracters are hired specifically to write abstracts for some journals and organizations. But to speed the process of collecting and publishing abstracts and to ensure their accuracy, many organizations and journals rely heavily on authors of the original articles for abstracts. Certainly, the student needs to know how to write one. Two forms are commonly distinguished: the informative and the descriptive.

Informative Abstracts

The informative abstract summarizes the principal findings reported in the document. It emphasizes what the document says that is *new*. The author stresses the objectives of the work (the problem and purpose), along with the chief results, conclusions, and recommendations. He elaborates on (but does not repeat) the title and answers any questions posed by it. He describes procedures only briefly, with emphasis on departures from the customary. He omits supporting details so that only the essential message remains.

The abstract must be intelligible and complete in itself; it should not be necessary to read the report in order to understand the abstract. The relative emphasis and organization of the report are maintained. Moreover, the author neither criticizes nor evaluates the report in the abstract. In this respect it differs from an annotation (see Appendix A). In a few well-selected words the informative abstract tells the reader the main points of the investigation.

The journal or organization that will use the abstract sets the desired length and form, but in general informative abstracts should not exceed 6 per cent of the length of the original (less for long manuscripts); most are 150 to 300 words. Figure 8-1 gives one set of guidelines for preparing an informative abstract in the biological sciences.

Descriptive Abstracts

Whereas the informative abstract presents the chief materials of the parent document, the descriptive abstract (sometimes called a topical abstract) simply indicates the topics covered. Informative abstracts discuss the investigation; descriptive ones talk about the report. A descriptive abstract rarely exceeds one or two sentences, regardless of the length of the original. It lists the topics discussed without giving conclusions or supporting evidence. Most begin, "This [report] [article] discusses . . . ." Easier to write, it is less useful than the informative abstract that is usually required by editors and organizations. The statement "The cross-section was found to be 6.25 ± 0.02*b*" (informative) is more valuable in an abstract than "The cross-section was measured" (descriptive).

Figure 8-1. Example of a set of instructions for preparing an abstract. (Reprinted with permission of Bioscience Information Service of Biological Abstracts.)

BIOSIS GUIDE TO ABSTRACTS—1977

INTRODUCTION

An abstract is a noncritical, informative digest of the significant content and conclusions of the primary source material. It is intended to be intelligible in itself, without reference to the paper, but not a substitute for it.

An abstract includes—

1. Objectives of the study.
2. Scientific and/or common names of organisms (if given in the article) with special emphasis on new taxa or new distribution records.
3. Materials, methods, techniques and apparatus, and their intended use, as well as new items and applications of standard techniques and equipment.
4. Specific drugs (generic names preferred) and other biochemical compounds, including the manner of use and route of administration.
5. New theories, terminology, interpretations or evaluations concisely stated.
6. New terms and special abbreviations and symbols defined.

An abstract generally excludes—

1. Additions, corrections or any information not contained in the original published paper.
2. Tables and graphs and direct references to them.
3. Detailed descriptions of experiments, organisms, standard methods, techniques and apparatus.
4. References to literature.

Format

Bibliographic Citations for Serials:

Example—DOE, JOHN A.* and RICHARD ROE. (Dep. Biol., State Univ., 123 Appian Way, Philadelphia, Pa. 19173, USA.) **Selenium metabolism in the rat.** J BIOPHYSIOL 37(4): 152-165. 1977. An asterisk(*) indicates the author to which the address corresponds (if there is more than one author). An English title appears exactly as on the first page of the article, including any abbreviations and subtitles. If the title is not in English a translated version is provided. Citations which have no statement of language fulfill the following criteria: (1) the text of the article is in English; (2) there is an abstract or summary; and (3) the abstract or summary appears only in English. Serial article titles appear in boldface type.

Bibliographic citation for non-serials and books:

Example—MUELLER, KARL. **Blaualgen genetik.** [Blue-green algae genetics.] [In Ger.] 596 p. Illus. Blauer und Sohn: Berlin, West Germany. 1976 [recd 1977]. Paper. Pr. DM 98.00 ISBN 2-442-12345-5.

An English book title is printed in boldface type exactly as it appears on the title page. However, non-English book titles are printed in boldface type followed by an English translation in brackets. Additionally, the original language of the book (if not in English), number of pages, inclusion of illustrations, imprint, price and ISBN are given.

CHEMICALS AND DRUGS: (See also "Abbreviations and Symbols Used In Abstracts." Parts 4. and 5. on next page.)

1. Colloquial terminology and trade names are avoided; generic names (when given by the author) are preferred.
2. Chemical formulas and compounds are defined.
3. Registered proprietary names are always printed with an initial capital. For example, Levanil is a proprietary name for ectylurea, the generic name for (2-ethyl-crotonoyl) urea.

GEOGRAPHY: (See also "Abbreviations and Symbols Used In Abstracts." Part 6. on next page.)

The state (province, prefecture or republic) and country of geographic locations, e.g., Moscow [Russian SFSR, USSR], Berlin [New Jersey, USA] are indicated.

SYSTEMATICS: (See also the chart summation "Key to Representation of Scientific Names of Organisms" below.)

1. For Latin names of genera, subgenera, species, subspecies, varieties and forms:
   a. if previously named (established), they are italicized and only the initial letter of generic and subgeneric names are capitalized (e.g., *Philornis aitkeni*).
   b. if newly proposed, they are printed in boldface italic type with the entire new generic or subgeneric name upper-cased (e.g., ***Philornis downsi*** sp. nov., ***ATLANTOPSIS canariensis*** gen. et sp. nov.).
   c. the specific epithet of an organism is never used without its accompanying generic name (which may be abbreviated if first given in full), e.g., *Escherichia coli*, *E. coli*.
2. The names of all new or revised taxa at the generic level or higher, as well as the names of new species, subspecies, varieties and forms are included, except when the number would require a long list. In that case, the number of new taxa are indicated in the appropriate category, e.g., "Fifty new taxa are described: 1 new species and 10 new varieties in *Rosa*, 12 new species in *Prunus*, 2 new species and 2 new combinations in *Panicum*, 4 new species and 6 new combinations in *Solanum* and 13 new combinations in *Acacia*."

THE EFFECTS OF COLLEGE COMPOSITION ON THE WRITING BEHAVIOR OF STUDENTS

F.E. Beckett

This paper presents the results of a test to determine the effect of composition courses on the writing skills of college students. [descriptive]

Freshmen students of equal ability were paired. One member of each pair enrolled in freshman English. In a test three months after completion of the course both members of each pair were asked to write a theme and evaluate some errors in sentence structure. The group not having had freshman English made fewer errors on the test than those who had completed the course. In a statistical analysis of the data the difference was not significant at normally accepted probability levels. A somewhat similar study with similar results was carried out with students in a technical writing course.

An extensive review of the literature was made. The results reported by other investigators were very similar to the results of this study. It was concluded that college composition courses do not improve the writing behavior of students.[1] [informative]

TECHNOLOGY TOYS AND SEX ROLES IN AMERICA, 1920-1940

C. Pursell

The author examines the role of toys—especially "technology toys"—in socializing American children during the decades of the 1920s and 30s, and draws a conclusion concerning the disproportionately small representation of women today in the professional fields of science and technology. [descriptive]

During the decades of the 1920s and 30s, American toys were used to socialize children into appropriate sex roles. This was especially true of "technology" toys—those thought to embody modern examples of useful science and technology. For girls, these were usually small electrical appliances which prepared girls for careers of cooking, cleaning, laundering. For boys, they fell into one of four categories: tools, vehicles, construction sets, and science outfits. Unlike girls, boys were encouraged by their technology toys to be bold, inventive, constructive, and curious about the principles underlying modern science and technology. Although seldom acknowledged, the result was to teach girls "their place." Boys, on the other hand, were deliberately encouraged to develop their personal capacities to the fullest extent possible. It seems likely that this distinction accounts, in part, for the disproportionately small representation of women today in the professional fields of science and technology.* [informative]

*Permission to reprint granted by Carroll Pursell.

The descriptive and informative forms may be mixed in an abstract—sometimes called an indicative abstract—that begins with a description of the topics covered in a document and then states major findings (although no numerical information is given). But the writer should keep the two forms separate unless specifically asked by a publication to mix them.

Key Words

In addition to an abstract, an author who submits a report or an article for publication may be required to provide about ten key words (known also as index terms or descriptors). These are used to place the article in an information retrieval system. The words may come from the title, from the abstract, or from the thesaurus for the particular discipline being discussed. The author should choose those words he would use if he were searching an index for the most important topics in his article. The key words are often typed at the bottom of the abstract.

Summaries

Although sometimes the terms are used interchangeably, a distinction exists between an *abstract* and a *summary*. A summary (called synopsis, introductory summary, summary of conclusions and recommendations, terminal summary, or executive summary) does not, like an abstract, preserve the emphasis of the original in a reduced form. It often reiterates introductory material. It stresses the purpose of the investigation and the chief conclusions and recommendations. It is usually longer than an abstract. An executive summary from a 300-page report, for example, might run 20 pages. Often managers take action on the basis of the summary alone. An abstract would not give them enough to go on—although it would tell them whether they wanted to read the report. A report may have both an abstract and a summary.

Writing the Informative Abstract

The abstract should be concise, clear, and accurate. Balancing generalizations and details requires a clear understanding of the parent document and how researchers will read it. The first sentence states briefly the objective of the work reported. A statement of scope may appear next (such terms as *brief*, *comprehensive*, and *exhaustive* may be used). Where space permits, important new quantitative data are then included. The statement of results is as precise as possible. The theoretical or experimental plan is mentioned. If the procedures are novel, the basic principles involved, operational ranges covered, and degree of accuracy attained are stated. The writer can assume that the reader has some knowledge of the subject but not of this particular treatment. Familiar abbreviations may be used, but terms the audience might not know should be written out. References are usually not cited in the abstract.

One way to approach writing the abstract of a report is to think of it as a prose form of the table of contents. The table of contents is, in effect, the final outline; it is easily fleshed out into an abstract, as the following example shows. On the left is the table of contents, and on the right is the abstract written from that outline.

Table of Contents	*Abstract*
The need for genetic counseling Definition of genetic counseling Statistics on genetic defects Purpose of genetic counseling	Genetic counseling is a service for people with a history of hereditary disease. One in 17 births contains some defect; one fourth of the patients in hospitals are victims of genetic diseases (including diabetes, mental retardation, and anemia). One of every 200 children born has chromosome abnormalities.
The counseling process Evaluating the needs of the counselees Taking a family history Estimating the risks Counseling the family	Genetic counseling offers parents an alternative to genetically diseased children and assistance for those with already afflicted children. The first step in counseling is to evaluate the needs of the parents. A family history is prepared and risks of future children being afflicted are evaluated. The life expectancy and possible methods of treatment of any afflicted child can also be determined. Alternatives are presented.
Determination of a genetic disorder	Four prenatal tests are used to determine if a genetic disorder

Amniocentesis Karyotyping Fluorescent banding Staining	is present: amniocentesis, karyotyping, fluorescent banding, and staining.
Advantages of genetic screening Lower cost Increased availability	The development of these four relatively simple methods has lowered the cost of genetic counseling and increased its availability.

Of course, this system works only if the table of contents is neither too detailed nor too skimpy. Any good outline of an article or a report provides the best beginning for an abstract.

The goal of conciseness cannot be achieved at the cost of coherence. Sentences in the abstract should be complete and grammatical. Verbs, conjunctions, and articles (*the*, *a*, *an*) are not omitted. A writer needs in particular to avoid both a series of short, choppy sentences and overlong sentences that contain too many piled-up clauses. Proper use of subordination is essential. Whole paragraphs of the original are condensed to a sentence, sentences to a phrase, phrases to a single word. Participles are especially useful.

Where possible, the author should keep verbs in the active voice. He should not shift tense unnecessarily. Unless directed otherwise, the author should arrange his abstract in one paragraph.

Before being submitted, the abstract should be shaken down several times to see if it might not be further shortened. The author should scout for words that are not carrying their weight. Expletives (*it is*, *there is*, *there are*), for example, can almost always be eliminated (see Section A in the Handbook). Someone else should read the abstract to check for completeness, proper emphasis, and objectivity. The particular instructions of the journal or organization to which an abstract is being submitted should also be followed. Many journals of the American Chemical Society, for example, allow an abstract to contain references to figures, tables, or structural formulas presented in the body of the paper. Others do not.

Abstracts: The Key

Abstracting requires special language skills and discipline from a writer. It forces him to confront his own ideas stripped of the details: to examine the relationships among them, their logical sequencing, their relative importance, and their relationship to his purpose or problem. There is little room for restatement. In writing the abstract after he has finished a manuscript, the author may discover redundancies and extraneous material in the original and make appropriate changes. Writing an abstract *before* completing a paper—a common practice for papers to be presented orally—often clarifies one's objectives. The abstract merely needs to be expanded with supporting details. Writing abstracts has real value for the writer.

The abstract is also valuable for the reader. Abstracts are read by more people than any other part of a report or article. The American Chemical Society concludes: "In general it is of utmost importance that abstracts be rich in indexable information to guide interested readers to the original paper."[2] A major product of research is reports and publications. Only proper abstracting assures that reports and articles will be used.

NOTES

1. *IEEE Transactions on Education*, E-14 (February 1971), 7.
2. American Chemical Society, *Handbook for Authors*, Washington, D.C., 1967, p. 24.

EXERCISES

1. Determine the key words that would apply to each of the abstracts given in this chapter.
2. Shake down—that is, condense—the following abstracts from student reports. At the same time, make them more coherent.

ADVANTAGES OF ULTRAFILTRATION FOR PROCESSING WHEY

The report was done for the Che-Dar Company, who asked for information on whey-processing methods. A recommendation of one of these methods was also requested. Spray drying of whole whey, electrodialysis, and ultrafiltration were the processes discussed. After a review of the advantages and disadvantages of the three methods, it was recommended that ultrafiltration be used. This decision was based on the lower energy requirement, the low initial investment, and the greater profitability of ultrafiltration.

A description of the ultrafiltration process and cleaning procedures is given in the final section of the report. The whey is concentrated by passing it through a semipermeable membrane that allows water, lactose, and nutrients to pass through. Protein molecules are too large to pass through the membrane and remain in the concentrate. The permeate and concentrate are spray-dried to obtain lactose and protein-rich powders.

Cleaning and sanitation must be done on a regular basis because operating temperatures and whey components are favorable for microbial growth. The procedure consists of cleaning with detergents containing proteolytic enzymes, sanitizing, and rinsing with water.

SILVICULTURAL PLAN FOR THE HORSTER FOREST

Accessibility to markets and high prices being paid for timber have been responsible for the increased demand for development of silvicultural plans of management. The silvicultural plan of management presented in this report was developed for a 50-acre hardwood forest in northwest Ohio. Five variables were taken into consideration in developing this particular plan of management. Those variables that were investigated are discussed in the following order: (1) soil types and pH values; (2) accessibility to the forest; (3) stocking levels present; (4) value of tree species present; and (5) federal funding programs. After the preceding variables were assessed, it was found that the limiting factor in the forest appeared to be the high level of stocking. Therefore, the recommendations given at the end of the report are based heavily on control of stocking levels.

3. Write an abstract of one of the lectures in a technical class or of a guest lecturer's presentation on campus.

CHAPTER 9

Proposals

Persuasive Writing

Proposals, like advertisements, are selling devices. Both are supported by facts, but a fundamental difference separates the two types of writing. Basically, the proposal deals with the unknown—what is yet to be—whereas the advertisement deals with what is known—what already exists. In other words, advertisements usually promote products that are already available. Proposals, on the other hand, strive to sell a concept of a product, to change an existing system, or to establish a new service; consequently, their audience, techniques, and language are distinct. The audience for advertisements is usually heterogeneous and not always interested in the subject. To attract it, advertisements often include flamboyant techniques, overblown language, and visuals highlighted with obtrusive images—a beautiful woman (or a man) standing beside a new car—simply for their emotional value. Proposals seldom rely on emotional appeals; rather, they employ a rational approach, a restrained point of view, and conservative language supported by appropriate graphs, charts, and tables. They are written primarily for a limited and concerned audience—management and the technical staff—involved in determining the feasibility of a project. One requirement for success, however, is common to proposals and advertisements: Both must be persuasive.

To be persuasive, the author must analyze his audience, present essential details, organize and reason logically (even though advertisements often appear to be illogical), supply illustrations, and select appropriate language.

Definition of a Proposal

A proposal is a planning document designed to convince a potential customer (individual, government, business, or profession) of the advisability of engaging another individual or company to (1) supply a product, (2) institute a change, (3) study the possibility of a change, or (4) perform a service.

Purposes can be illustrated by a beginning sentence:

> It is proposed to develop an acoustical tile for selective absorption of sound in the frequency range of 800 to 1150 cycles per second.
>
> I propose that a study be made to determine the possibility and advisability of replacing individual workers with computers in the Registrar's Office at the University of Guam to improve efficiency and save time and money in registering students.
>
> We propose to investigate the causes of scab, the most damaging apple disease in the nation. Once the causes are detected, proper measures for the control of the disease can be recommended.

Solicited and Unsolicited Proposals

There are two types of proposals: solicited and unsolicited. A solicited proposal is written in response to an inquiry, an invitation, or a directive from a superior; an unsolicited proposal is initiated by an individual or a group looking for an opportunity to solve a problem pertinent to a given situation. The government is one of the big customers for solicited proposals. It *advertises* its needs and invites bids. Because obtaining the government contract means a lucrative profit, many companies or research institutes vie with each other in submitting what they hope will be the successful proposal. The competition is fierce and the stakes are high. A simplified example of a solicited proposal is a directive from management to an employee to investigate the causes of accidents in a subsidiary plant and to propose a solution for improving the situation. If, on the other hand, an engineer in that particular plant sends the parent company an account of the situation and his proposed safety program, he is submitting an unsolicited proposal. In either case the purpose is the same: to convince the audience that one solution is feasible, that it is the best possible solution, and that it can be best handled by the initiators of the proposal.

Proposals should never be undertaken without considerable research into the present state of the art (see Chapter 3), possible alternative techniques, availability of facilities, personnel competence, costs, and, extremely important, the needs of the customer. Consequently, proposals are often expensive undertakings.

Cost of Proposal Preparation

Actually, writing proposals has become a multimillion-dollar enterprise, a huge business expense. This figure is based on the tremendous number of proposals submitted and the time and manpower required to produce them. (Remember that practically any accomplishment is preceded by some type of proposal.) Writing proposals is a fine art demanding psychological insights concerning the customer's needs and desires, skill in organizing and handling sentences, and discretion in the choice of language. It is a major creative challenge, the results to be judged on accuracy of technical information, readability and clarity, and tone of confidence. Because of the critical importance of proposals for business success, companies assign some of their best talents to the job of preparing them and may spend months on a single proposal with production costs ranging up to many thousands of dollars. So important have proposals become that recently several organizations have sprung into existence with the sole purpose of writing proposals or advising on how to write them. Obviously, it is paramount that acceptable proposals be submitted in order for companies to recover their expenses as well as carry on a profitable business.

Student Involvement

A student may feel that writing proposals, which in industry is usually delegated to a highly experienced staff, is of no present concern to him, but the fact is that even in his academic career he is apt to find himself involved in writing simple proposals. Some professors may demand a proposal before a student undertakes a project. Consideration for participation in an honors program or undergraduate research scholarship program often calls for what is in essence a proposal. A request for a grant from a foundation or from a university for research and development program support takes the form of a proposal stating the purpose and the objectives of the project as well as the central idea. Such a proposal must justify research on the subject and indicate in what way it is related to the larger context of which it is a part. Because grants are in reality responses to requests for funds to carry on the research, a specific figure on the cost is included and this figure must be reasonable. An example of a student proposal for an undergraduate research scholarship is offered.*

UNDERGRADUATE RESEARCH SCHOLARSHIP PROJECT PROPOSAL

APPLICANT: Gregory Miller

ADVISOR: Dr. George Williams, Jr.

TITLE: Evaluation of a Tissue Culture Technique to Screen for Whitefly and Leaf Miner Resistance in Tomato for Application to Plant Breeding

OBJECTIVES:

1. Ability of cultured tomato tissue to support whitefly and leaf miner populations.
    a. To determine whether whiteflies and/or leaf miners can exist on undifferentiated tomato callus in culture.
    b. To compare undifferentiated callus with differentiated leaf tissue for ability to support insect populations.
2. The use of cultured tomato tissue to screen for host plant insect resistance.
    a. To determine if tomato cultivars that show signs of insect resistance in the greenhouse will show comparable results in tissue culture.
    b. To compare the resistance of cultured callus with cultured leaf tissue.

*Courtesy of Gregory Miller.

JUSTIFICATION: It is well established that Ohio is a leader in tomato production. It is also well established that certain insect pests such as whitefly and leaf miner have a detrimental effect on Ohio's tomato production. Control of whitefly is difficult because the immature stages are somewhat resistant to many insecticides currently used. The frequent applications of insecticide for control of this insect are costly. A very plausible and economically sound approach to this problem is breeding insect-resistant strains of tomato.

The first step in a breeding program of this type is to locate selected tomato plants that show some resistance or tolerance to one or both of these insects. The main problem thus far encountered in this search is developing a reliable screening technique. Most screening experiments with whole plants in a greenhouse environment have consistently encountered complications of one sort or another. If cultured tomato tissue could be used instead of greenhouse-grown plants, several advantages would be immediately apparent. Tissue culture would be relatively fast and require little space, replications would be easy, and environmental factors could be rigorously controlled. Also, if tissue culture proved successful with tomatoes, it could probably be applied to many other host plant resistance studies.

PREVIOUS WORK AND PRESENT OUTLOOK: Work has not been extensive or very successful in screening for resistance to whitefly and leaf miner in greenhouse tomatoes.

In experiments conducted with potted tomato plants, Curry and Pimental (1) found results that were inconsistent with previous work. Some of the problems encountered were: 1) performance of tomato cultivars varied from sampling date to sampling date, and 2) population levels were often unrelated to damage levels. Lindquist (2) has reported that whiteflies and leaf miners, when given the choice of many different tomato cultivars, tend to prefer some over others. However, when the unpreferred plants are their only choice, these insects don't hesitate to proliferate. It is difficult to assess damage done by either leaf miners or whiteflies because too often tomatoes infested with one pest are also infested with the other.

No work has been done using tissue culture to screen for insect resistance. Because of more precise control over conditions, many of the above-stated problems would be minimized in the tissue culture procedure.

PROCEDURE: To carry out the first objective I will perform the following steps:

1. Start cultures of the tomato cultivar Ohio M-R 13 using standard procedures with White's medium (3) in Erlenmeyer flasks and allow callus to develop for a period of time.
2. Treat half of the flasks with the growth regulator kinetin to encourage shoot development.
3. After sufficient development of leaves, introduce 10

adult whiteflies into each of several flasks containing callus tissue and likewise several flasks containing shoot tissue. Repeat with leaf miners.

4. Make survival counts for as long as necessary to determine whether callus or leaf tissue or both are able to support adult insects.

5. As an extension of the above procedure, introduce sterilized insects (not infertile, just free from bacteria) and allow them to carry out one or more life cycles.

To carry out the second objective, I will repeat all the above steps with many different tomato cultivars and relate any difference in survival to insect resistance of the host plant.

BACKGROUND: I am majoring in horticulture, specializing in plant breeding. I am also very interested in pest control development. By the end of this quarter I will have completed 23 hours of horticulture and 30 hours of chemistry and biochemistry. Next year I will complete courses in horticulture, genetics, microbiology, entomology, and statistics. I have become very interested in tissue culture and its applications to plant breeding.

ARRANGEMENTS: Tissue culture equipment and tomato plants will be made available through Dr. Williams. Whiteflies, leaf miners, and additional tomato plants will be made available by Dr. Lindquist.

REFERENCES:

(1) Curry, James P. and David Pimentel, "Evaluation of

Tomato Varieties for Resistance to Greenhouse Whitefly." J. Econ. Entomol., 64:1333.

(2) Lindquist, Richard K., "Research Dealing with Insect Pests of Greenhouse Vegetable Crops in 1972." Greenhouse Vegetable Research--1973. O.A.R.D.C., 1973.

(3) White, P. R., The Cultivation of Animal and Plant Cells, 2nd ed. New York: The Ronald Press Co., 1963.

ADVISOR APPROVAL: George Williams

DATE: 3-17-75

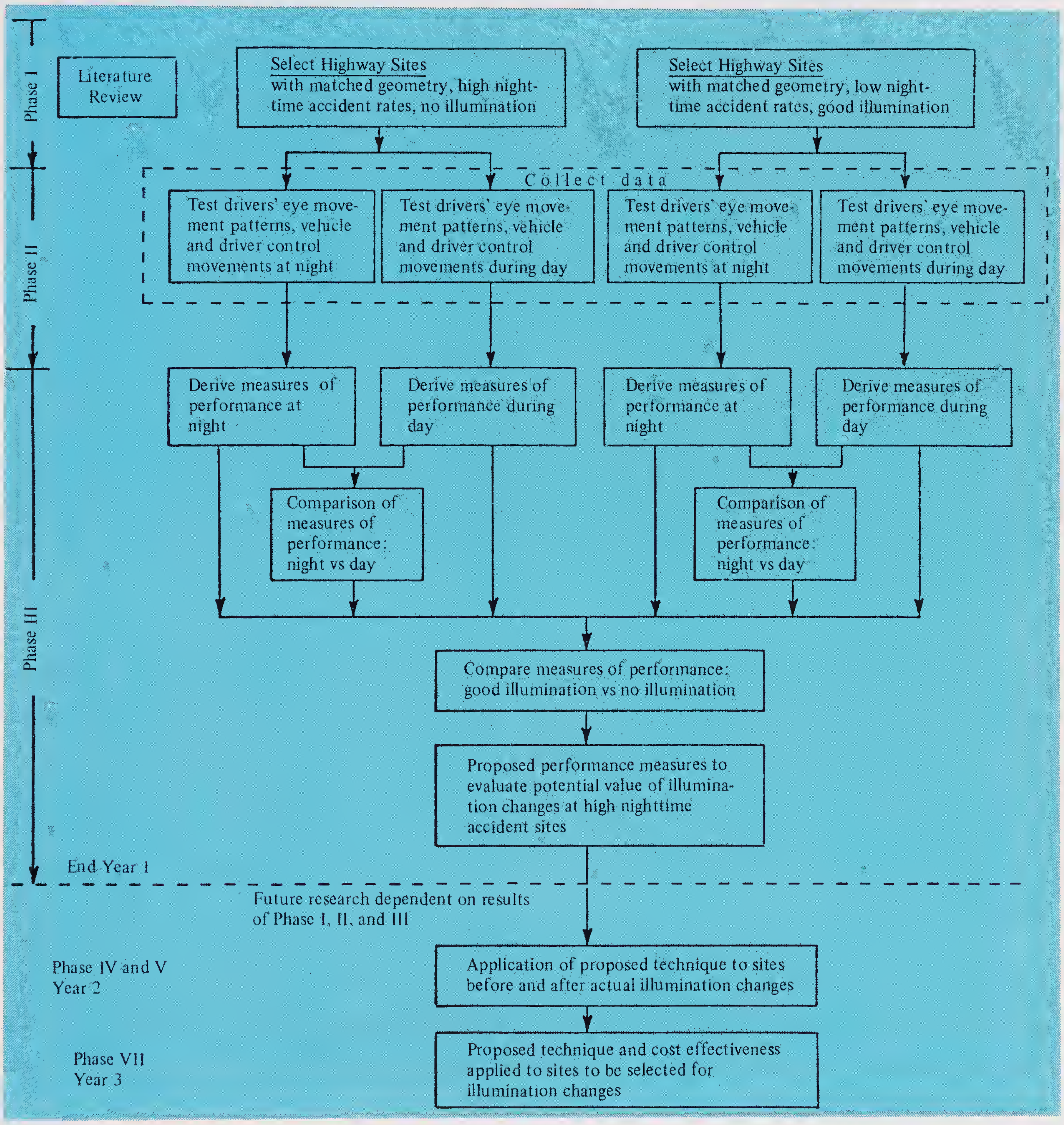
Forms and Information

Proposals are presented in a variety of forms. At one time oral proposals were common in industry, but today the emphasis is on written communication, sometimes supported in the final stage by an oral defense. If you approach your boss, saying, "We ought to install a computer system in the Cost Department. It would save money in the long run," he will probably direct you to put your idea in writing before he will consider it. As a result, you will submit your suggestion as a memo, a letter, or an informal or a formal proposal depending on the importance and the complexity of the project. Naturally, information included varies in accordance with the proposal's purpose, complexity, and length. All forms contain a statement of the proposal itself: "We propose to evaluate flaws in weld jointing, such as cracks, lack of penetration, and porosity." It is necessary to describe the purpose, define the problem, and detail the procedure to be followed. Other elements may appear, such as a justification of the project, a literature survey, a discussion of the qualifications of the personnel and organization and availability of facilities, and estimates of cost and time. In projects requiring a long period of development, the number of progress reports to be submitted is also stipulated.

RESEARCH PLAN

A proposal must be carefully planned. Anyone who is especially visual-minded may find it helpful to chart the steps in the research first. Such a technique is effectively used by the Ohio Department of Highways. In the following example from "A Proposal to Evaluate the Illumination Designs for Accident Reduction at High Nighttime Accident Highway Sites," the chart appears at the beginning and becomes part of the proposal package:

Figure 9-1. Sample chart of a research plan. (Courtesy of Ohio Department of Transportation.)



A diagram, however, does not take the place of the formal outline, which eventually appears as the table of contents in the finished proposal. Thus the highway report includes the following:

Table of Contents

As in almost any piece of writing, a good outline is a real help. Moreover, a complex proposal usually requires teamwork; the outline directs and integrates information from several workers. The elements must be systematically and coherently presented. The division indicators, or headings, place limits on each section and improve readability because they alert readers to those sections of particular interest to them.

Although no one pattern of organization is suitable for all proposals, the following outline suggests a basic approach that may be modified to meet specific situations (as illustrated by the outline for the highway report, where some of the elements are omitted and others combined):

One Pattern for a Proposal

1. Introduction
   a. Statement of the proposal
   b. Purpose and objectives
   c. Problem and/or justification
   d. Feasibility of solution
2. Literature review
3. Advantages to the customer
4. Qualifications
   a. Of the company doing the work (reputation, capabilities, facilities, personnel)
   b. Of assigned personnel (names, titles, and qualifications of key personnel)
5. Method of attack (Procedure--sometimes termed "Technical Approach" or "Discussion")
   a. Analysis of major problems
   b. Plans for phases, experiments, tasks
   c. Special procedures or techniques
6. Anticipated requirements
   a. Facilities
   b. Manpower
   c. Support
7. Costs
   a. Breakdown of costs
   b. Method of payment

Note: In government proposals, the cost *must* be separated from the technical proposal so that the technical evaluaters will not be influenced by cost considerations. Cost is considered only after the selection of the top three or four proposals.

This section discusses the situation giving rise to the proposed project.

This section is often presented at the end of the proposal or in the appendix

Usually tabular—includes salaries, travel, and equipment. Section is quite often presented separately and becomes an important appendage to the proposal.

8. Time requirements

9. Reports to be submitted

Segments of proposals are not necessarily presented in this order. Moreover, some segments are combined under one heading.

TITLE

The title of a formal proposal should, if possible, be limited to 15 or fewer words. It should tell what it is (a proposal), state the purpose of the program (an evaluation, a design, study, development, fabrication, production), and give the subject (material, equipment, service, item) plus the technique. The following title exemplifies these elements:

> A Proposal to Establish the Atomic Arrangement in Biomolecules by Higher-Resolution Electron Microscopy

It is a common practice in a long, formal proposal to follow the title with an abstract (see Chapter 8), often designated "Summary," best written after the completion of the main text. Because this is the first section read, extra time and care spent in writing the summary are well worthwhile. Indeed, it is sometimes the only part of the proposal read completely and slowly by all of the evaluaters. It should excite their intellectual curiosity and engage their interest.

INTRODUCTION

Some proposals combine the summary with the introduction, as shown in the following Westinghouse Electric Corporation proposal:

> 1. SUMMARY AND INTRODUCTION
>
> The Westinghouse Electric Corporation proposes a twelve-month program to develop corrosion-inhibiting primers for adhesive bonding of aluminum alloys. The objective will be to develop primers which are reproducible and less costly to apply than presently available corrosion-inhibiting primers and which are compatible with state-of-the-art structural adhesives having 250°F curing and 180°F service capabilities. Compatibility with 350°F service adhesives is an additional program goal. The primers must also be compatible with aircraft paint primers and paints,

must be easy to apply in uniform film thickness to complex shapes, and must lend themselves to automated processing.

The difficulty of maintaining homogeneity in low-viscosity pigmented resin solutions is well known. Uniform film thickness is difficult to achieve by conventional application techniques. The 250°F curing and 180°F service temperatures are not particularly difficult to obtain; the 350°F service temperature, however, could be harder to achieve.

Materials are available which, when added to pigmented resin solutions, act as dispersing agents and deflocculents. Uniform thickness of coatings can be achieved by the electrocoating immersion process (electrophoresis) or by electrostatic spraying of a liquid or powder coating. The use of higher temperature resistant polymers may yield primers with 350°F service temperatures.

The program will be conducted at the Westinghouse Research Laboratories, Pittsburgh, by personnel who have been involved in a number of similar projects in the past. Program contributors have many years of experience in the formulation, evaluation, and recommendation of primers, paints, and powder coatings for the corrosion protection of metallic substrates.

Since the Laboratories conduct research for the numerous Westinghouse operating divisions with coating and corrosion problems, excellent specialized facilities are available for this program. Modern equipment for the preparation and evaluation of coatings, polymers, and resins is fully proved and operational.

The program can begin immediately on contract award.*

Other proposals do not include a summary, and without it the introduction becomes the first contact with the reader. It calls his attention to and acquaints him with the proposal itself, the purpose and significance of the study, and the problem, although it may contain other elements. The purpose should be clear and focused precisely on a limited goal—not addressed to the problems of the universe.

In the following unsolicited proposal, the introduction is limited to a statement of the proposal, the purpose, and the problem:

Statement of proposal

We propose to prepare a design manual for High-Efficiency Air Filtration Systems. The purpose is to establish minimum design requirements for these systems and to provide guidance in their design that would be desirable not only in applications involving radioactivity but also in applications involving clean rooms and biological environments.

Purpose (note: purpose suggests organization)

*Courtesy of Westinghouse Electric Corporation.

The major problem is that engineers and architects overall do not understand the specialized requirements for high-efficiency air filtration systems. Because of this lack of understanding, many systems are more costly to construct and operate than necessary or do not afford the degree of protection demanded by application. At present there is no single source of technical information that provides effective guidance concerning the specialized requirements of such systems. There is no textbook, engineering manual, or report that provides a comprehensive view of the problem involved.*

Because this is unsolicited, the problem must be explained in detail.

JUSTIFICATION OF NEED

The discussion of the problem generally justifies the investigation, but not always. In some proposals it is wise to head one section "Justification of Need." This section is especially important when the proposal is a request for funds to carry out some sort of research. Unless the project is justified in the beginning, any administrator may decide to kill it. The following section from a proposal requesting funds for a new facility justifies the need:

Justification of Need

Decontamination Area

The existing Building No. 819 used for equipment decontamination does not satisfy the Laboratory's requirement for protection of operating personnel. Although the level of radioactivity has increased tremendously over the years, the decontamination facilities are almost as crude as they were in 1955 when the first decontamination building was put into action for the removal of low-level contamination.

This general statement must be supported.

The lack of ventilation and shielding presents one of the greatest hazards. . . .

Equipment even moderately contaminated with alpha cannot be handled in the existing building. . . .

The lack of ventilation and shielding permits only direct handling of low-level contamination. . . .

Supporting data. [Specific data omitted.]

*Oak Ridge National Laboratory, "Design of a Manual for High Efficiency Air Filtration Systems." Reprinted by permission.

The lack of space forces the operators to do decontamination work near objects that have already been cleaned and are waiting for the results of a smear survey. This practice sometimes results in recontamination of the clean objects and always presents the possibility that some recontaminated equipment may be sent out of the area without detection.*

LITERATURE SURVEY

A literature survey—the summarizing of all that has been published about a subject—is often included in a proposal (see Chapter 13). It acquaints the reader with the state of the art. Whether or not the survey results are included in the proposal, the survey is imperative at the outset of the project. Research on a problem that has already been solved is a useless exercise.

In a Battelle-Columbus Laboratories proposal to the National Institutes of Health to consider several approaches for the analysis of nortriptyline, the author after his introduction discusses the results of his literature survey:

> It has been reported that the most effective relief of psychological depression occurs when plasma concentrations of nortriptyline are in the range of 50-140 ng/ml[1]. Less effective control of depression was seen when plasma nortriptyline concentrations were either above or below this range. On the other hand, Braithwaite et al.[2] found a positive correlation between increased amitriptyline and nontriptyline plasma levels and improved therapeutic response. Kragh-Sorenson et al.[3] found an inverse relationship where increased plasma levels were associated with decreased clinical response. And finally, Burrows et al.[4] found no significant correlation between plasma nortriptyline levels and relief from depression. The contradictory results reported by these four investigators may be due in part to genetic differences, differences in protein binding, or inadequate drug analysis methodology. A better analytical method for widespread use in clinical laboratories might help resolve these apparent contradictions. Also it is important for the physician to know his patient's nortriptyline plasma levels so that he may adjust the drug dosage to obtain the desired drug level and therapeutic effect.†

*Oak Ridge National Laboratory," "Justification of a Need." Reprinted by permission.

†David A. Knowlton, "Development of Clinical Laboratory Methodology for Determination of Tricyclic Antidepressant Compounds," Battelle-Columbus Laboratories, 1975. Reprinted by permission.

ADVANTAGES

Advantages to a company (the sponsor or the customer) to be derived if the proposal is accepted may be listed as part of the introduction because they are strong selling points, but they may also appear in a separate section. In a proposal to investigate the efficiency of an accounting system in a company that had had a good many problems, the student chooses to use a separate section heading:

<u>Advantages to the Company</u>

A system that can meet the demands of the manufacturing plant would enable better coordination between the accounting department and the purchasing and sales departments. A backlog of due bills conveys the impression to creditors that the company is poorly organized or possibly financially embarrassed. A new system would promote higher morale among all employees and a better external image.

There may be a question of tone here unless the author has firmly established the problems

At times the advantages or benefits are stated in broader terms:

<u>Benefits</u>

The sponsoring firms are expected to be able to use the information developed in this program as a basis for making equipment/process modifications to reduce the steel loss in the milling operations. Because of the many companies engaged in large-scale ore-milling operations, all would benefit from a broad-scale attack on a common problem. A cooperatively sponsored program ensures the maximum benefits from a modest investment.

QUALIFICATIONS

Discussion of the qualifications of the company making the proposal varies in both content and length depending on the company's reputation and previous successes in solving similar problems.

Company Qualifications

Our company has long had a reputation for successful research and development projects. We pioneered the development of the XYZ generator, and because the AB engine is based on the same principles, developing and testing such an engine should be simply a matter of applying the principles to the heavier engine. All facilities for testing are available.

Note: In both examples qualifications include a prediction of success.

Available facilities that are uniquely suited to the project are listed and described. Sometimes included is the history of the company, emphasizing its interest in the activities related to the field of the proposal. All information included must be germane to the project.

BIOGRAPHICAL INFORMATION

Offering personnel descriptions may be somewhat complicated by a preponderance of necessary biographical detail. Consequently, biographies are sometimes appended to the proposal in a separate appendix headed "Program Personnel." More often, a condensed version in a narrative form appears in the proposal proper. Interesting, up-to-date, and accurate resumes of the workers assigned to the project add significantly to the strength of the proposal. These resumes should indicate each worker's name, title and field, education (degrees), and professional achievements. The content of each résumé is often tied into the prediction of the success of a program.

Sometimes personnel qualifications are stated quite generally and combined with the benefits of the project:

Personnel and Prediction of Success

Because our personnel have published several similar manuals, there is every reason to believe that with the proper research into existing facilities throughout the country they should be able to develop a manual that would prove invaluable to your company as well as to government agencies.

In a student proposal, seldom a team endeavor, it is sufficient to explain briefly the student's background, as illustrated in the following example from a proposal to investigate the aggressive behavior of animals under designated conditions listed in the proposal:

Qualifications

Academic background

My course work during my undergraduate years at Michigan State has provided me with a sound background in the area that I am proposing to investigate. My courses include statistics, calculus, biology, general zoology, animal behavior, principles of wildlife management, psychology, wildlife biology techniques, chemistry, and microbiology.

Experience

In addition, last summer I was fortunate enough to obtain employment with the Natural Resource Department of Michigan, where I was able to gather some valuable information on the aggressive behavior of animals. Moreover, I have designed and conducted my own individual study of a wildlife area for Dr. M. H. Goode during my vacations. Thus I believe that I have the necessary experience and academic background to conduct this study. Both Dr. Goode and I think that such a study would be beneficial in two ways: (1) It would provide new information on aggression in confined areas. (2) It would provide recommendations for biologists managing wildlife populations.

A justification for the study

PROCEDURE

A critical point of the proposal is the technical discussion that covers the procedures, techniques, and facilities to be used to solve the problem. This section must be realistic and specific enough to convince the client to trust the proposer. It must demonstrate an understanding of the customer's problems and needs, competence in the procedures to be carried out, availability of facilities needed for testing, and originality of approach.

Whereas the first part of the proposal (carefully read by top-level people) may contain a sophisticated discussion of system philosophy and technical challenge, the procedure gives a blow-by-blow account of the intended procedures: methods, tests, and apparatus to be used (often accompanied by tables and figures). This is the section that is minutely analyzed by technical experts.

A brief summary of the procedure section from a professional proposal is offered as one example:

PROPOSED RESEARCH TO FIND CORROSION INHIBITORS USEFUL IN GRINDING ENVIRONMENTS

Existing methods for testing the wear of grinding steel are slow and costly and not adaptable to evaluation of the hundreds of variables involved. It is proposed that a rapid test developed by Battelle be utilized to determine the rates of corrosion and abrasion of grinding steel in actual ore pulps to overcome these difficulties. With this test, the effect of chemical inhibitors—there are hundreds of them—on grinding steel corrosion can be determined in the presence of various minerals, flotation chemicals, and soluble salts, and at various levels of pH. Then the effect of optimum corrosion-inhibiting conditions on flotation or other processes can be tested. Finally, corrosion-control techniques will be demonstrated on a pilot-plant basis to provide scale-up data.

RESEARCH SPECIFIC TO EACH SPONSOR

Each sponsor's ore, steel, and mill chemistry will be tested for abrasive and corrosive wear, wear-control methods or inhibitors, and their effects on subsequent processes. These data will be reported directly to each sponsor. In addition, each sponsor will receive consolidated reports of all tests which will be of value to him for a correlation of the broad range of all the parameters involved. The cost effectiveness of proposed corrosion-control techniques will be determined for a generalized situation which can be used to fit the individual sponsor's economic requirements.*

Even though a student's proposal may be shorter and simpler than a professional proposal, he is still obligated to include details of his procedure. Thus the student writing a proposal to investigate the "Effects of Photoperiod on Mammalian Reproduction" includes his experimental procedures†:

EXPERIMENTAL PROCEDURES:

A. Analysis of Commercial Records

Large volumes of commercial data on factors affecting rat conception rates will be statistically analyzed in conjunction with Dr. W. R. Gall: season, temperature, and photoperiod.

B. Experimental Alteration of Photoperiod

The rats will be divided randomly into three groups. Each group will contain two males and four females. One group will serve as a control; these rats will receive 12 hours of light per day. Group two rats will receive 4 hours of light per day. In group three rats will be exposed to 20 hours of light per day. In all groups the temperature will be controlled at 25°C.

After a 2-week period of exposure to controlled photoperiod, estrus cycles of females will be examined

*Courtesy of Westinghouse Corporation.

†Courtesy of Christopher Hayhow.

with vaginal smear techniques, and the females will be caged with the males. After mating, as determined by sperm in the vaginal smear, females will be removed and allowed to litter. When pups are weaned, the process will be repeated to a minimum of three complete reproductive periods. The following data will be recorded for each female: length of estrus cycles, rate of fertility, length of gestation, and number of pups born. Upon completion of the breeding experiments, data will be summarized for each photoperiod group.

Another student prepared a proposal to submit a new method of combine harvesting of grain to a research and testing program. The purpose of the proposed program was to determine the efficiency of the components of the combine to improve the machine wherever possible by modification of the design in accordance with the results of the tests. He does not follow the conventional form. Instead, he breaks his method of attack into three sections:

General Method of Attack (Procedure)

We have at our disposal an experimental farm on which the tests on the combine will be conducted. During the testing period we will test the combine in at least two varieties each of oats, wheat, rye, and barley. Results from these tests should give a representative picture of the value of the combine and its probable success.

We will build a test combine from the original design for the various components and provide the necessary personnel to operate it. The testing program, modified slightly to obtain additional data on moisture condition of the grain, will be the one suggested by your consulting engineer. The test data will be interpreted by the members of your engineering staff.

Information Sought

In testing, we will evaluate the efficiency of each of the components of the combine. This will include threshing fan efficiency, first-stage separating efficiency, separating efficiency of the two cleaning stages, and overall machine efficiency. We will attempt to determine the optimum values for machine operation, machine capacity, and all brush wheel, fan, and separating cylinder speeds. These values will be determined for each of the eight varieties of grain to be tested.

Also, because the grain is subjected to a large volume of air as it passes through the machine, we will attempt to determine whether this air decreases the moisture content of the grain and, if so, to what extent.

Specific Method of Attack

The efficiency of each component of the machine will be determined by the method suggested by your consultant. The speeds of the various components will be determined by taking a tachometer reading from the main drive shaft and using pulley ratios to obtain the individual speeds. The one exception to this will be the threshing fan, which will have a tachometer mounted on its shaft, because it is to be driven through a variable-ratio pulley. Horsepower requirements will be determined by dynamometry. Prevailing weather conditions and moisture tests of the grain before and after combining will enable us to determine the machine's effect on grain moisture content.

REQUIREMENTS

A list of costs for manpower, equipment, and time is extremely important in a professional report. Usually, the technical writer involved in preparing the proposal offers estimates, for example, man-hour (day) requirements, and they are a cost factor. He also may specify manpower skill levels, another cost factor. He can get assistance from the financial staff in translating these estimates to dollars and also in figuring such costs as travel and hotel expenses. However, it is unrealistic for a student to estimate costs unless that student has worked intimately with similar projects and has some understanding of costs and requirements.

It is, of course, possible for a student to suggest an estimate in his proposal. The student writing on the combine test had been closely associated with related aspects of other projects and their demands. He was thus able to recognize both the requirements and costs and included them in his report:

Requirements

Following is a list of the basic requirements for testing the combine. The cost estimate may be higher than necessary dependent on the availability of construction materials.

MANPOWER

One chief engineer

Two consulting engineers

Three technicians to build and operate the machine during tests

Two students to run tests, tabulate and process data

EQUIPMENT

One hand-built test combine

One 14-ft John Deere header to use on combine

One 12-ft John Deere header to use on combine

One pickup truck to move equipment and provide transportation for personnel between headquarters and test site

Testing machine

Moisture tester, scales, etc.

Our shop will be used to construct the combine.

TIME REQUIRED

March 19xx to June 19xx--construction of combine and test machine

June 19xx to November 19xx--testing and experimentation

November 19xx to January 19xx--final analysis of data and design of production model combine

ESTIMATED COSTS

Salary, chief engineer $7,500

Salary, consulting engineers	8,000
Salary, operating personnel	7,875
Salary, students to run tests	1,550
Cost of experimental combine	15,325
Cost of test machine and equipment	300
Pickup truck	2,580
Miscellaneous expenses	1,000
TOTAL	$44,130

Expense accounts will be submitted for payment at the end of each 30-day period.

Graphic Plan

After a proposal has been submitted and approved, it is often followed by a graphic plan showing the expected progress of the project, the sequence and relationship of tasks, and the costs. These graphs (networks) are known by several names: *critical path method* (CPM), the most commonly used; *program evaluation and review techniques* (PERT); *critical path scheduling* (CPS); *critical path analysis* (CPA); and, in some companies, *project schedule*.

They are commonly used in systems installations, research projects, and construction jobs. Indeed, they have become so important that many states require by law that a contractor submit a CPM with all of his construction contracts. Management finds them particularly valuable because (1) they show complex interrelationships and constraints among the activities; (2) they predict, with considerable accuracy, the outcome in time and cost; and (3) they are flexible and permit the program to be updated under changing conditions. Henry Ford once said, "No task is particularly hard to do if you divide the work into small jobs." And, in a way, this is exactly what these methods do.

The tasks must be diagrammed in the logical order in which the activities are to be performed. Care must be taken to make sure that each task is bite size. Activities must also be diagrammed sequentially. In constructing bridge pier footing, for example, concrete cannot be poured until the forms are completed and the reinforcing steel is in place. The reinforcing steel cannot be assembled and placed until it is obtained and forms are completed. And the forms cannot be placed until the excavation is finished.

In a speech to the Ohio Highway Conference, Professor Emmett H. Karrer of The Ohio State University offered a simple illustration of CPM:

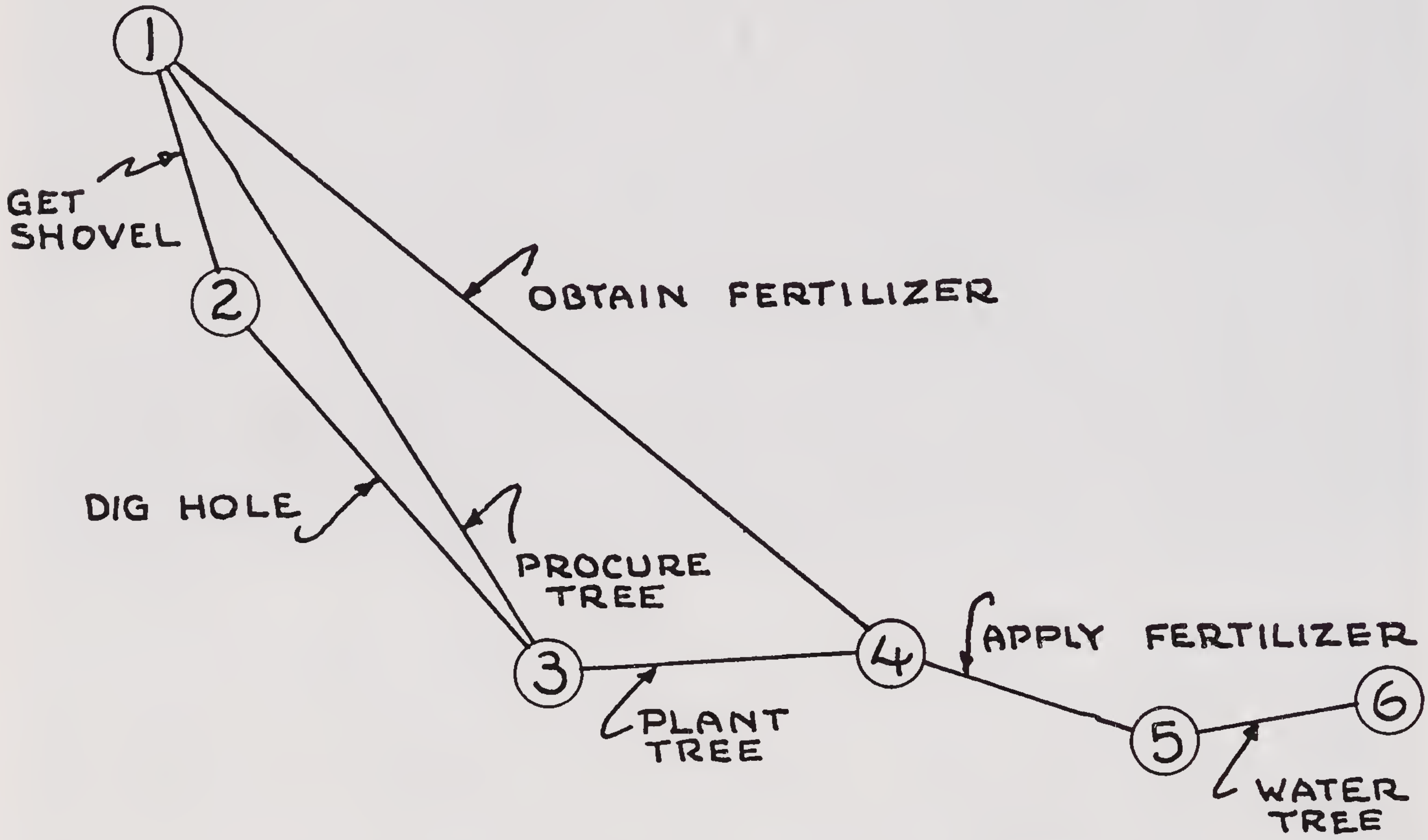


Figure 9-2. CPM network—planting a tree. (Courtesy of Emmett H. Karrer.)

Let us assume that this Saturday when you get home your wife tells you that she is going to the nursery to buy a tree and that she wants you to be ready to plant it when she gets back. Following the CPM theory we will divide the total project into a series of tasks and assign numbers to each task. We then will draw an arrow to represent each task and connect the arrows into a series to show the sequence of tasks. As your wife leaves to get the tree, you can go out into the garage to hunt the shovel, preparatory to digging the hole. So, we will call this task No. 1-2. After you find the shovel you dig the hole, so we will call this task No. 2-3. By the time your wife gets back with the tree you will probably have the hole dug. We will call her trip task No. 1-3. You will probably now stand back and have your teenage son lift the tree into the hole and replace the earth; task No. 3-4. Next you will add the fertilizer which we will call job No. 4-5. However, presuming that you did not have the fertilizer on hand and had to borrow it from a neighbor, we will draw another arrow from the beginning which we will call task No. 1-4. You could have procured the fertilizer at the same time that you did the tree, so the arrow representing this task starts at No. 1. Watering the tree will be task No. 5-6.

Next we go back and assign an estimated time to each of these tasks. Then by starting at the beginning and running through each path we can add up the total time required for each list of sequential jobs and find which series of jobs takes the most time. This series will be known as the "critical path."*

It is not possible in this text to go into all of the complexities of CPM. Suffice it to say that the methods do form a kind of bridge between proposals and progress reports, as shown in Figure 9-3, which is the form used by the Denison Division of Abex Corporation. In this company, after a proposal for an internal engineering research project has been approved, the engineer submits a project schedule that indicates tasks and their completion dates as well as expected cost. Later this report can be updated to show the actual progress and cost.

Figure 9-3. A project schedule. (Courtesy of Abex Corporation.)

Abex CORPORATION
RESEARCH AND DEVELOPMENT

PROJECT DESCRIPTION	PROJECT SCHEDULE ENGR. ASSIGNED ____ ASSIGNED DATE ____ SCHEDULE REVISED DATE ____	SCHEDULE APPROVED BY: DEPT. HD. ____ DATE ____ DIR. OF RES. ____ DATE ____

PHASE	EST. HRS.		COST $	NOTES
1 DESIGN STUDY & LAYOUTS				DIR. OF SALES ____ PATENT AGENT ____ DIR. OF ENGR. ____ PLANT MGR. ____
2 DETAILS ASSEMBLIES BILLS OF MATERIALS				
3 MANUFACTURE OF EXPERIMENTAL UNITS				
4 TEST EXPERIMENTAL UNITS				
5 REDESIGN & CHANGE DRAWINGS				
6 REBUILD EXPERIMENTAL UNITS				
7 TEST REBUILT UNITS				
8 REDESIGN & DETAIL FOR PRODUCTION PRODUCT BANK				DIR. OF RES. ____ DIR. OF SALES ____ PLANT MGR. ____
9 PREPARE PERFORMANCE & INSTALLATION DATA				SCHEDULED COMPLETION DATE
SCHEDULED MANPOWER: DESIGNERS				PROJECT NO.
SCHEDULED MANPOWER: DETAILERS				
SCHEDULED MANPOWER: TECHNICIANS				

FORM NO. 2601

*Courtesy of Emmett H. Karrer.

Obviously, proposals are important to industry; but they are also helpful to a student in a number of ways. Probably most important is that they assist him in organizing his final report. The following is an example of a student's proposal in which he includes some of the elements discussed. The report is written in letter form.*

SAMPLE STUDENT PROPOSAL

1735 Neil Avenue
Columbus, Ohio 43210

October 19xx

Dr. J. T. Peters, Chairman
Department of Zoology
1735 Neil Avenue
Columbus, Ohio 43210

Dear Dr. Peters:

I propose to investigate the possibility of DDT residues in snow melt water from the Antarctic. This research problem is designed to test the conjecture that DDT residues are picked up by global air currents, transported to the Antarctic, and redeposited by snow-out. This investigation will be concerned with six melt water samples from Plateau Station (79 15'S 40 30'E) Antarctic. Each sample will be thoroughly tested for pesticide residues.

Proposal Purpose — *General statement of procedure*

Pollution of the environment by persistent pesticides is essentially a universal problem (Cohen, J. M. and Pinker-

Problem

*Courtesy of Jacob Lehman.

ton, C., 1970), which has been studied by several investigators. DDT residues have been found in a variety of animals in the Antarctic (Tatton, J. G. and Ruzicka, J. H., 1971), but the source of this contamination has not as yet been determined. The benefits derived from this proposed research will be primarily a solution to the problem of how DDT residues reach the Antarctic continent. Secondly, this information could be used as background material for a journal publication. Finally, the procedure for sampling and detection could be used in a global network for sampling municipal water supplies for the detection of pesticides as well as radionuclides.

Literature search

Benefits of the investigation

I have had considerable experience in sampling and detection procedures while employed at The Ohio State University. I have worked as a research assistant on three doctoral research projects, all pertaining to pesticide problems. Therefore, I believe this proposed research can be completed without difficulty and I further believe the results will indicate that DDT residues are present, the source being snow-out of polluted wind currents.

Qualifications

Ultimate success

Procedure

To examine this problem, I plan to prepare eight carbon-adsorption filters. Two of these filters will serve as controls, one remaining here, the other accompanying the

Specific steps in the procedure

six sampling filters to the Antarctic. Dr. S. D. Cranston, of the Institute of Polar Studies at Ohio State, has agreed to arrange the shipment and installation of the filters at Plateau Station. I have chosen this location because no pesticides have been used in this area. The filters will be installed in parallel with the station's water supply system for a scheduled length of time.

Flowmeter readings will be taken during the period so that flow rate and water volume can be recorded. After the sampling is completed, the filters will be returned by air freight, all the charcoal filters will be desorbed with double-distilled hexane solvent in a soxhlet extractor, and the solvent will be concentrated in a Buchi evaporator and injected into a Barber Coleman electron-capture gas chromatograph. If the results are positive, I plan to further substantiate them by use of thin-layer chromatography and microcoulometry. The use of these three methods of microdetection should eliminate any doubts as to my results or laboratory techniques.

I anticipate the need of one laboratory aide, whom the department can employ through the work study program. His salary will be reimbursed by federal funds at no expense to the department. The only new equipment needed for this project is the eight charcoal filters. The machine shop on campus has given me an estimate of $160.00 to prepare them.

Anticipated requirements

Estimate of cost

Should this research proposal be accepted, the project will require approximately 3 months for completion: 45 days to prepare, ship, install, sample, and return the filters and 45 days to perform the laboratory work and write the final report. I plan to submit a progress report within 60 days and a final report 30 days later.

Time requirement

Report to be submitted

I believe the results from this research project will far outweigh the expenses involved, both to you and to the department. I would appreciate your decision soon so the sample filters can be prepared and taken with the polar studies group when they depart on November 15.

An attempt to persuade the recipient to accept the proposal

Sincerely,

Rejection of Proposals

Unfortunately, many professional proposals are rejected for various reasons, some of which are the following:

- Problem is of no interest to the potential sponsor.
- Objectives are not clearly stated.
- Proposed program is too complex.
- Solution to the problem is not feasible.
- Research is too costly.
- Language is ambiguous and unclear.
- Overall plan is not sufficiently detailed.

It is important, then, to evaluate proposals before submitting them to forestall any reasons for rejection.

Evaluation of Proposals

In planning, writing, and revising a proposal, one must remember that it is a *sales document*. As such, it should of course be accurate and should not promise what cannot be delivered. Moreover, it must be adapted to the reader. A thorough analysis of the customer's needs and perceptions is made before the proposal is written and the entire document is adjusted to this profile. A reader of a proposal will not buy what he does not need or what he does not understand. Therefore, the language should be as simple as possible, especially because the proposal may be evaluated by a variety of people with various technical backgrounds. The tone should be confident and enthusiastic, although not overly so: hard facts are more effective than hard sell.

The final proposal (solicited) is submitted with the proper number of copies requested, in the form specified by the requester. Often, page limits are imposed; these should be rigorously followed. Any signatures or approvals necessary before the proposal can leave the company—or be submitted by a student to a university agency—must be obtained. Finally, the proposal must be submitted on time. If a proposal is due at a government agency in Detroit on December 1 at 1:00 p.m. and it arrives at 1:01 on that date, it simply will not be considered as part of the competition.

As mentioned in the first part of this chapter, proposals and advertisements have differences and similarities. Even though proposals and advertisements have similar goals—to sell a product or a service—they differ substantially in that advertisements through emotional appeals persuade thousands of people who read and see commercials to buy products that they neither need nor can afford. Proposals, however, must be individually tailored and objectively presented. A proposal must satisfy a client's needs and recognize the limitations of his budget. A proposal meeting these criteria may well persuade a client to accept the project. And acceptance is the final goal.

EXERCISES

1. Write the introduction to a proposal on any subject of your choice.
2. Justify your request for funds to carry out a research project that might make you eligible for a scholarship or an honors program.
3. Propose to your department chairman that the present requirements in your area be revised. Be sure to indicate what the present requirements are, why they should be revised, and what the changes are that you think should be made.
4. Write a letter proposing to your sister or brother that a change of universities would be advantageous to her or him. Suggest the specific university and the courses offered; include the reasons for such a change and the advantages to be gained by attending the university suggested.

5. Write a proposal in letter form to your department librarian suggesting three journals that should be added to the library. Explain their value to students, indicate what type of audience each appeals to, and give the publication data and the price.
6. Submit to the homecoming committee the design foı a float that your sorority or fraternity proposes to enter in the competitive parade.
7. Write a formal proposal to the board of trustees for the establishment of a day-care center on the campus.
8. Write a formal proposal suggesting a change in company procedure. Perhaps you might deal with a more efficient method of hiring personnel, a change in the recreational program to improve the morale of workers, improvements in safety practices, changes in a tool setup, or a new method of handling inventory.
9. Construct an outline for a research proposal on any subject of interest to you.
10. The most practical assignment for you is to present to your instructor a proposal for your final report. Such a proposal will aid you in planning the organization of the final report, and it will allow the instructor to evaluate your purpose, method of gathering material, and procedure.

CHAPTER 10

PROGRESS REPORTS

Value of Progress Reports

A progress report is what the name implies—a record of the progress of a project. It is the history of an undertaking over a fixed period of time. Progress reports are considered vital by most companies even though many employees view them as interruptive, annoying, and boring. Often workers have encountered nothing but problems and consider that little progress has been made. Nevertheless, they will find that submitting well-written progress reports calls attention to themselves and their work. The interruption each report offers provides an opportunity to survey and appraise the project as a whole, as well as to evaluate a segment of it. Most important, a series of progress reports eases the burden of writing a final report. In a project of any size, memory as a source of information is a fragile thing, for details are easily forgotten. Progress reports provide a detailed, written account that can be converted at the end of the project into sections of the final report. The researcher thus profits from what he is forced to write as he works. Many of the data he may (or may not) want to incorporate into his final product are already on record.

Supervisors and administrators consider progress reports to be links in their chain of communications. Such reports serve as vehicles to keep management informed and thus make possible intelligent decisions on matters of money, manpower, equipment, and materials. They help managers and administrators establish and evaluate trends that may show whether a project should be perpetuated, reoriented, or abandoned. Submitted to a sponsor, they often inspire renewed confidence in the feasibility of the work and convey an optimistic image of the company involved in the project.

Frequency of Progress Reports

Interim or status reports, both of them types of progress reports, usually review progress only when one phase of a project has been completed, whereas a general progress report may be submitted any time it is called for during the work. The frequency of progress reports varies. They may be presented weekly, monthly, or sporadically at the discretion of the supervisor. A proposal or a government contract may stipulate the number of progress reports to be submitted and their spacing throughout the project.

Record of progress can be submitted in formal reports, simplified fill-in reports, memoranda, or letters.

Formal Progress Reports

The classic form of a progress report is designed to discuss three elements: (1) past, (2) present, and (3) future. The first progress report, of course, has no past work to discuss. Instead, it offers introductory material: the subject, the purpose of the investigation, the problem or background, and sometimes the significance of the problem. As in all progress reports, it indicates the dates covered by the investigation. Subsequent reports summarize past work in order to bring the reader up to date on what has been done on the project. They usually repeat the subject and often the purpose of the investigation. The second element details the present work accomplished since past reports. It includes specific data on the work in progress as well as the problems encountered. It is usually the most important segment of the progress report. The third element indicates briefly future work: what steps will be taken to complete the remaining work on the project and why.

EXAMPLES

The following examples may help clarify the requirements of progress reports.

Introduction to a First Progress Report.

```
This is the first semiannual progress report on contract
RF1204 between the Universal Olympia Steel Company and
the Department of Metallurgical Engineering of X
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identification

University. It covers the period June through October, 19xx. This project is an investigation of Thermodynamic Equilibria in the Tantalum-Oxygen System. Subject

The investigation will determine (1) the phase diagram for the Tantalum-Oxygen System and (2) the physical and thermodynamic properties of the oxides of tantalum. Problem and objectives

The purpose of this investigation is to obtain data to use in designing ultrahigh temperature alloys of tantalum for space applications in rockets and missiles. Purpose

Introduction to a Second Progress Report. The opening of a second progress report serves to brief the reader on what has gone before and to tell him where to place this report in the series*:

This is the second progress report on the analysis of Antarctic water samples for DDT residues. Subject

It covers the period between October 25 and November 25, 1977. Dates covered

Work Previously Completed (detailed in Progress Report 1). Past work, preliminary background information, and work completed were presented as follows: Review of first progress report including literature survey

1. DDT residues have been found in many endemic species of the Antarctic (Tatton et al., 1967).
2. I have theorized the source of this contamination to be snow-out from global air currents.

*Courtesy of Jacob Lehman

3. To test this theory I prepared eight charcoal adsorption filters and sent seven to Plateau station, Antarctica; six were to be used to sample snow-melt water used there. The seventh and eighth would serve as controls.

Present Work. Present work can be organized chronologically or topically.

Often, of course, present work is discussed chronologically. Although a disadvantage of this approach is that it weighs every step equally, the approach is simple and natural and demonstrates the ability of an individual or a group to move steadily forward.

Chronological Organization.

First: I mailed 450 questionnaires to Recreation Directors in various cities. To date no answers have been received.

Second: I interviewed the city Mayor and the Director of Columbus Recreation. Both approved of the program, although there were some questions on financing it.

Third: I obtained a copy of Cleveland's program and found it similar to ours. There are several fundamental differences, however, which should be examined to determine the feasibility of incorporating these new ideas in our program.

If the report of present work is to be organized topically, the writer has three choices: to present the components of systems, to divide work into tasks to be performed, or to divide the material into broader divisions and concepts. Organizing the report topically has the same disadvantage as the chronological approach; that is, the arrangement allows details on one subject under one heading to appear to be of equal importance, as the following sections illustrate:

Division by Components.

Divisions by Components [a reactor system]

The Sr^{90} storage facility [mentioned in previous reports] that is to be installed in Cell 18 has been designed and is ready for fabrication.

<u>Cell 12 Modification</u>

The design criteria for the modification of Cell 12 into a manipulator cell have been established. The project is now in the design stage.

<u>L^{125} Loop</u>

The estimated cost of installing the iodine loop--an estimate obtained with the cooperation of the Cost Department--would be about $95,000, exclusive of processing and pile rent.

Division by Tasks. Basically, tasks are arranged chronologically. In a report on the development of a program to improve the traffic department billing service in the 419 operating district of a telephone company, the following tasks are indicated:

<u>Present Work</u>

Task 1: Section of a Sample

My first step was to have all chief operators in the 419 District select 10 per cent of their operators to serve as the study group. This study group was chosen solely on its billing service record and is composed of an equal number of good, average, and poor operators. The criteria for the selection of these operators were based on company policy regarding billing service, i.e., 1 1/2 errors per month for a good operator. The group contained a total of 36 operators.

Task 2: Comparison of Billing Records of Sampling

I carefully examined the billing records of the study group to determine those towns in which poor operators are weakest. A breakdown of operator errors on various sections of the Mark Sense tickets shows a definite variation between good and poor operators. The statistics cited below are the average per month for good, average, and poor operators. [Statistics then follow.]

Task 3: Interviews

I personally interviewed each operator to determine if good operators' habits differ from those of poor operators. The interviews usually lasted 25 minutes and I asked the same questions of all operators. Their responses are summarized below.

Broad Divisions. Organizing a progress report into broad divisions allows more latitude for emphasis, as is shown in the following outline for a second progress report to the Ohio Department of Transportation. This is a rather long formal report entitled "Development of a Pilot Program for Maintenance and Inventory Control of Highway Lighting Systems."* It is interesting to note that much of the detail is relegated to the appendix.

Because it is a formal report, the outline is contained in the table of contents.

Statement of Problem

Introductory Background and Significance

    Maintenance and Inventory Control Systems

    State Highway Lighting System

*Courtesy of Ohio Department of Transportation.

Review of Objectives

Anticipated Benefits of Implementation

Work Plan Progress

- Phase I: Orientation, Project Management, and Survey of Literature
- Phase II: Maintenance Subsystem
- Phase III: Inventory Subsystem
- Phase IV: Documentation and Feedback Subsystem
- Phase V: Presentation of Results and Reports

Summary of Project Status

Plans for Future Activities

References

Appendixes

- Appendix 1-Q2, Investigation and Analysis of Generalized Maintenance Problems
- Appendix 2-Q2, Flow Diagram of Information Gathering Process
- Appendix 3-Q2, Problems Encountered in the Field Data Collection
- Appendix 4-Q2, Flow Diagram of File and File Structure Used
- Appendix 5-Q2, Example of Six Output Reports and Flow Diagram of Reports Program

Future Work. The final section, or future work, should be brief and realistic. It should not make unwarranted promises. This section is illustrated in the following example:

FUTURE WORK

The next work will be testing tantalum. This will be started immediately; at least part of the thermodynamic data on the oxide should be determined by the next progress report. Analyzing the diffraction patterns to determine the crystal structure of the oxides will probably take a longer period because the patterns are complex. The time required to complete the entire project depends on the number of oxides in the system, and this is not known at present. Any unexpected problems could extend the time requirement.

In the transportation report, future work is stated positively:

PLANS FOR FUTURE ACTIVITIES

Additional work on Phase 1 will essentially consist of completing correspondence with highway departments in other states, with power companies, and with manufacturers and vendors. Project administration via monitoring of research tasks will become more important in the next calendar quarter, because all research phases will be active. Phase 2 work has increased during this last quarter. The continued work on this phase during the third quarter will consist of a complete, detailed analysis of the findings. Compilation of inventory data for Phase 3 has also reached its high point. The third quarter activities for this phase will consist of finishing Franklin County and checking the reliability of the data using a statistical sampling technique. The software development will also proceed with the final edges of the program being smoothed. Work on Phase 4 has begun during this past quarter and will continue until documentation and feedback have been provided. Scheduled Phase 5 work will be completed with the publishing of the third quarter report.

Variation of the Formal Report

In an effort to develop more informative progress reports, to improve their readability, and to save time for both management and supervisors, some companies have departed from the classic forms. The variations in patterns they prescribe enable management to grasp immediately the points significant to management without reading through all the technical data. These data, normally scattered throughout the reports, are relegated to a separate division for the benefit of the supervisors or technical directors.

Such progress reports are organized not as summaries, present work, and future work, but rather in the following manner:

- Introduction
- Summary
- Conclusions
- Recommendations
- Results of experiments
- Technical experimental details

Simplified Forms

Simplified forms do not necessarily shorten the information; they merely have the advantage of readability and emphasis. Unusually long, formal reports, regardless of their importance, are not without problems. A series of these reports often becomes unwieldy for the reader who has a difficult time sorting significant details from insignificant details, both of which are scattered throughout the reports, often with the same emphasis. A series frequently becomes repetitious, especially when authors insist on spending more time summarizing past work than they do describing present work. Finally, the information in these reports is often out of date by the time it is received. An author intrigued with continuing his project considers writing a report anticlimactic, and as a result he postpones his task. This postponement creates a damaging lag between past and present work.

As a result, simplified and shorter forms have been established to suit a company's need and to keep supervisors up to date. The supervisors forward the pertinent information to management.

Many companies provide printed forms to be filled out weekly or monthly. Naturally, these forms vary, depending on the information which fits the company's needs. A job progress form is shown in Figure 10-1.

ABC Const. Co.
Company

Report No. 6

JOB PROGRESS REPORT

Job No. 156 Name Adams County Day / Week Ending / Month 10-18 19 71

Reported by Allen Johnson Page 1 of 1

Cost Code	Contract Item No.	Description	Unit	Quantity			
				Previous Report	This Period	Adjustment	To Date
C 5.00	2	Clearing & Grubbing	A	14	4	--	18
C 27.00	4	Strip Topsoil	CY	2420	450	--	2870
C 32.00	7	Earth Excavation	CY	12410	3400	+250	15560
C 37.00	9	Rock Ex (Drill & shoot)	CY	3500	1200	--	4700
D 14.11	22	18" R.C. Pipe	LF	220	110	--	330
D 14.14	24	24" R.C. Pipe	LF	80	40	--	120
D 14.18	26	36" R.C. Pipe	LF	460	--	--	460
F 11.00	34	Structure Excavation	CY	235	110	-40	310

*Adjustments are for correcting amounts on previous reports as firm quantities are available on each section on work to adjust errors in estimated quantities reported.

Figure 10-1. A job progress form. (From Dan Brock, *Cost Accounting Manual for Highway Contractors,* American Road Builders' Association, Washington, D.C., 1971. Reprinted by permission.)

Memoranda

Many companies require workers to fill out a weekly memorandum that calls for a description of present work completed, work to be completed, variance from projected schedule, and what is being done to correct the variance:

Interoffice Correspondence
XYZ Grain Dryer Co.

To: G. I. Smith — Date: August 11, 1977

From: M. O. Eddy — Reference: C. D. 500B

Subject: Progress report on energy conservation gizmos for grain dryers

1. Work completed (in%)

Gizmo	No. 1	No. 2	No. 3
Design	100	100	100
Detail	100	100	100
Prototype Models	100	100	100
Construction	100	80	60

2. Work to be completed (in%)

Gizmo	No. 1	No. 2	No. 3
Construction	0	20	40
Test	100	100	100
Post-test Changes	100	100	100

3. Work performed this week

Gizmo No. 1 was transported to the test site. It will be ready as scheduled for preliminary tests on the layer-dryer when the corn harvest starts in the latter part of September. The construction of gizmo No. 2 for batch dryers is progressing smoothly and no difficulty in meeting the September 15 schedule is anticipated.

4. Variance from schedule

The construction of gizmo No. 3 for continuous-flow dryers is about 5 days behind schedule because of a foundry error making it necessary to scrap one of the aluminum castings used in the hot air recycling device.

5. Correction of variance

A new casting has been made and we have arranged with our machine shop to process it immediately upon delivery. Our prospects for making the September 25 schedule look good as of now.

Amount spent this week	$ 2,676
Amount authorized	35,000
Amount spent to date	15,170
Current balance	19,830

JDB:NOP

Monthly memoranda are popular with some companies. They usually include only a brief statement of the present work, often indicating some of the problems involved, as illustrated in the following memorandum:*

To: T. A. Brown Date: July 1 to Aug. 6, 19XX

From: J. C. Teller Subject: The Cascade

All the leaks in the methane carbon-13 cascade were apparently repaired, and the cascade was put in operating condition.

The cascade was started without the chemical scrubbing

*Courtesy of Oak Ridge National Laboratory.

recovery system in operation. After 4 days of operation, samples taken at the end of the column showed approximately 60 per cent CO_2, 13 percent N_2, and small quantities of water vapor and argon. The CH_4 concentration was so low that it was impossible to calculate an accurate isotopic carbon-13 concentration from mass spectrometer data. It appeared that the product methane contained approximately 8 per cent carbon-13.

A ground developed in the 460-volt electrical system supplying the column heaters and forced a temporary shutdown for repairs.

The cascade was started up again but continued to show a very high concentration of contaminants and only 10 to 20 per cent methane. Because the cascade operates at 45 psig pressure, there probably is no inleakage of atmospheric gases. The contamination may be coming from very small amounts of unwanted gases in the tank methane being enriched through the cascade to unbearable concentrations. This will have to be investigated.

Letters

Letters are also frequently used, as in the following student report, which is shorter and more informal than the long report, although it follows a similar pattern:*

*Courtesy of Karl P. Kraven

November 12, 1977

Mr. Don I. Slockten
City Engineer
City of Upper Arlington
2800 Tremont Road
Columbus, OH 43221

Dear Mr. Slockten:

This is the second progress report for the period of November 1 through November 12 on my study of the intersection of Tremont Road, Fishinger Road, and Northwest Boulevard. The Upper Arlington City Council has requested that the intersection be studied to determine the feasibility of improving the safety and the decongestion of the intersection. Three alternative designs will be prepared based on data collected from traffic counts and present geometry dimensions. By capacity analysis and an economic benefit-cost study of the three alternative designs, I hope to produce an adequate plan capable of meeting the safety requirements of the City Council.

PAST WORK

An 18-hour traffic count of the intersection was conducted on November 9, 1977, from 6 a.m. to 12 a.m. to determine the peak hours of the morning and afternoon. Data pertaining to the geometry of the intersection were collected. Geometry and the peak hour data will be used to compute the present intersection capacity.

PRESENT WORK

1. Peak Hours

Based on the data collected from the 18-hour traffic count conducted on November 9, 1977, from 6 a.m. to 12 a.m., the morning peak hour was found to be from 7:13 to 8:13 a.m., with the heaviest traffic movement from eastbound Tremont to southeast Northwest Boulevard. Similarly, the afternoon peak hour was found to be from 4:55 to 5:55 p.m., with the heaviest traffic movement from Northwest Boulevard to westbound Fishinger Road.

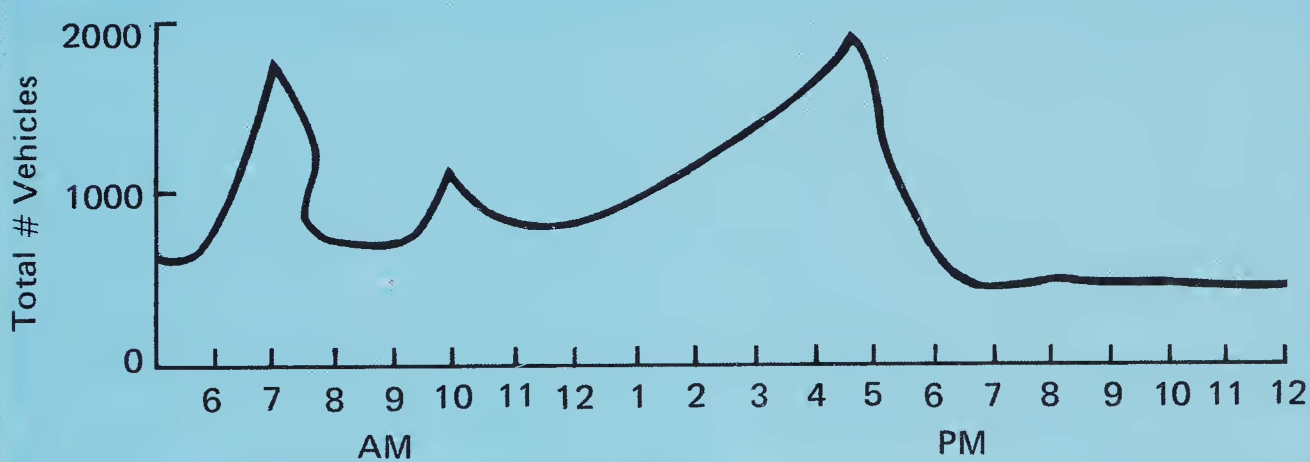


Figure 1. Graph of the 18-Hour Traffic Study

2. Present Geometry

Dimensions of the existing approach lanes of the intersection were measured and are tabulated below:

APPROACH	NUMBER OF LANES	LANE WIDTH
Tremont (S)	2	12 feet
Tremont (N)	2	10 feet
Fishinger (E)	2	10 feet
Fishinger (W)	2	12 feet
Northwest (NW)	3	10 feet

FUTURE WORK

The remaining steps in the study are:

1. Preparation of three alternative designs.

2. Preparation of a model of the selected alternative design.

I hope to improve the safety of the intersection by preparing an alternative design based on the American Association of State Highway Officials (AASHO) specifications for different intersection geometry and signal timing; the design will be the most economical and efficient of the three designs.

I will submit my final report on November 26, 1977.

Sincerely,

Language of Progress Reports

It is a great temptation for the author of a progress report, especially if he feels he has little progress to report, to try to cover up by using ambiguous language or empty generalities. But an effective progress report requires clarity, conciseness, and unambiguous language. It is simply a waste of time, for both the writer and the reader, to pad a report with meaningless phrases that can be interpreted in a number of different ways. A chemical company has collected the following examples:*

*From *Cyco News*, published by American Cyanamid Company. Reprinted by Permission.

LABORATORY SEMANTICS

For some time we have noticed in the monthly summary reports that there has been a marked tendency to use rather loosely certain of the standard phrases that are necessary in these reports. This practice has frequently caused considerable confusion in certain circles where a spade, if called a spade, is often assumed to be a spade. Therefore the following guide has been prepared with the hope that it will in the future help to avoid this mental discord. Some of the most frequently used phrases are listed, each with a typical example of the correct interpretation that should be placed upon it.

Phrase	*Interpretation*
. . . a preliminary study of the problem is being made.	. . . I am trying to find out what this is all about.
. . . this approach to the problem will be undertaken at the first opportunity.	. . . This looks like it's going to be a heck of a job. I wonder if there are any openings at Monsanto.
. . . a literature survey of the problem is being made.	Somebody told me that he thinks there was a paper on a related problem in the Analytical Edition of either July 21, 1975 or June 12, 1957. Both of these issues seem to be missing.
. . . in conferences with other members of the technical staff, their past experiences bear out the fact that	. . . a bull session on sports, sex, television, sex, foreign affairs, sex, and related subjects.
. . . other work done on this subject shows that	My prof at Brooklyn Poly thinks that possibly he may have tried the reaction in a test tube, but he's not sure.
. . . work has been started.	. . . Eimer and Amend promise delivery on the necessary reflux column in two months. All of the vacuum pumps are tied up at the moment.
. . . preliminary results are promising.	. . . some of the elder chemists smelled traces of the product in the air.
. . . work is progressing.	. . . have succeeded in finding vacuum pump.

Phrase	*Interpretation*
. . . this line of attack is still being pursued.	. . . the preparation has now been on the steam bath for 29 days.
. . . some delay has been incurred in finding special equipment.	. . . no clean 50 ml beakers.
. . . the final phase of the work is being completed.	. . . the reflux column has arrived by way of Stratford with seven of the eight bubble caps broken but otherwise in good condition.
. . . tests show that heat is an important variable in the reaction, greatly influencing the yields obtainable.	. . . The guy at the next bench broke two flasks while heating the neck to remove frozen adapters, losing all the product.
. . . a complete tabulation of the results is being made.	. . . Six of the seven observed values will have to be discarded if a straight line is to be obtained.
. . . allowing for experimental error, yields are good.	. . . 3% of theory.
. . . yields are nearly quantitative.	. . . 16.3% of theory.
. . . a complete report of this work is being written.	. . . as soon as the vacuum pump is repaired, I will start all over again.

It is the progress report that will probably introduce the new employee to the world of report writing. Obviously, different companies employ various methods to disseminate information. But the language itself should be precise and concise. If no model of organization is available to the author of a progress report, he can usually safely organize his material into sections discussing past, present, and future work.

Sample Student Progress Report*

First Progress Report on a Comparative Evaluation of Three Methods of Solid Waste Disposal: Sanitary Landfill, Incineration, and the Recovery System

Introduction

Purpose

The purpose of this first progress report covering October through December 19xx is to present work that has been completed in an investigation comparing three methods of solid waste disposal--sanitary landfill, incineration, and the resource recovery method system--in order to determine which method the city of Akron, Ohio, should adopt. Specifically, this progress report covers the description of landfill facilities and projected needs for solid waste disposal, and also the description, environmental impact, and economic feasibility of the incineration method of solid waste disposal.

Background

Disposal of solid waste is a problem that has plagued Akron and surrounding Summit County for many years. Recently, the situation has been further complicated by inflation, increased air and water pollution standards, and the energy problem. Consequently, Akron

*Courtesy of Steven T. Shira.

is searching for a disposal system that will not only meet current needs but also establish a solution for many future years.

Present Work

Existing Landfill Facilities

A survey of the existing facilities has been completed.

Solid waste from Akron and surrounding Summit County is presently disposed of by landfill in four landfill sites operated within the county. In addition, some solid wastes are being transported for disposal in rural areas.

Only two of the county's four landfills handle large volumes of waste--Akron Sanitary Landfill on Hazel Street and the Akron City Landfill on Hardy Road in Northhampton Township. The Akron City Landfill is the largest in Summit County, covering about 100 acres. This landfill has been in operation since June, 1970, under an 8-year contract with Northhampton Township, and averages about 313 tons of solid waste per week. Its life expectancy is estimated to be at least 5 more years.

Akron Sanitary Landfill, a private operation, is considerably smaller in acreage (40 acres) than the City Landfill, but handles a larger volume of waste. The landfill disposes on the average of 714 tons per week and has an expected life span of 1 more year.

Clinton Village, the third landfill site, has a 6-acre Village-owned landfill that is open 1 day per month for the village's own disposal purposes. The fourth landfill in the county is the Harris Street Sanitary Landfill in Akron, which is limited to relatively small quantities of construction and demolition wastes. Because of the small volumes handled at these two landfills, they have little relevance to the overall solid waste disposal problem.

In addition to the four landfills, there are two major solid waste transfer stations in Summit County that handle solid waste along with other salvageable materials. These two companies, H and G Transfer Station in Barberton and Budhoff Iron and Metal Company, extract salvageable materials from solid waste and dispose of the residual materials in landfills. H and G handles approximately 30 tons of waste per day and the Budhoff Company handles approximately 178 tons of solid waste per day.

Future Solid Waste Disposal Needs

Future solid waste quantities are extremely difficult to estimate, especially in view of today's energy crisis and the recent concern over recycling of our natural resources. Table 1 identifies future solid waste quantities based on the current disposal rate of 4.11 pounds per person with the projected increase in population.

TABLE 1
Estimated Future Quantities of Solid Waste

	AKRON		SUMMIT COUNTY	
	Population	Tons/Day	Population	Tons/Day
1980	267,000	548.7	582,000	1225.1
1990	277,000	569.2	648,000	1331.6
2000	286,000	587.7	690,000	1418.0
2020	320,000	657.6	772,000	1586.5

Incineration

Description of System

Incineration uses the chemical process of oxidation to combine chemically the hydrocarbon compounds of the combustible refuse with oxygen in the air to form carbon dioxide and water, leaving the minerals and metals as solid residue. The oxidation releases high energy, which sterilizes the residue, destroys odorous compounds in the refuse, and converts the water into vapor that is released into the atmosphere.

Operation

When the solid waste arrives at the incinerator, it is deposited in a below-grade storage bin where it enters the feeding system. The feeding system is composed of a traveling crane with a grab bucket that lifts and carries the refuse high above the furnace and releases it into a funnel-shaped hopper that leads to a chute that allows the refuse to slide into the furnace under the action of gravity.

The furnace is a refractory-lined compartment that contains primary and secondary combustion chambers. The refuse moves through the primary combustion chamber on a grated stoker that agitates the refuse to expose new surfaces to heat and oxygen. The refuse is burned by overhead gas jets with oxygen supplied from a forced draft fan that blows air through a smooth metal-lined chute extending down into the furnace. A conveyor picks up unburned residue and transports it to a storage hopper.

After primary combustion, gases and solid particles swept along with them are burned in the secondary combustion chamber. The final product then exits the furnace to a dust collector where particulates are separated from the exhaust gases.

Environmental Impact

The major waste products from incineration are residue, fly ash, and process water. Pollutant gases such as unburned hydrocarbons and carbon monoxide from the main combustion chamber are minimal if the equipment is operated properly.

Residue from incineration of municipal solid waste contains ash, metal cans, glass, rocks, and unburned organic substances. Because pollution can occur when water leaches through the residue and enters the ground water, incinerator residue must be disposed of by sanitary landfill methods.

One of the products of combustion is fly ash, which consists of particulate matter carried by the combustion gases. Fly ash includes ash, soot, cinder, and mineral dust that is removed from the exhaust gases by a dust collector. After collection, the fly ash is stored in closed containers and disposed of by sanitary landfill methods.

Incinerators use process water for residue quenching and fly ash sluicing. In this process water can be discharged into a sanitary sewer for subsequent handling in a central treatment plant.

Capital Cost

The initial cost of an incinerator will range from $4000 to $10,000 per ton of refuse per day.

Some of the major equipment costs included in the capital gain are scales, cranes, furnaces, blowers, air-pollution control devices, residue removal systems, and instrumentation. Major construction items include the building, ramps, tipping area, storage pit, refuse hoppers, offices, employee facilities, piping, and chimney. Miscellaneous items included under capital cost are site preparation, excavation, and foundation preparation.

The operating cost of an incinerator will range from $5.00 to $9.00 per ton of refuse per day.

Some of the operating costs include employee wages, utilities, and residue and fly ash disposal costs.

Future Work

The next stage in the investigation is to estimate the costs for landfill operation. Following this will be the description and analysis of the resource recovery system using the same three criteria: environmental influences, compatibility with related methods, and economic feasibility. The best method will then be selected based on its overall impact on the environment and costs associated with future changes in pollution regulations and solid waste disposal quantities.

EXERCISES

1. Write a progress report in letter form to your parents relating your progress in a difficult subject.
2. Indicate to your instructor your progress in completing your final report. Such a report could include your outline, the data gathered with any discussion, the results of some of your experiments, problems encountered, and authorities consulted. Be sure to include bibliography material. Indicate which progress report you are writing and what period it covers. If it is the second or third report, supply the summary of previous progress reports.
3. Show how you would set up a progress report in a simplified form. Include present performance, costs, variance from schedule, and correction of variance.
4. Analyze and criticize the following progress report:

   We are now in the sixth month of this research project in which our preliminary study has resulted in negative results. The survey of the types of sound was also negative. We started work on the research immediately after receiving the order, but we had trouble in determining the development of acoustical tile for the selection of sound in the frequency of 800 to 1150 cycles per second. We hope to make further tests of the tile, but although the material seems to be operating satisfactorily now, we do not know that it will continue to do so until we have found the basic causes of our instrumentation difficulties.

   Considering the latest data that we have gathered, we feel that the next tests will prove positive. Later we will give you a complete tabulation of our results.
5. Assume that you are president of a campus activity such as Engineering Week, Homecoming Week, or Greek Week. Prepare a progress report on programming, publicity, selection of meeting places, speakers, judges, and financial arrangements. Include a statement of future work needed to complete the plans.

CHAPTER 11

Final Reports

Final reports are tangible proof that an investigation has been finished. No project is complete until the final report has been written to furnish a permanent record of the research and its application. Many research institutes make a point of saying, "Reports are our only product." The significance of reports could hardly have a better witness than such a commercial affirmation.

Because reports are varied—long and short, formal and informal — and are written for different purposes and different audiences, they are difficult to classify. Nevertheless, for convenience of discussion we shall put them in two large general categories: information reports and decision-making reports (sometimes called action reports). First we will define the two types and discuss their differences in purpose and their similarities in the use of data. Then we will present the elements that make up both types of reports: title, introduction, body, and terminal sections.

Information Reports

Although it must be conceded that some reports and many articles are written to supplement their authors' incomes, in general the authors of pure information reports are motivated by a desire to share facts and judgments with other people on the assumption that such information is interesting. Behind this motive is the belief that knowledge contributes to the advancement of science and technology and leads to a fuller life for everyone. Consequently, information reports concerned with findings and their relationships to each other and to already known facts are written to disseminate information or to provide a record and an evaluation of activities. Included in this category are periodic statements on the status of an organization (annual reports), reports of laboratory findings, classifications, field records, trip reports, and progress reports. The vast majority of information reports involve research. Some research reports compile and synthesize facts already known; others deal with the results of experiments on new methods, products, or applications. The scientific and technical world depends on research reports.

Decision-Making Reports

Decision-making reports are action oriented. They rely on the examination of research to induce their readers to take action to solve a specific problem. They can be classified into several subtypes: reports that examine the feasibility of an action; reports that justify an action by providing information; reports that examine and evaluate a situation by analysis of collected data; reports that provide data for recommendations; reports that assemble proposals for action, for further examination, for change.

Subject Matter

The objectives of the two main types of reports obviously differ, and one might suspect that their contents would distinguish them. However, much of the same material can be used in both types of reports. The following list of subjects demonstrates that identical data can be used in information and decision-making reports; it is the purpose, not the content, that determines the direction and treatment of the material.

Information (research reports)	*Decision Making (problem-solving reports)*
Review of methods for drying corn	Comparison of corn-drying methods to determine which method is most effective in Iowa
Study of available safety devices for cars	Analysis of the most effective safety devices for passenger cars and a recommendation for a national law requiring all manufacturers to install such a device

History of the development of milk cooperatives	Feasibility of initiating a milk cooperative in western Wisconsin
Statistical examination of the number of red-winged blackbirds in Sandusky County	Determination of the extent of damage to crops caused by red-winged blackbirds with a means of controlling the birds
Types of available nonglare glass	Types of nonglare glass for use in XYZ Factory in Phoenix, Arizona
Value of solar heating	Feasibility of solar heating in the Elliott Office Building in Lexington, Kentucky

Choice of Subject

For the student, choosing a subject for either an information report or a decision-making report often presents difficulties. If an individual is an employee of a particular company, the concerns of the company will doubtless determine the topic and the direction of the report. However, a student learning about the construction of reports must begin by choosing his own subject. If he intends to write an information report, his first step is to select a subject and then limit it to manageable proportions. A student's personal interest can determine his final choice of subject if the interest is matched by an adequate technical background. However, a superficial interest in, for example, bridges will involve a student in all kinds of difficulties if he chooses to write on bridges but lacks an engineering background. For one thing, he will not know the terminology of the subject, and this will hamper his search for material. Another common problem is choosing a subject that is too broad. A subject covering all government programs, for instance, is too broad to be manageable in a single report. However, if the topic is restricted to one type of program such as the Food Stamp Program, it qualifies as a restricted subject and a good possibility for a report-writing assignment.

Student reports will vary in length just as do professional reports. If the instructor does not suggest a length, the student should select a topic that can be handled in 15 to 50 double-spaced typewritten pages, anywhere from 3000 to 12,000 words.

If the student is interested in choosing a subject for a decision-making report, his first step is to isolate a problem that requires a decision. Professional problem-solving reports usually concern a company's efforts to find more efficient methods of production, to raise profits, or to search for new procedures and applications of theories. These are specific problems, but students often want to tackle world-shaking situations, such as pollution or the energy crisis. Such broad issues should be avoided in favor of a limited problem that can be handled within the scope of experience, research opportunities, and schedules—such as a campus problem, an educational problem, or one suggested by a hobby, a part-time job, classwork, or free-time reading.

Elements of Final Reports

Information and decision-making reports in their final form look quite similar. Both types consist of a title, an introduction, a body, and terminal sections. They differ in their purposes, their introductory approaches, and the content of their terminal sections.

TITLE

Titles are (1) informative, (2) brief and clear, and (3) indicative of subject and purpose. The reader of a report first notices the title, although it is probably the last thing an author considers. First or last, it is obviously important. Titles in reports are not meant to be stimulating, imaginative, or creative. Their function is to convey information. The specific purpose of an information report is generally made apparent by the use of such terms as *description*, *study*, *explanation*, *history*, *development*, and *examination*. On the other hand, in a decision-making report such terms as *comparison*, *determination*, *feasibility*, *analysis*, and *justification* are common. Thus an information report may have as its title "A *Description* of the Effects of Mastitis in Cattle" whereas the title of the decision-making report on the same subject would be "*Determination* of Ways to Control Mastitis on the Sun Valley Davis Farm."

What constitutes a good title for an article rarely is appropriate for a report. A startling title such as "Mass Murder" might be excellent for an article, but it is not informative on the content of the report, which should be entitled "Prevention of Traffic Accidents on Freeways." Similarly, a title that depends on jargon or terminology explained in the report is not sufficiently informative. "An Explanation of Pips and Poops in the HRT" may at first glance be amusing, even intriguing, but it is meaningful to only a very few specialists.

A more meaningful and dignified title would be "An Explanation of Sudden Power Surges and Drops in a Homogeneous Reactor Test."

Titles should be checked for clarity and completeness. The omission of one or two words may give an erroneous impression of the content. The title "Men's View of Women in Labor" is obviously misleading; the phrase should be ". . . in the Labor Force." "Fluctuations of Quail in Northern Missouri, 1970-1975" requires the insertion of "Population" after "Quail." In "Comparison of Dried Milk Preparations for Babies on Sale in Seven European Countries," the words should be reordered or some should be dropped: "Comparison of Dried Milk Preparations for Babies in Seven European Countries."

To be informative, titles should be specific. A title such as "Discussions on Management" gives very little clue that the report is a survey of managerial methods for raising morale among employees. The title "Research and Development Standards Program" conveys little idea that the report is really an *evaluation* of the program.

Titles should be as brief as possible because short titles are easier to remember, but information should not be sacrificed in the interest of brevity.

Four examples of titles follow:

THE FEASIBILITY
OF
DESIGNING AN IMPROVED SYSTEM FOR TESTING
HYDRAULIC BRAKES

SUGGESTED IMPROVEMENTS
FOR
HEAT TREATMENT FURNACES

DEVELOPMENT OF IMPROVED AIR-VENT
MECHANISMS FOR THE X PUMP

AUTOMOTIVE EMISSION SYSTEMS:
THEIR PRINCIPLES AND MAINTENANCE

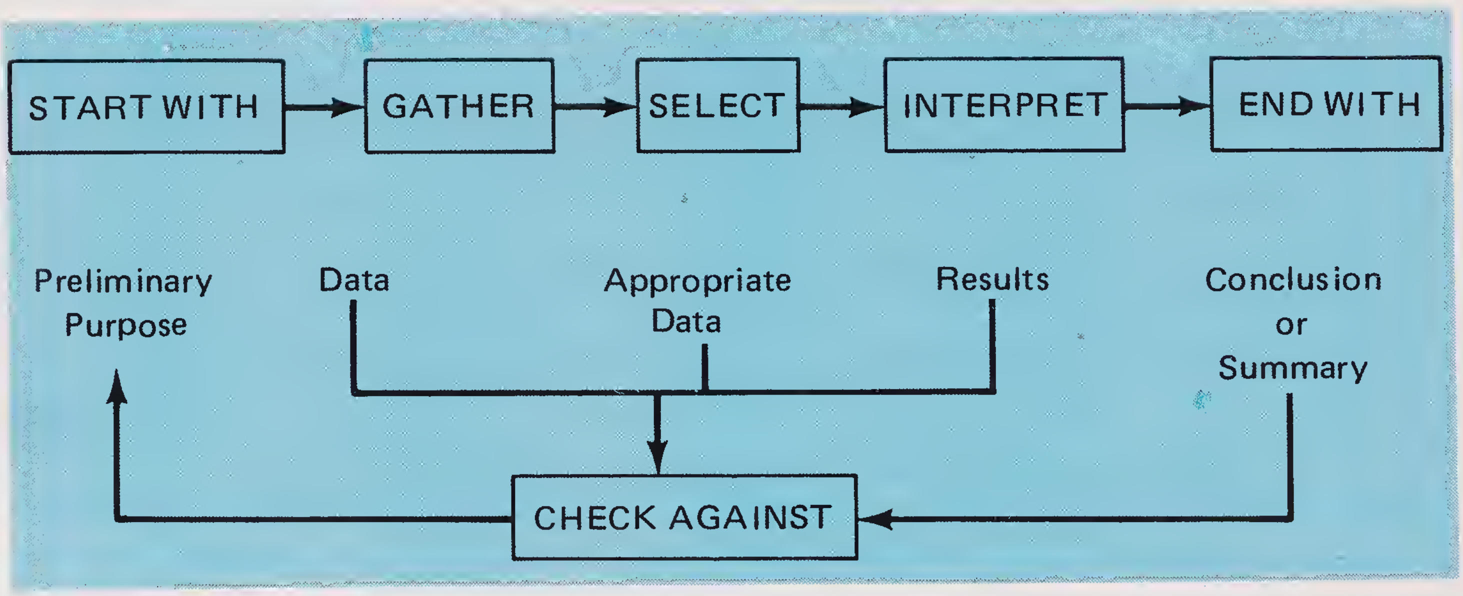
INTRODUCTION

Introductions include some or all of the following parts: (1) statement of purpose, (2) thesis sentence, (3) statement of problem and background, (4) statement of limitations, (5) statement of scope, (6) statement of procedure, (7) description of criteria, (8) definition of terms, (9) reminder of theory, and (10) summary of conclusions and recommendations.

Introductions to information reports and decision-making reports can be quite similar. The basic function of the introduction is to orient the reader to the material presented in the body of the report and to disclose the attitude of the writer toward his subject. To these ends, the introduction presents at least two essentials: the purpose of the investigation and the problem or background material. The writer is obligated in the interest of clarity to furnish the purpose of the report and enough background to make the situation clear. Other elements may then follow.

Statement of Purpose. The overall purpose of an information report is to offer facts and describe their significance, whereas a decision-making report's purpose is to initiate the solution of a problem through action or through evaluative judgments. The preliminary version of a specific purpose statement provides the writer with a means of limiting the research and selecting appropriate data to satisfy the objectives. It also provides a check on the validity of the information presented in the body of the report and its terminal sections, as can be seen by the report circuit commonly followed by most investigators (Figure 11-1).

Figure 11-1. Report circuit.



A preliminary purpose statement is cast in the present tense to help the writer determine just what the purpose of his investigation is to be. It is this statement that directs the research and organization of the report (see Chapter 9). Once the investigation has been completed, the purpose statement that appears in the introduction of a final report is written in the past tense—to acquaint the reader with what the purpose *was*.

> *preliminary purpose*: The purpose *is* to investigate the feasibility and cost of substituting styrene [plastic] caps on relays for the metal caps now used.

reworded for the introduction: The purpose *was* to investigate the feasibility of substituting styrene caps on relays for the metal caps now used.

The purpose may be expressed either explicitly or implicitly. In general, purposes in decision-making reports are overt statements:

> The purpose of this study was twofold: to design a safe and adequate facility for storage of small stocks of solvent and paint convenient to the paint shop and to evolve an improved method of storage for the disposal of liquid waste combustibles from shop operations.

It is also acceptable, especially in information reports, to state the purpose implictly in the first paragraph or so:

> *Recycling* is a relatively new term coined for the utilization of waste materials. Its potential as a solution to the solid waste problem has been established only recently, but its economic value has not yet been confirmed.

Although not directly stated, the purpose of the report is clear—to examine the economics of recycling solid waste. However, the direct rather than the indirect statement of purpose is doubtlessly clearer.

The more specific the preliminary version of the purpose statement, the easier it is to limit and direct the research. If the writer of an information report selects fences as his subject, he must decide on a specific purpose for writing about fences. Is the purpose to describe the types of fences, the construction of fences, the available material for fences, the function of fences, or is it to estimate the value of fences on the farm or in the city? In a decision-making report a preliminary purpose statement such as "The purpose of the investigation is to design a device that will meet operating requirements" is better stated specifically as "The purpose of the investigation is to determine why device X does not respond to impulses from device Y and to redesign the circuit to correct the deficiencies."

The statement of purpose in the finished report should never reveal bias or prejudice. If it does, the reader may well assume that the investigation was not carried out objectively. Thus if the subject is the ever-growing population of dingoes in Australia, the writer of the information report must not state his purpose to be "to explain the *destructive* habits of dingoes." His stated purpose should be "to explain the habits of dingoes." In a finished decision-making report an accurate purpose statement might be "The purpose of the investigation was to determine whether the predatory habits of dingoes are harmful enough in conditions of overpopulation to justify their eradication" (it is doubtful that anyone—even an Australian farmer—could justify such an extreme measure). Furthermore, the purpose statement cannot reveal conclusions; it is intended to indicate what is to be done, not what the accomplishments are. A statement that "This investigation *proved* that the control of the rabbit population by dingoes far outweighs their occasional depredations on livestock" or that "This investigation showed that dingoes are useful in Australia" is not a purpose statement. Used as a purpose statement, either would imply that the answer had been found before the investigation began.

Thesis Sentence. Actually, the two preceding statements are thesis sentences. The purpose statement and the thesis sentence are sometimes confused. Especially with information reports, the writer may gather his information, construct a thesis sentence, and work from it rather than from a purpose statement. However, the two have different functions. A thesis sentence is a mini-abstract that states the conclusions of an investigation, and of course it cannot be written until all data have been gathered. In a decision-making report the thesis statement cannot substitute for the purpose statement in directing the gathering of information. If we state as our purpose, for instance, "to determine which of the three wiring processes used in the Johnson Manufacturing Company is most efficient and best suited to the plant," we have a guide for selecting material. Once that material has been gathered, interpreted, and analyzed, it is possible to state the thesis: "The best-suited wiring process is the printed process." Another example of the difference between the purpose and thesis is "The purpose of the investigation is to determine what methods may best eliminate soil erosion on Mr. Blank's farm." After the information has been gathered and examined, it is possible to state the thesis: "The best methods of controlling soil erosion on Mr. Blank's farm are contour farming, strip planting, and reforesting."

Background/Problem. Another essential part of the introduction is a brief discussion of the background of the subject or problem. Its function is to bring the audience up to date on the existing situation. It is a statement of what brought about the need for the investigation; it may be an explanation or a description that makes the material offered in the body of the report understandable. The nature and the amount of this information depend on the audience. Some reports require only a statement of the problem; others require a description or a short explanation, simply as a reminder of information vaguely familiar to the reader, as the following example illustrates:

> In the past years, street striping operations were expensive and time consuming because no set procedures were available. The stripes were sprayed under different conditions: the amount of thinner used and the striping machine settings were not kept constant; therefore, the pressures differed. The differences resulted in nonuniform stripes at varying costs.*

This statement probably repeats information already known to the traffic department, but it is included as a sufficient reminder of the problem and situation, and it serves to justify the investigation to determine a suitable method of striping.

Other reports, however, require a more elaborate explanation because the background is more complex or because the audience has little knowledge of the subject.

A writer whose intent is to describe in detail the manufacturing processes carried out in a particular plant may feel that his audience should first understand the layout of the plant:

> Simple expansion of the Industrial Truck's main plant did not provide a practical solution to new space requirements; thus a decision was made to establish a separate facility for the manufacture of electrical vehicles. The inside of the building is so designed that the lift truck fabrication starts with welding the truck frames at the rear of the building. *(Problem / Purpose)*
>
> A subassembly area separates the welding area from the main assembly lines. Three assembly lines--one each for sit/ride, narrow-aisle, and walkie-type vehicles--operate from east to west across the front of the manufacturing area. Finished vehicles move along the west side of the building for electrical testing, installation of masts, accessories and trim, and final inspection.
>
> Overall layout of the plant follows the point of use storage philosophy. That is, each work area includes storage for all materials required to perform a particular function.[1] *(Explanation and description of the facility)*

If the amount of background material needed becomes unwieldy, there is probably some error in organization, and some portion of the background material most likely belongs in the body of the report.

Limitations. A description of what limitations were imposed on the subject is often included in the introduction. If, for instance, the opening of a report indicates that it will present an evaluation of some of the activities of the Peace Corps in Africa, the writer may want to protect himself from the accusation of incompleteness by stating the limitations of the discussion:

*Courtesy of John D. Franco.

This discussion is in no way meant to give a complete picture because it does not include Peace Corps services in Uganda and Nigeria.

Scope. Scope statements (the plan of the report) are sometimes added as finishing touches to the introduction. They are usually found in decision-making reports:

> This study is divided into three parts: the various types of sun control mechanisms, the advantages and disadvantages of each in relation to its possible use in the Drake Union, and installation costs.

It is easy to see that the scope statement reiterates the major divisions of the table of contents. Many people argue that both limitation statements and scope statements are unnecessary, because an effective title, a clear statement of purpose, and the table of contents furnish all the information needed. Nevertheless, some companies require scope statements in their reports, and the writer is well advised to follow company policy.

Procedure. A statement of procedure or method of attack outlines what means have been taken to gather material and incorporate it into the report. (Procedure is not to be confused with scope, the content of the report—what has been included and what has been omitted.) Procedure may be explained in either the introduction or the body of the report; sometimes it appears in both places, presented in general terms in the introduction and in specific terms in the body of the report. If the procedure is detailed and emphasized, it usually appears in the body. Laboratory reports, for example, include it there. In other reports a procedure statement placed in the introduction strengthens the validity of the report and inspires confidence in the minds of the audience. A report that discusses the feasibility of establishing a recreation facility for dramatic arts should include the procedure in the introduction, as the following example illustrates:

> PROCEDURE
>
> First a survey of the need for a building and possible financial support was taken that resulted in a positive response. Three designs submitted by local architects—Rich and Sons, Architect/Planners, Inc., and Frambes and Associates—were examined and the estimated costs were compared. Finally the possible uses such as meeting halls and banquet facilities were studied for such a building.

To use a different kind of example, in the following procedure statement the writer is concerned with a design for a windmill and feels that the reader should understand his approach at the very beginning of the report:

PROCEDURE

Before consideration of the design of a windmill capable of generating electricity, wind data were obtained from the Port Columbus weather station. The data were used to determine wind velocities and the distribution of hours of useful wind throughout the year. Three types of wind wheels were compared for extracting energy from the wind (multivane, turbine, and propeller). The airfoil cross-sections of a number of propeller blades were studied. These data provided information for the design.

The writer still must discuss procedure in the body of his report, giving specific information on wind velocities and describing in detail the three types of wind wheels.

Procedure statements in the introduction are more typical of decision-making reports than they are of information reports.

Criteria. Criteria delimit the boundaries of an investigation or a discussion. They are sometimes offered in the introduction rather than in the body of the report. Often, however, they are not described under a separate heading; instead, they become part of the scope or procedure statement. A comparison of systems of automated source data collection might include in the introduction the four criteria for comparison: flexibility, ease of operation, reliability, and durability.

In the introduction of a report discussing how to choose a medical school a student familiarized his audience with the criteria for choice:

Schools should be selected on the basis of their size, cost, reputation of faculty, facilities and location, and basic requirement for graduation. Students educated in engineering should consider the provisions made for the combined fields of engineering and medicine.

Definitions. If understanding a whole report hinges on one specialized term, that term should be defined in the introduction. Thus someone writing on smoke abatement needs to stipulate what he means by "smoke" (see Chapter 6):

The term *smoke* in this report refers to the gaseous and solid products of combustion, visible and invisible.

Theory. If a report relies on a theory or a law, the introduction may include a brief reminder of what it states in order to improve the readability of the report. In a report on energy conversion, for instance, it might be a courtesy to the audience to remind it that the first law of thermodynamics states that the total amount of mass and energy cannot be increased or decreased. If the writer feels that a more thorough explanation of the theory is imperative, he includes it in the body of the report.

Conclusions and Recommendations. Finally, some long decision-making reports include in the introduction a summary of conclusions plus recommendations. Of course, if the report is arranged to have maximum psychological effect—that is, if the conclusions and recommendations are presented at the beginning of the body of the report rather than at the end of the report—listing conclusions in the introduction is unnecessary.

WRITING THE INTRODUCTION

Constructing effective introductions is not always easy. Often they are written after the body and conclusions of the report have been finished, for then it is simpler to examine the process that has taken place and determine which elements should be emphasized.

BODY

Much of this text has been devoted to the treatment of the elements contained in the body of a report. Of significantly greater length than any other portion, it presents, depending on the nature of the report: (1) background and procedure if they are long and complicated, (2) data, (3) interpretation, (4) analysis, (5) evaluation, (6) reasoning processes, and (7) designs.

The body contains the heart of the report. Because a report might be on any one of a thousand subjects, this discussion of the body of the report is necessarily general. It applies to both information and decision-making reports. Selection of material for the body depends on the purpose of the report, a logical pattern of organization, and the intended audience. By the time the data have been gathered, the writer is ready to select the appropriate data and discard the unessential details. He then includes all necessary details and excludes those that add nothing to the body of his report. The body must be arranged so that readers can easily follow the lines of reasoning.

The body supplies information on what the report is about. It deals with facts, their relationships and significance. It offers generalizations and amplifies and supports them. It employs inductive and deductive reasoning processes and the demonstration of causal relationships to support the eventual conclusions. It explains the bases for opinions and the methods used by the writer to arrive at his conclusions. The body is often composed of explanations of theories and descriptions of apparatus and processes accompanied by a discussion of the results. It includes also reasons for changes and additions and designs for various types of apparatus or for rearrangements of merchandise or buildings. It includes analyses, evaluations, and interpretations. Visuals are used where needed to clarify material. The body makes use of any or all of the techniques discussed in Chapters 6 and 7.

The length of a body depends on the complexity of the subject, the background and knowledge of the audience, and the importance of the problem.

Because it is impractical here to cover the great variety of subjects for a final report, the student would do well to examine examples of complete reports offered in this text on pp. 268–289 and 304–323.

TERMINAL SECTIONS

Terminal sections contain, where appropriate: (1) discussion of results and findings, (2) summaries, (3) conclusions (usually part of decision-making reports only), and (4) recommendations (usually part of decision-making reports only).

Terminal sections differ among various types of reports. Aristotle, in the fourth century B.C., said that any piece of creative writing has a beginning, a middle, and an end. It is interesting that he used the word *end*, not *conclusion*. In report writing, a good deal of confusion is generated by the indiscriminate use of *conclusion* to mean always the end. Depending on the type of report, the policies of an employer, or the directions of an instructor, a number of ways to end the report are available: *discussions of results and findings*, *summaries*, *conclusions*, and *recommendations*. Since their meanings differ, these terms should be used with discrimination.

Discussions of Results and Findings. Discussions of results and findings, often part of the body of a report, can also serve to end a report. They involve the interpretation and evaluation of data. Used as an ending, they are most typical of a laboratory report. Because the object of a laboratory report is to describe an experiment, designate the results, and interpret them, there is no need to include a formal ending.

Summaries. A summary usually terminates an information report. It is a recapitulation of the distinguishing features of a report and a repetition of the intended emphasis to make sure the audience understands the writer's meaning. An information report, because its main objective is to relay information to an expectant audience, does not deal in conclusions and recommendations; the sensible alternative is to present a summary. The terminal summary should not be confused with the introductory summary, abstract, synopsis, or digest that appears at the beginning of a report (see Chapter 8).

The following is a terminal summary of a report on an "Aerobic Swine Waste Handling System":

> The Kansas State University Swine Research Unit's aerobic-oxidation waste disposal system is functioning satisfactorily with minimum maintenance and supervision. Labor requirements are low. Odor is no problem. Waste fluid can be spread on the fields any time without creating a "public nuisance." Pigs are performing satisfactorily in the unit. Flies are easily controlled, and suitable sanitation is easily maintained.[2]

Because of the nature of the information, it is difficult sometimes to keep summaries from becoming choppy, as in the example just given. Where possible, a writer should strive for fluency. An article in *The Western Electric Engineer* reporting on "Multiplant Loading and Scheduling for Exchange Area Cable" summarizes the material in a more fluent style even though the information given is not as specific as in the preceding summary.

> Within the framework of the Product Control Center the information system described makes it possible for management to control efficiently the company's manufacturing facilities for exchange area cable.
>
> The system effectively supplies a bridge between management policy and service and cost and the thousands of small but related decisions about who makes what when and for whom that must be made regularly to satisfy new demands. The system may have other applications. In general a few of the algorithms developed are important to the product, cable. Thus, for example, one development group has found that many of the models used in this system are applicable to its work with vinyl products.
>
> Finally, the system is serving as a base for further development for exchange area cable in areas of material planning, sequencing within the shop, accounting, billing, and cable reel control.[3]

Terminal summaries sometimes become nothing more than a numbered list of conclusions:*

*Courtesy of Ralston Russell, Jr.

SUMMARY

The exploratory studies herein reviewed, based for the most part on compositions in the Cone 9 to Cone 16 range, seem to indicate the following:

1. Compounds or mineral phases representing Alpha Cristobalite, Alpha Wollastonite, Anorthite, and Gehlenite may be thermally synthesized readily. Nepheline Syenite and Feldspar may readily be fused to produce homogeneous glasses. Kaolin may be calcined easily to yield a product predominating in Mullite but including a secondary phase, possibly a poorly crystallized Cristobalite.

2. With the use of small prism-shaped specimens fired over a range of temperature and the evaluation of their as-fired condition, it is readily possible to rate comparative fusibilities and deformabilities. It is also possible using selective criteria for prism gloss and deformability to estimate with reasonable success PCE values based on standard cone behaviors for the same firing conditions. A large number of compositions may be screened fairly efficiently using this approach.

3. While visual analysis of fired prisms was the primary basis for the comparisons herein reported, more exact measuring techniques could be used in an attempt to enhance the judgments.

4. It is not known whether studies based on small prism-shaped or cylindrical specimens can be used in elucidating differences due to firing rate or atmospheres, or for that matter freezing tendencies, although the approach appears to be sufficiently sensitive to allow such indications.

5. Compositions based on historic Seger cone formulas are considerably more refractory than comparably numbered Orton compositions, due at least in part to differences in magnesia content.

6. Orton compositions representing Cones 12, 13, and 14 together encompass a rather narrow temperature range, and in the firings seemed to be less than one-half cone apart in deformation behavior. The difference between Cone 14 and Cone 15, however, appeared comparatively great.

7. While replacement of regular Potters Flint (Quartz) with Cristobalite in formulating compositions should theoretically result in more refractory behavior, the opposite effect was noted for some compositions studied. Other uncontrolled factors may, however, be contributing to this seemingly anomalous behavior.

8. Formulations calculated to contain the following batch materials appear to merit further consideration:

1. Nepheline Syenite A400-Non-Fer-Al Whiting-EPK Florida Kaolin-Cristobalite C1
2. Nepheline Syenite A400-Calcined Wollastonite WCl-EPK Florida Kaolin-Calcined Georgia Kaolin KCI-Cristobalite Cl

CURRENT RESEARCH PLANS

Current plans relative to the cone freezing problem in the Cone 8 to Cone 16 range involve primary attention to the manufacture and testing of cone-shaped specimens. Testing will primarily involve the conventional observation and comparison of cone deformations using different firing rates, such as 5°, 10°, 60°, and 150°C per hour (9°, 18°, 108°, and 270°F per hour).

Early attention will be directed to 12 series of compositions, with each series comprising 4 compositions calculated to chemically represent Seger compositions for Cones 9, 11, 13, and 15. Firing will be effected in one of two periodic electric furnaces as available, using an ambient air atmosphere. Special atmospheres will be considered later if deemed necessary.

ACKNOWLEDGMENTS

The conscientious laboratory efforts of Sergio Meriani, the principal assistant, and Liselotte Schioler are gratefully acknowledged. The special help and advice of Dr. Charles E. Chaille of the Edward Orton Jr. Ceramic Foundation, and also of Joseph H. Saling, Thomas H. Booth, and Mrs. Colleen Murphy, are much appreciated.

Conclusions. Conclusions are the result of an evaluation of the evidence. They are derived from generalizations, which are derived in their turn from the examination of the data and through the processes of reasoning. They are the result of a writer's appraisal of the significant information. Decision-making reports demand conclusions: conclusions are the reason for their existence. Without them the audience will probably react to the report by saying, "There is no point to this thing" or "So what?"

Conclusions are presented as clear, positive statements. That is, even though the results are negative, the writer does not state them negatively or timidly: "The project does not appear to have yielded the expected results." Rather, he uses a positive approach: "Apparently, the project should be abandoned." The following conclusions from a Battelle report on pumps are stated clearly and positively. Conclusions are usually preceded by an introductory sentence.*

The following nine specific conclusions were drawn on the basis of the survey and laboratory research conducted during this program.

(1) Battelle project team observations substantiate AID's conclusion that there is a serious need in the developing countries visited for hand water pumps, particularly in rural areas of the world of interest; to AID, the challenge is tremendous and a major effort to alleviate the situation is indicated.

*Courtesy of John D. Wallace.

(2) The state of the art in foreign countries relative to pump design is minimal and technical improvement is required in almost every aspect, particularly in the areas of design and materials utilization.

(3) Imported pumps are quite often too expensive for a developing nation and generally do not meet local requirements.

(4) Better means for determining well sites and depths are needed.

(5) Maintenance programs are very poor:

   (a) Needed skills are not available.
   (b) Responsibility for maintenance is not defined and maintenance records are not kept.
   (c) Adequate inventories of good replacement parts are not readily accessible.
   (d) Cooperative, communal attitudes do not prevail in many villages that need pumps.

(6) The basic pump design devised during this program will meet the needs identified.

(7) Some additional work is advisable:

   (a) Dissemination of information to interested agencies and organizations.
   (b) Field evaluation of proposed pump design.
   (c) Further research in cups, valves, and cylinders.
   (d) Development and implementation of educational programs.

(8) The manner in which the proposed pump design is introduced will have extensive implications for the success of the pump and field trials; the production and installation programs must take this into consideration to be successful.

(9) Adequate facilities and skills are available in most of the countries visited for local manufacture of pumps designed on the principles outlined in this report.

Such conclusions were drawn from the evidence presented in the body of the report. Because they are based on evidence and logic, they do not introduce new material. It is possible, of course, to combine the separate conclusions and present them in a general concluding statement:

> There is serious need in the developing countries for hand water pumps; the basic pump design devised during this program will solve their difficulties and fulfill their needs.

In a logically developed report the conclusions appear at the end in one of two ways: they can be numbered and listed (the system used in the Battelle report) or they can be written in paragraph form.

If a report calls for a great many conclusions, listing is the only practical method. If, on the other hand, only a few conclusions are indicated, the writer may present them in paragraph form. Even though listings are generally arranged from the most important to the least important conclusions, their apparent values seem nearly equal; conclusions written in paragraph form can indicate emphasis, relationship, and priority.

The following examples illustrate the two methods.*

CONCLUSIONS

After evaluating four methods of harvesting timber—clearcutting, select cutting, seed tree cutting, and shelterwood cutting—in order to determine which one of these methods is, in the short and long run, most economically feasible to use on the Barneby Tract in Fairfield County, and after determining which of four tree species will be most profitable, some conclusions may be drawn.

1. For the initial cut of the Barneby Tract the seed tree method would be best because it would allow the tract to be regenerated by one species.

2. In the long run, that is, after the initial cut, the clear-cutting method will provide the greatest economic gains of the four methods studied in this investigation.

3. Of the four tree species in the major association, tuliptree will yield the greatest economic returns. Tuliptree requires the least management because it grows straight, self-prunes well, has good seed dissemination, and is windfirm. Also, it is the fastest grower and most resistant to disease of the four tree species of the major association. These different assets of tuliptree will be of great importance, economically, in the long run.

4. Both clearcutting and seed tree cutting will meet the silvical requirements of tuliptree.

5. Examination of the tract showed that the area is well adapted for production of timber.

6. Select cutting and shelterwood cutting both fail to be of any use in harvesting tuliptree because these methods provide too much shade and protection for regeneration of the tuliptree seedlings.

The following material is rewritten in paragraphs:

CONCLUSIONS

After evaluating four methods of harvesting timber—clearcutting, select cutting, seed tree cutting, and shelterwood cutting—in order to

*Courtesy of Ed Pepke.

determine which one of these methods is, in the short and long run, most economically feasible to use on the Barneby Tract in Fairfield County, some conclusions mày be drawn. The findings of this investigation point out that the consecutive use of two methods of harvesting timber will be most profitable.

For the initial cut on the Barneby Tract the seed tree method will be best because it will allow the tract to be regenerated by one species. In the long run, that is, after the initial cut, the clearcutting method will provide the greatest economic gains of the four methods studied in this investigation. Both of these methods, seed tree cutting and clearcutting, will meet the silvical requirement of tuliptree as opposed to select cutting and shelterwood cutting.

Of the four tree species in the major association, tuliptree will yield the greatest economic returns. Tuliptree requires the least management because it grows straight, self-prunes well, has good seed dissemination, and is windfirm. Also, it is the fastest grower and most resistant to disease of the four tree species of the major association. These different assets of tuliptree will be of great importance, economically, in the long run.

As a matter of consistency, if conclusions are written in paragraph form, the recommendations appear in paragraph form. If conclusions are listed, recommendations follow the same system.

Conclusions can appear either at the beginning or at the end of a report (see Chapter 5). Some people object to placing them at the beginning on the basis that this method violates logic; others maintain that the arrangement has its advantages in a decision-making report because management is especially concerned with conclusions and recommendations.

Recommendations. Recommendations, included in numerous decision-making reports, are based on conclusions. They are an end product, and, like conclusions, they do not permit the admission of new material. They make specific suggestions for a future course of action after the research has been completed and the conclusions have been presented.

For example, if evidence in a report indicates that DDT weakens the shells of eagle eggs, thereby interfering with the eagle's reproductive process, one might conclude through inductive and deductive reasoning that eagles are a threatened species and offer a recommendation that DDT be banned by law.

To take another example where a report presents a comparative study of two summer camps, and the evidence points to the conclusions that Camp A is better located than Camp B, that the supervisors are better trained, and that although Camp A is slightly more expensive it offers a more versatile recreation program, the recommendation is quite obvious. Send Johnny to Camp A. Certainly not all recommendations are so clear. Making a recommendation to install a solar heating system in a geographical area where sunny and cloudy days are approximately equal during the winter months is a far more complicated issue.

Although recommendations are predicated upon conclusions, the audience is not necessarily obligated to act on the recommendations. Indeed, they may be ignored. And sometimes recommendations about what to do are based on intuition, experience, and feasibility judgment. Students are not equipped to make intuitive judgments; they should stick to the rule that recommendations follow conclusions that have been supported by definitive evidence. Recommendations are never afterthoughts or the result of hasty judgments, nor should they be confused with conclusions.

The following recommendations for the installation of ventilating fans in a horse barn, for instance, are based not on intuition but on evidence offered in the report:

1. Provide 1 ft^2 of inlet or vent area for each 750 cfm fan capacity.
2. In barns with mows or attics, install inlets that allow incoming winter air to be tempered above the ceiling before being drawn or forced into the building. Close the inlets during hot weather to prevent hot attic air from being drawn into the building.
3. Provide an adjustable control over the inlets or outlets to vary the air control. The outlets in a pressure ventilation system are usually self-closing doors.
4. Permit air to circulate through the space above the ceiling during summer months to prevent excessive heat buildup. Do not draw hot attic air into the animal shelter.
5. Do not install inlets where air from manure storage may be drawn in.
6. Provide large insulated wall panels that can be opened for natural ventilation during hot weather.[4]

Recommendations are not necessarily presented in the second person, as the following example from "DDT in Antarctic Snow" illustrates:

1. If a similar research project is undertaken with the use of charcoal adsorption filters, the filters should be rinsed with double distilled water and acetone and oven-dried at 20°C. A hexane rinse of the charcoal should be analyzed by ECGC (electron capture gas chromatography).

2. A sulfonation cleanup of all samples before the florsil column cleanup procedure should be used to remove as much particulate matter as possible.

3. A paper relating to the results of the research project should be prepared as soon as possible to inform the scientific community of this ecological hazard.

At times both conclusions and recommendations are presented under one heading—"Conclusions and Recommendations." Care should be taken to distinguish between the two. Conclusions present the evaluation of evidence; they are usually offered first, followed by recommendations that present the solutions to a problem.

Sample Student Final Report

Because final reports are the culmination of many hours spent in research of one sort or another, they should be designed carefully. The finished product should be skillfully organized to intrigue the audience, it should offer complete information without unnecessary and confusing details, and it should make use of all elements that contribute to a clear, readable style.

An example of a student's final report follows, illustrating the use of many of the sections discussed in this chapter:*

*Courtesy of Thomas F. Klose.

REMODELING PLAN

FOR

ENERGY CONSERVATION

Submitted to E. R. Fancher
155 Stoneyway Road
Xenia, Ohio

By Thomas F. Klose
November 22, 1977

418 Patterson Avenue
Columbus, Ohio 43210
November 22, 1977

Mr. E. R. Fancher
155 Stoneyway Road
Xenia, Ohio 45385

Dear Mr. Fancher:

I have studied your house in order to recommend a remodeling plan to conserve heat. Here is the report you requested in August 1977.

The report includes an analysis of heat loss problems in your home and recommendations for repairs to conserve energy in the winter.

I appreciate your cooperation in making the history of the house available. As you know, I found the house to be structurally sound and believe that if you follow the proposed plan for remodeling, many of your heating problems will be eliminated.

If I can be of any further help, please contact me.

Sincerely,

Thomas F. Klose

TABLE OF CONTENTS

iii

LIST OF ILLUSTRATIONS

ABSTRACT

This report provides a remodeling plan for the Fancher residence, a 50-year-old farmhouse. The rising cost of energy makes essential the repair and improvement of structural elements of the house to conserve heat. Heat is lost as it is transmitted through the building material and as cold air is allowed to infiltrate. To stop heat loss the following steps should be taken: weatherstrip all doors and windows; install storm doors and windows; caulk and patch all cracks and openings; plant evergreens on the north side of the house; build an entrance foyer; and insulate the structure. These improvements will retain heat in the house for longer periods, lower fuel bills, and increase the comfort of the occupants.

v

INTRODUCTION

Significance and Purpose

Even though the environment outside is constantly changing, we try to maintain a nearly constant environment inside our homes. In the past the cost of fuel was low enough that furnaces could provide enough heat, despite heat losses, to keep homes at a comfortable temperature all winter. Now with dwindling fuel reserves and rising energy costs, it is more economical to repair a house to conserve heat than to pay increasing fuel bills.

The purpose of this report is to recommend a remodeling plan to conserve heat in a 50-year-old farmhouse. These improvements should retain the heat in the house for longer periods, lower the fuel bills, and increase the comfort of the occupants.

Limitations

This report is limited to heat loss problems and proposed solutions for the Fancher residence. Only those solutions that are economically feasible are suggested in the remodeling plan. This plan indicates what needs to be done, but it does not discuss in detail what methods or materials to use. For these reasons, costs are not discussed.

Scope

The report is divided into two main parts: the causes of heat loss and recommended solutions to alleviate these problems.

1

The causes of heat loss are heat transmission through the building materials and air infiltration (passage of air through openings in the structure). Transmission of heat is simple to understand, so most of Part I centers on air infiltration.

In Part 2 the recommended solutions are organized into seven categories. They are

Weatherstripping
Storm windows and doors
Caulking
Vapor barrier
Windbreak
Entrance foyer
Insulation

Procedure

First the history of the building was ascertained. Then the structure of the building and of foundation walls was carefully examined for cracks and openings. The windows and doors were thoroughly checked for air leaks. The ventilating fan and fireplace were also inspected as possible sources for air infiltration.

PART I: THE PROBLEMS

Heat Loss Through Conduction

The farmhouse was built at a time when very little insulation was used. This means that much of the heat produced by the furnace simply passes through walls and

2

ceilings by conduction. Conduction through walls is a serious problem, but windows and doors present the worst situation. These are made of thin materials that waste vast amounts of heat. Conduction through doors and windows can be cut with the installation of storm doors and windows, as explained on page 8. Conduction through walls, ceilings, and floors can be taken care of with the insulation plan shown on page 13.

Air Infiltration

Most older homes suffer from problems of air infiltration. The window sashes and casings in the house are loose, doors do not close tightly, and the foundation walls are cracked. These openings allow cold, dry air to enter the house and hot, moist air to escape. Contrary to what people often believe, insulation is not the most important priority in an older house. Far more energy will be saved at a far lower cost and with less effort by attending to the infiltration problems first.

The three main causes of air infiltration are

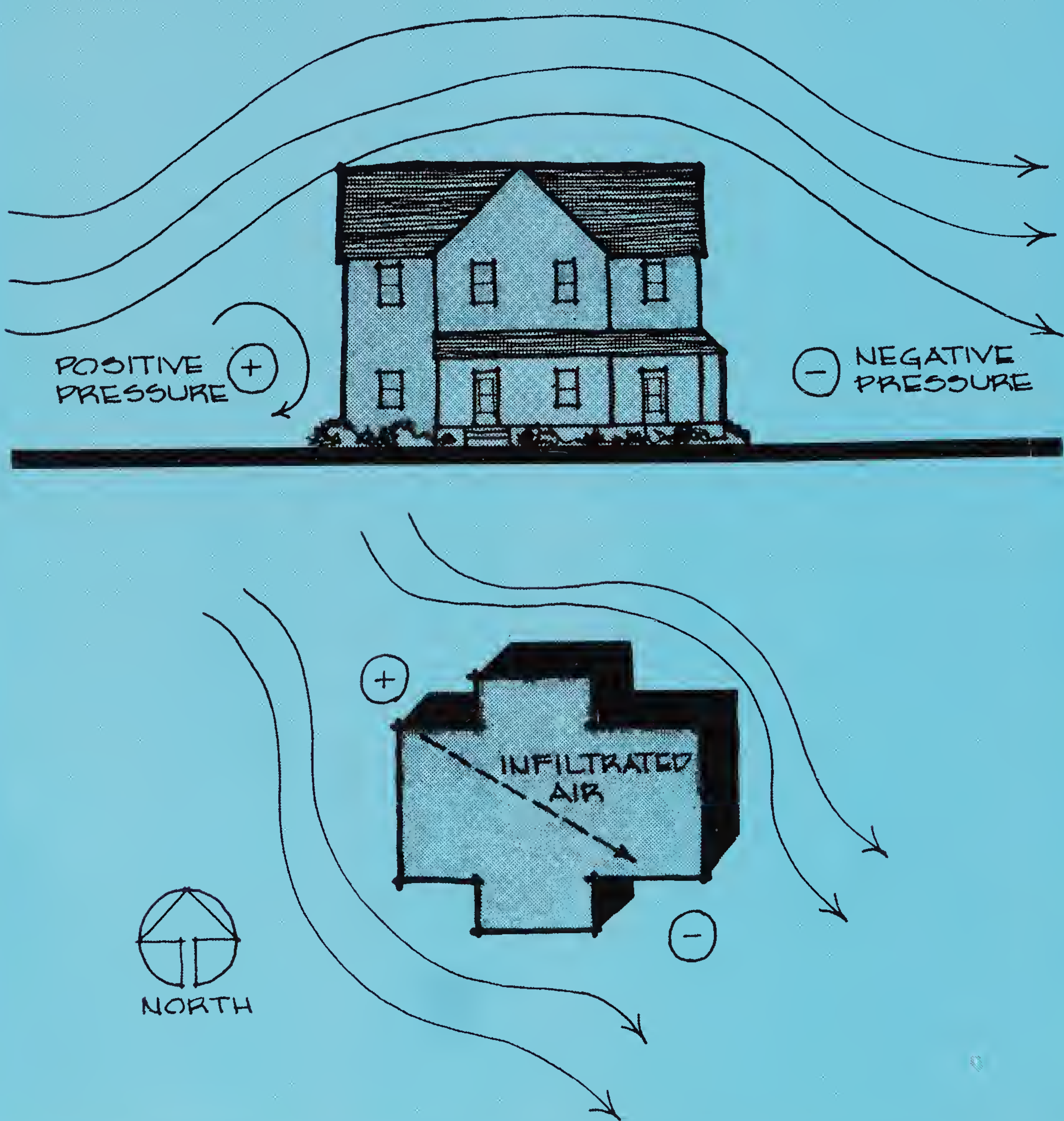
1. Positive and negative pressures outside the house created by wind.
2. Temperature difference between the outside and inside air.
3. Negative pressure within the house caused by various exhaust mechanisms.

The three causes of air infiltration are further explained.

Positive and Negative Pressures Outside

Because the wind plays a major role in air infiltration, it is important to understand the dynamics of outside air movement and its effect on the house. On the windward side of the house the air is compressed and a positive pressure is built up. On the leeward side a negative pressure is created by the suction of air away from the side of the house (see Figure 1). This pressure difference is one of the driving forces that causes air infiltration.[1]

Figure 1. Windflow patterns around the house.



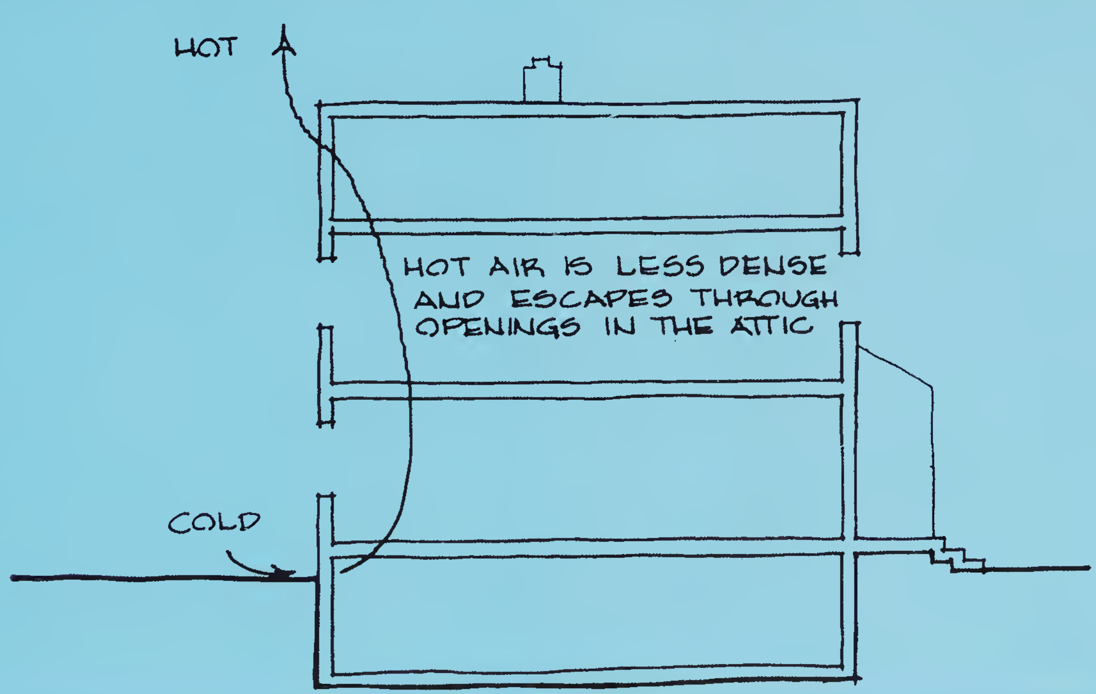
4

To analyze these conditions, consider air as similar to water flowing in a pipe. If the pipe air is capped at one end, no water will flow regardless of the pressure applied. The same condition exists for air in a house; there must be an inlet and an outlet for the air to travel through. Infiltrated air enters through cracks and spaces on the windward side and exits on the leeward or negative-pressure side .

Temperature Difference Between Inside and Outside Air

The difference in density between the outside and inside air and the vertical height separating the inlet and outlet openings also cause air to infiltrate. Air leaks inside from cold areas around the base of the house as hot air escapes from high window openings or cracks into the attic (see Figure 2). Even with a small temperature difference over a short vertical height, a significant amount of infiltration can occur.[2]

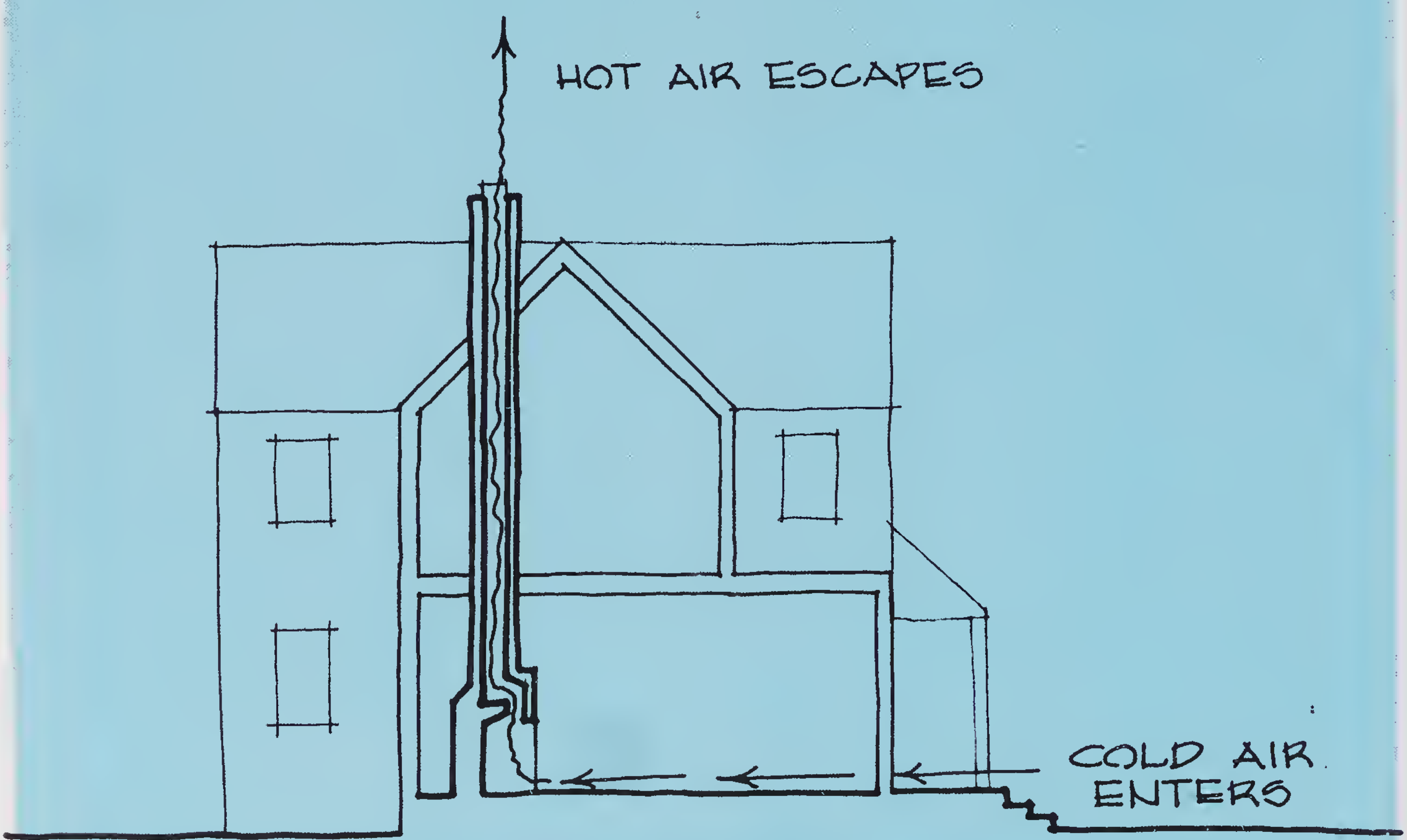
Figure 2. Infiltration due to temperature differences.



Pressure Caused by Exhaust Mechanisms

Air also enters when a negative pressure exists in the house. Such pressure results when air is exhausted for ventilation (i.e., the kitchen exhaust fan) or when a combustion unit is vented to the outside. The worst offender in this regard is the fireplace. It takes air from the living room, heats it in the combustion process, and vents it up the chimney. This results in a negative pressure on the inside of the house and causes the outside air to infiltrate (see Figure 3). An average fireplace will draw about 3000 cubic feet of air through the house per hour. This equals 1/3 air change per hour (an air change is a movement of a volume of air in a given period of time); with 1/3 air change per hour, all the air in the house will be replaced in a 3-hour period.[3]

Figure 3. Infiltration caused by an exhaust mechanism.



6

PART 2: THE SOLUTIONS

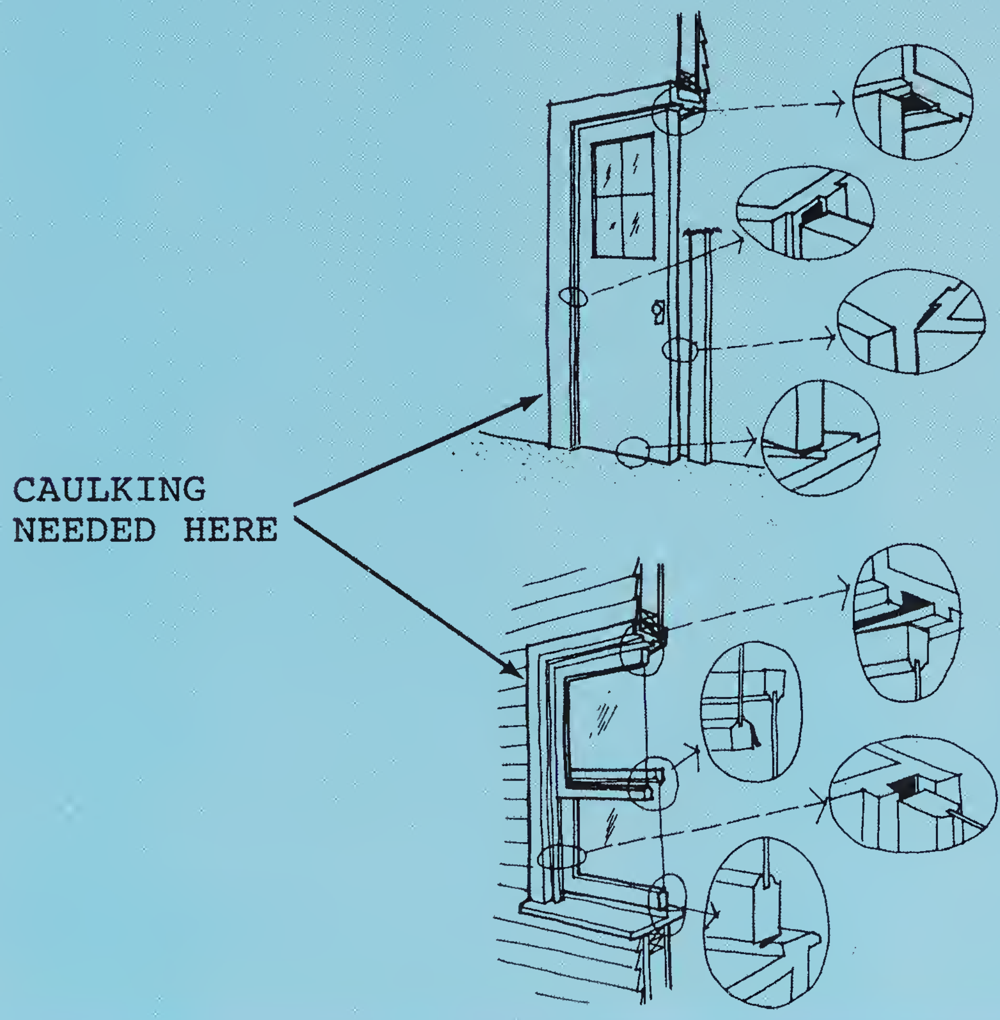
Reducing Air Infiltration

In an older house enough air can infiltrate through cracks and openings to cause two to three air changes per hour. Heat loss from these openings can easily account for 25 per cent of the heating bill.[4] Most of these cracks can be eliminated with easy techniques and low-cost materials. These techniques include caulking, weatherstripping, and adding storm windows and doors.

Doors and windows are definitely the first areas needing repair. Air enters through cracks where the doors and the wall meet the door frames and where the sash and the wall meet the window frame (see Figure 4).

Figure 4. Weatherstripping for doors and windows.

Source: U. S. Department of Agriculture.



7

Weatherstripping

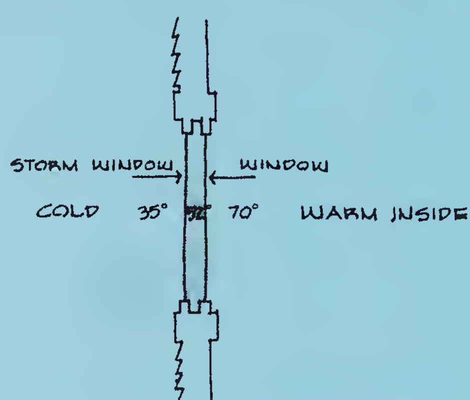
Weatherstripping on doors and windows, as shown in Figure 4, is the most important step in fighting air infiltration. The best weatherstripping to use on windows and doors is the spring-bronze or felt-hair type. When compressed between matching surfaces, these materials make a completely weathertight seal. To assure a good seal around all windows, new latches should also be installed. The latches should have a cam action that tightly forces the window sash against the weatherstripping.[5]

Storm Windows and Doors

After the doors and windows are tightened with weatherstripping, storm windows and storm doors should be added. These help block the cold winter air that seeps in around these openings in the building shell. With an average winter climate like ours, storm windows and doors represent a 7-year investment.[6]

Storm windows not only stop air infiltration but also provide another benefit. The heat that escapes by conduction through the glass is cut in half when the extra pane is added (see Figure 5).

<u>Figure 5</u>. Temperature effect of storm windows.

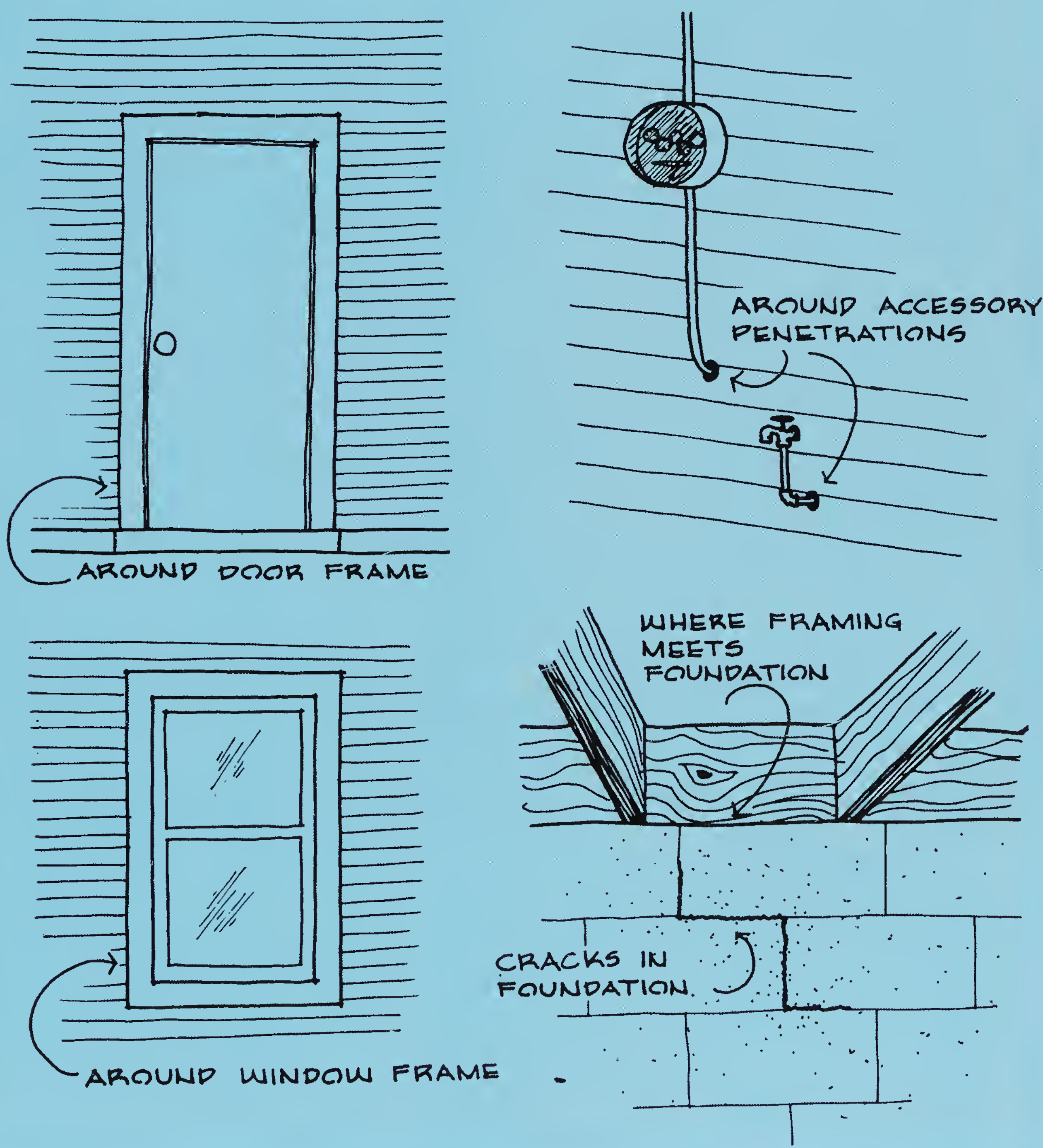


8

Caulking

Expenditures on doors and windows will do little good if the wind simply leaks in around the outer frames of openings. All cracks in the exterior shell require an airtight seal between the building materials. This seal is made with a flexible adhesive called caulking. Caulking should be applied to the trouble spots shown in Figure 6. A good caulking job is the most important step after weatherstripping to assure an airtight home.

<u>Figure 6</u>. Trouble spots that require caulking.



Vapor Barrier

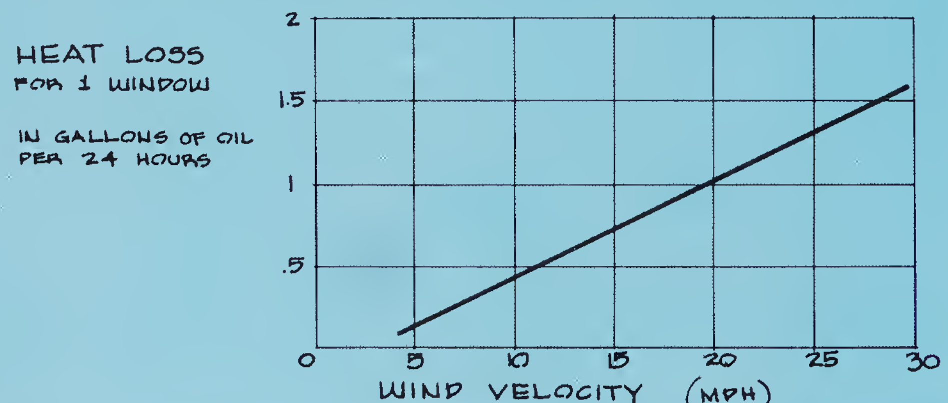
Caulking, weatherstripping, and a vapor barrier not only prevent air infiltration but also retain moisture in the house. Cold air has a much lower humidity content than warm air. If infiltrated air leaks in through tiny cracks in the walls, the indoor relative humidity could fall below an accepted minimum level of 20 per cent.[7] At this humidity a much higher temperature is required for thermal comfort. The higher the humidity content in a room, the less moisture given off by the body, so one feels warmer.

The plaster walls act as an effective vapor barrier. To get full protection from leaks, all existing cracks in the plaster should be patched. Added protection can be achieved with a paint barrier. Among the best is aluminum paint with spar varnish as a vehicle.[8]

Windbreak

The rate of air infiltration increases with wind velocity outside the house (see Figure 7). Winter winds reaching the house can be substantially reduced with proper placement of wind barriers. These barriers can be fences, garages, or dense growths of trees and shrubs.

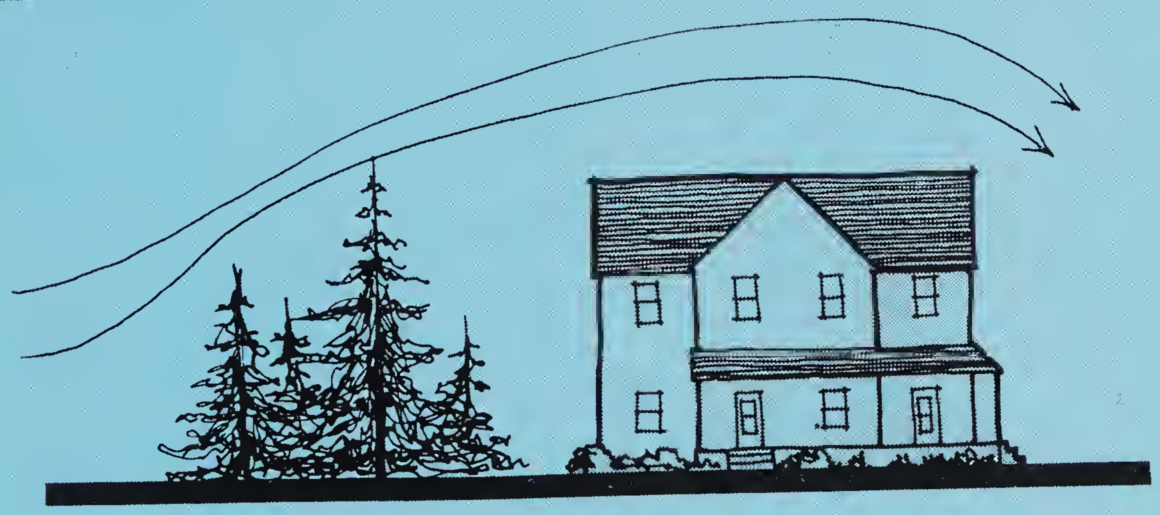
Figure 7. Relationship between wind velocity and heat loss.

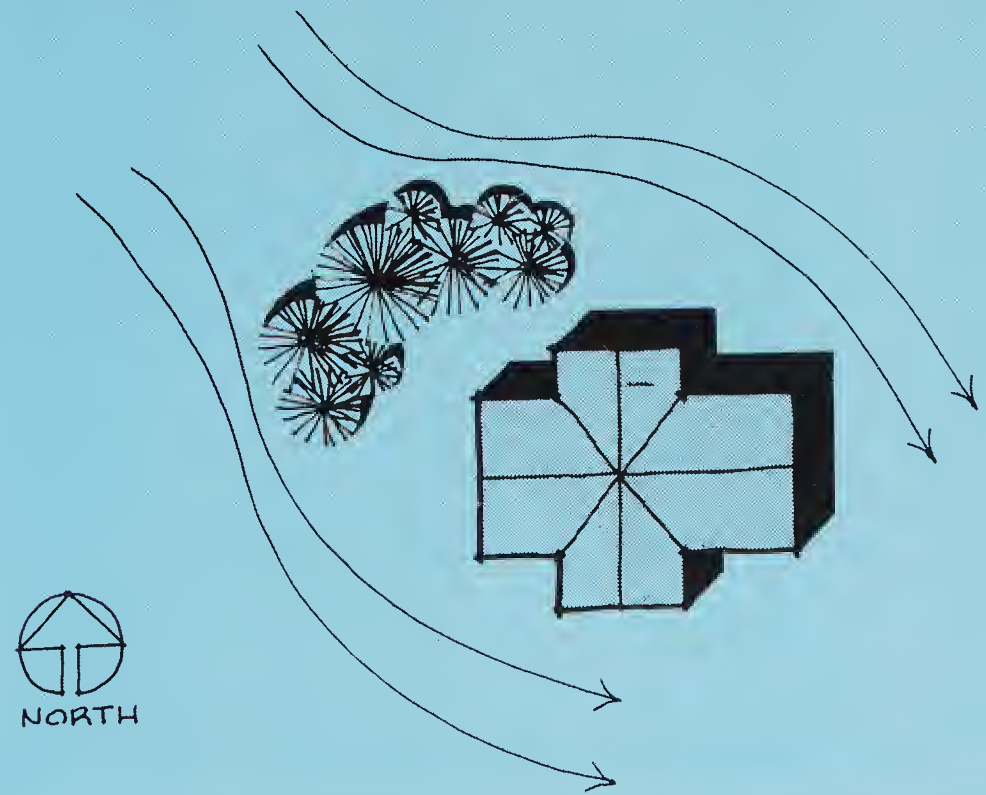


10

I recommend a thick planting of evergreens around the northwest corner of the house because the northwest is the direction of the prevailing winds during winter months in central Ohio. Evergreens, unlike leaf-bearing trees, stay dense throughout winter and will eventually become massive. The relationship between the proposed evergreen wind barrier and the Fancher house is shown in Figure 8.

Figure 8. Windflow around an evergreen wind barrier.



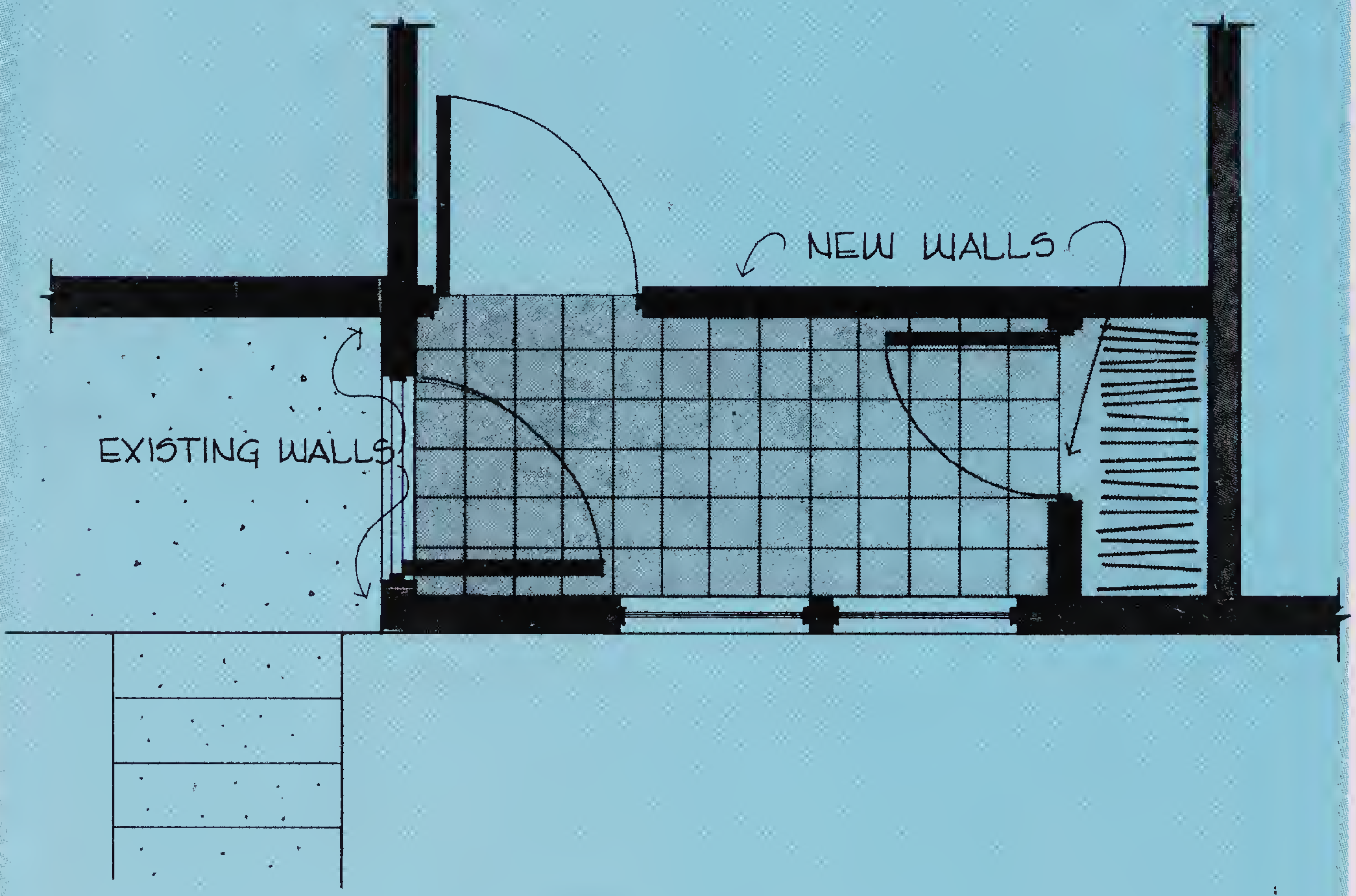


11

An Entrance Foyer

Another project to be considered is the construction of an entrance foyer. This would act as an air-lock, preventing large volumes of cold air from coming into the house each time the main entrance door is opened. A foyer consists of a small room with two doors, only one of which should be open at a time. A plan of a foyer at the main entrance is shown in Figure 9. A closet, a few hooks on the side wall, and waterproof floor material in the foyer will provide an area for wet winter clothes, thus saving some cleaning-up energy.

Figure 9. Plan of entrance foyer.



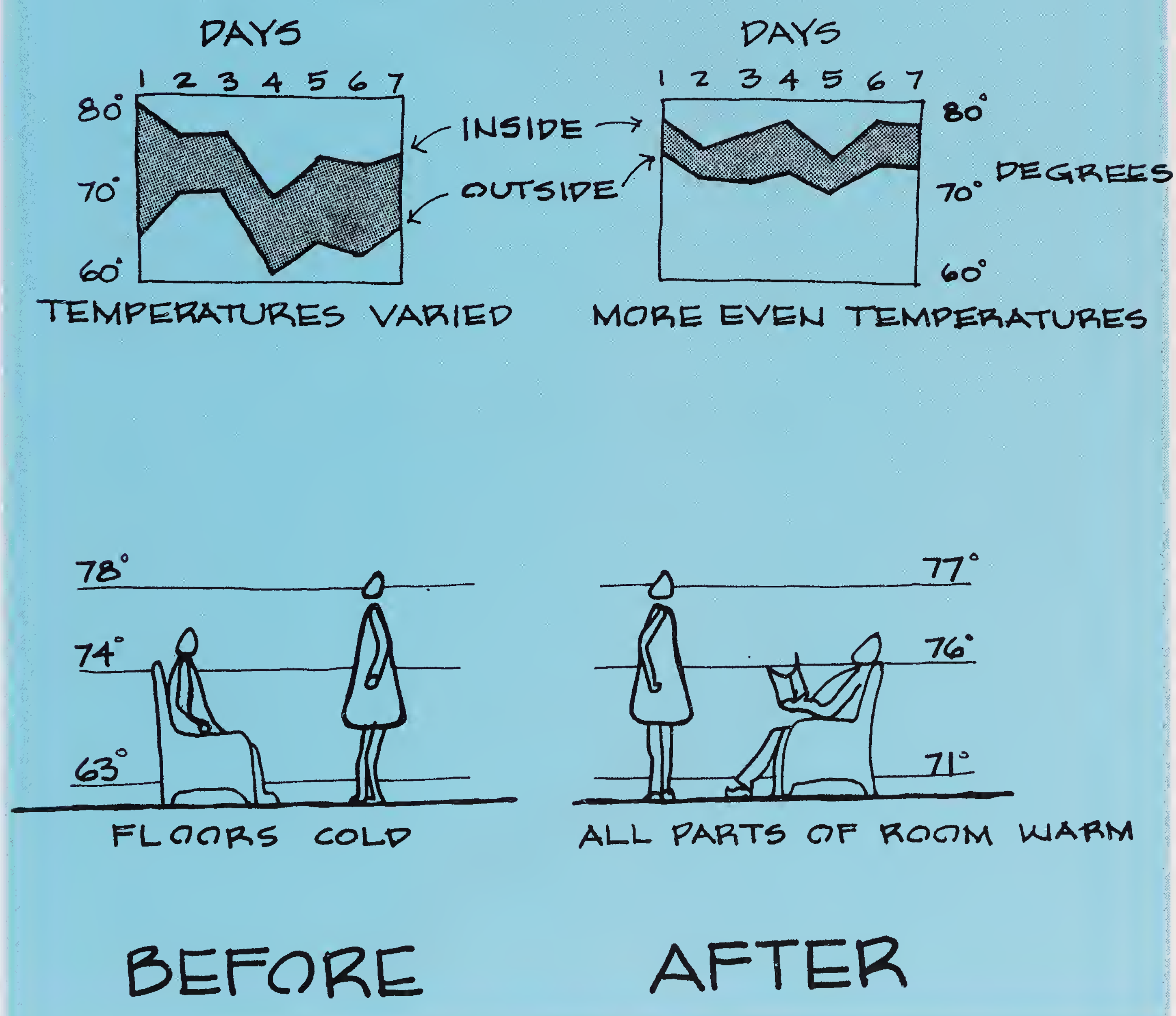
12

Insulation

Insulating a home is a good investment. The cost of insulating in central Ohio is repaid in fuel savings in about five heating seasons.[9] Insulating walls, ceilings, and floors not only saves money but also provides comfort and a pleasant sense of well-being. This is because the temperature of these surfaces will be higher in the winter, and a big part of the feeling of comfort comes from the radiant balance between our skin temperature and that of our surroundings. The before-and-after effects of insulating are shown in Figure 10.

Figure 10. Effects of insulation on comfort.

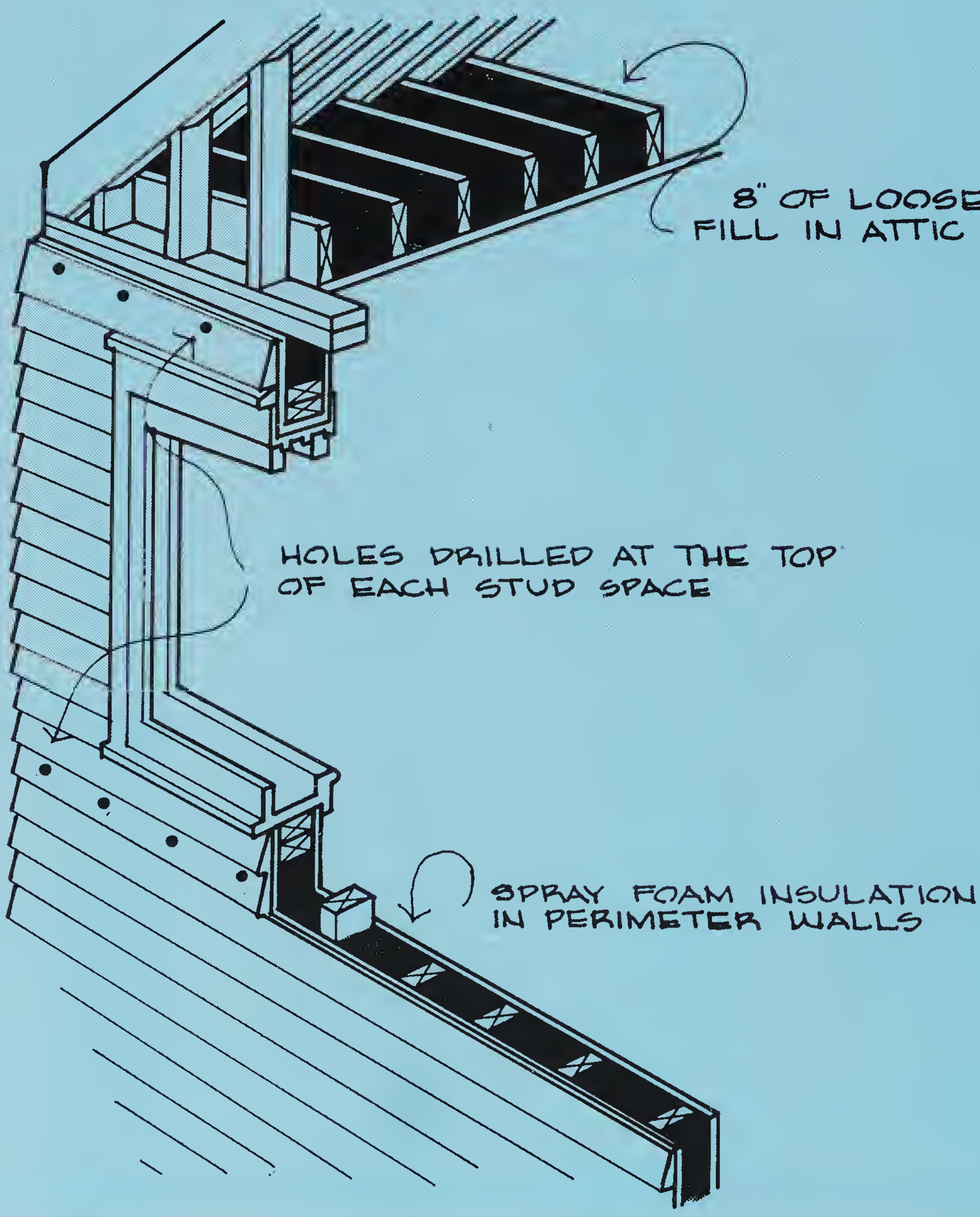
Source: Morril, p. 23.



13

At some point there is a balance between initial cost of insulation and cost of fuel bills, which adds up to a total minimum cost. With rapidly increasing fuel costs, it makes sense to plan ahead and even over-insulate now. Insulation costs, projected energy costs, and investment criteria have been analyzed by the Owens-Corning Fiberglass Corporation; they produced recommended standards for the most economical amount to insulate. Application of these standards to the Fancher home suggests the insulation plan in Figure 11.

Figure 11. Insulation plan.



14

The most important area to insulate is above the second floor ceilings. At least 8 inches of the loose fill insulation should be poured between the joists in the entire attic.[10]

The walls will be a little more difficult. Each cavity between the studs in the perimeter walls must be filled with insulation. The insulation recommended for existing wood frame construction is called blown insulation. This is a spray-foam type of plastic such as urea-formaldehyde. Small holes are drilled in the exterior walls at the top of each stud space. The foam is sprayed in to completely fill the cavities, and the holes are sealed up and the covering painted.

Uninsulated floors over the unfinished basement contribute to the heat loss and uncomfortable coldness of floors in winter. The proposed insulation plan calls for 6-inch-thick fiberglass insulation between the floor joists of the entire first floor.

CONCLUSIONS AND RECOMMENDATIONS

The examination of the Fancher homestead leads to certain obvious conclusions.

1. Air infiltration is the most serious heat loss problem in an older home. It is caused by
   a. Positive and negative pressures outside the house.
   b. Temperature difference between the inside and outside air.

c. Negative pressure inside caused by exhaust mechanisms.

2. Weatherstripping around all doors and windows is the most important step in fighting air infiltration.

3. Storm doors and windows represent a 7-year investment. They not only stop air infiltration but also cut heat loss through conduction.

4. All cracks in the exterior shell require an airtight seal between building materials. This seal is made with a flexible adhesive called caulking.

5. Patching all cracks in the plaster walls and ceilings assures a vapor barrier. A vapor barrier not only prevents air infiltration but also retains moisture in the house.

6. A thick planting of evergreens on the windward side of a house substantially reduces heat loss.

7. An entrance foyer acts as an airlock, preventing cold air from entering a house each time the front door is opened.

8. Insulating is repaid in fuel savings in about five heating seasons. Insulating walls, ceilings, and floors not only saves money but also provides much comfort.

These conclusions support the following recommendations for improving the Fancher homestead:

16

1. Weatherstrip all doors and windows.

2. Install storm doors and windows.

3. Caulk and patch all cracks and openings.

4. Plant evergreens on the northwest side of the house.

5. Build an entrance foyer.

6. Insulate the structure.

NOTES

1. John McDermott, "Air Movement Around Buildings," hand out in Environmental Design Course, The Ohio State University, School of Architecture (January 1976), p. 5.

2. Eugene Eccli, Low-Cost, Energy-Efficient Shelter, Rodale Press, Emmaus, Pa., 1976, p. 151.

3. Ibid., p. 153.

4. William Morril, The Energy Miser's Manual, The Grist Mill, Eliot, Me., 1974, p. 16.

5. Eccli, pp. 186-88.

6. Morril, p. 18.

7. ASHRAE Handbook, Book of Fundamentals, American Society of Heating, Refrigerating, and Air Conditioning Engineers, New York, 1972, p. 668.

8. Eccli, pp. 179-80.

9. Insulation Manual--Homes and Apartments, National Association of Home Builders, Rockville, Md., 1971, p. 89.

10. "How Much Insulation Is Best?" Professional Builder (February, 1976), p. 22.

NOTES

1. E. J. Carroll, "Lexington. . .A Unique Lift Truck Plant," Allis Chalmers *Engineering Review*, 40 (1975), 28.
2. B. A. Koch, R. H. Hines, R. L. Lipper, G. L. Allee, *Aerobic Swine Waste Handling System*, Kansas State University, 1974.
3. George J. Engelhart, William R. Gregory, Rodney G. Peterson, "Multiplant Loading and Scheduling for Exchange Area Cable," *The Western Electric Engineer*, July-October 1971, p. 130.
4. Joseph D. Blickle, *Horse Handbook, Housing and Equipment*, Midwest Plan Service, Ames, Iowa, 1971.

EXERCISES

1. Mark with an *I* those subjects that seem appropriate for an information report and with a *D* those that suggest a decision-making report. After doing this choose several subjects and provide titles that show how the same data could be used in both information and decision-making reports. For instance, the first subject below suggests a decision-making report and would be marked *D*. Data could, however, be used for both types of reports, i.e., types (information report) and control (decision-making report) of lawn weeds.

    Control of lawn weeds
    Fire warning systems for the home
    Facts about pesticides
    Motorcycle maintenance
    An investigation into the critical design parameters of a horizontal uniflow steam separator
    Improving the merchandise displays in the dairy department of Pick'n Pay Supermarkets
    Prevention of fraud in charitable organizations
    The ozone problems
    Development of a portable detector for plastic pipe and other underground objects
    The choice of a first camera for a 16-year-old
    Indiana fire codes for dormitories
    Effects of entrained air on concrete
    Architectural glass for sun control
    Selection of a suitable magnetometer for marine use
    A comparison of two welding systems: low inertia and high inertia
    The effects of accounting procedures on financial statements
    Correction of faulty expansion joints on U.S. 33
    Weldability of heat-treated carbon steels
    Man-made fibers
    Recommended sprays for apple trees
    Guidelines for forming a farm partnership
    Effects of freezing and thawing on the compressive strength during the curing period of concrete

Computer programming.
Detecting food spoilage in sealed containers.
Environmental issues concerning the construction of nuclear power plants.
Identification of poultry diseases.
Designing a farm pond.
Prevention of discoloring in plastic production.
Sewage disposal improvements.
Evaluation of certain stocks.
Measuring the intensity of earthquakes.
Identifying types of soil and rock formation.
Advantages and disadvantages of solar heating.
An argument for (or against) gun control.
Humane traps for animals.
Microwave ovens.

Some of these subjects may suggest a topic for your final report.

2. Present a numbered list of conclusions on any subject of your choice. Do not forget to include an introductory sentence. Rewrite the conclusions in a paragraph form.

3. Construct a purpose statement for a decision-making report and a thesis statement on the same subject for an information report.

4. In the following example distinguish between the conclusions and recommendations for a report on "Bears: A Danger to Tourists in Our National Parks":

    A great number of accidents occur in our national parks because tourists insist on feeding bears. Bears if unmolested pose no danger to tourists, but if hand-fed they often become aggressive, destructive, and dangerous. The most intractable animals should be removed from the park and transported to a less populated environment. Bears are wild animals; therefore, their behavior is unpredictable, especially when tourists dump garbage near their campsites or insist on getting out of their cars to feed them. Tourists who disregard warning signs should be shot. Some tourists take chances with bears in order to get "cute" photographs. Apparently, tourists do not realize the strength of these creatures, which can with one blow of a paw smash a heavy refrigerator case. All hopelessly vicious bears roaming the park should also be shot.

5. Before writing a decision-making report, you will find it very helpful in selecting a problem to ask a question and then define the boundaries of the report by setting down the subject, problem, purpose, procedure and range of content, and audience. The following provides an example:

question: Will maintaining two rights-of-way connecting the same cities be economically feasible?

Reorganize this section and place the conclusions first, the recommendations last. Once the two are separated, rewrite the section, paying close attention to unity and coherence. (What about the tone?)

subject: Conrail's request filed with the Interstate Commerce Commission pertaining to the abandonment of trackage in eastern Ohio.

problem: Conrail presently operates two parallel branches from Youngstown, Ohio, to Ashtabula, Ohio; both lines are in need of extensive repair because of lack of highway maintenance and the lack of funds.

purpose of investigation: The purpose is to determine whether maintaining two rights-of-way connecting the same cities is economically feasible and whether the operation of a single track will free money for maintenance that is presently tied up in operation of a second line.

procedure and content: The report will interpret the results of a survey concerning total daily train traffic on each of the two lines. These results will be used in an economic analysis emphasizing that the same total revenue can be realized daily by use of one track daily instead of two. At the same time, daily maintenance costs can be cut as much as 48 per cent. Further justification of the request will be presented by explaining the success of a computerized train-scheduling method that maximizes safety in the use of a one-track right-of-way.

audience: The Interstate Commerce Commission (primary audience), Conrail officials (secondary audience).

Before writing your final report, set down your program as illustrated in the example and submit it to your instructor.

CHAPTER 12

The Physical Format: Conventions

Physical formats of reports differ from company to company. They follow conventions set up to suit each company and its policy, but practically all companies require a format that will accommodate a complex organization in their comprehensive reports. Consequently, final reports are given a full-dress treatment and may include the following elements: cover, title page, letter of transmittal, table of contents, list of illustrations, foreword and/or preface, glossary, abstract, introductory summary, the report proper, references and/or bibliography, and appendixes. There may be some variation in the sequence of these elements: for instance, the letter of transmittal may be attached to the cover, or it may appear directly following the title page; the glossary may be placed in the prefatory material or in an appendix.

Cover

The purpose of the cover is to protect the pages, give the report a finished look, and identify the subject and the author. Various types of covers are available, and there is no need to purchase an expensive one. A manila folder with a label is acceptable. If a folder with a window is used, the title page should be arranged so that the title and the author's name are visible. With a plastic cover the whole title page is visible.

HEART RATE AND CARDIAC OUTPUT INSTRUMENTATION:

DEVICES AND TECHNIQUES CURRENTLY AVAILABLE

prepared for

Riverside Hospital, Mansfield, Ohio

by

Donald Glower

Electrical Engineer

May 6, 1976

Title Page

The title page provides information that distinguishes the report from others. Such information may include the code number, contract number, distribution categories, and security notices, when applicable. Sometimes the abstract, if short, is placed on this page. The layout should be balanced and symmetrical.

Letter of Transmittal

The purpose of the letter of transmittal is to present the report to the reader, and most formal reports contain such a letter. The letter becomes a permanent record of transaction, but it gives the author an opportunity to shed his objectivity somewhat and become more direct. It contains such essentials as the subject or title of the report, the authorization, and the date of authorization. The letter is a place for acknowledgments, if they have not been included elsewhere. Other elements often appear in the letter of transmittal (see discussion of letters of transmittal in Chapter 14). The length, tone, and placement of a transmittal letter vary, depending on company policy. It is sometimes clipped to the cover and sometimes precedes the prefactory pages. The tone of a letter of transmittal may be informal or formal. The audience addressed in the following example calls for a formal tone.*

*Courtesy of Ohio Department of Natural Resources.

January 1, 1975

The Honorable John J. Gilligan
Governor, State of Ohio

The Honorable A. G. Lacione
Speaker of the Ohio House of Representatives

The Honorable Theodore M. Gray
President Pro Tempore of the Ohio Senate

Gentlemen:

The Board on Unreclaimed Strip Mined Land is pleased to submit this report entitled *Land Reborn*.

The Board on Unreclaimed Strip Mined Lands was established under the provisions of Section 1513 of the revised code, the Ohio Strip Mine Law. The Board was directed "to gather information, study and make recommendations concerning the number of acres, location, ownership, condition, environmental damage resulting from the condition, the cost of acquiring and reclaiming to standards in Section 1513.16 of the revised code, and possible future uses and value of eroded lands within the state, including land affected by strip mining for which no cash is held in the strip mining reclamation fund."

The report contains the Board's findings and recommendations, which are based on an intensive 6-month study conducted by a team of eight consultants. The recommendations contained in the report, if followed, will lead to the reclamation of lands whose present condition is an abuse of the State's resources and a major burden on the people of southeastern Ohio. Implementing the recommendations will materially contribute to the goal of improving the quality of life in the region.

Respectfully submitted,

Robert Secrest, Chairman

Board on Unreclaimed Strip Mined Lands

Table of Contents

The major function of the table of contents is to list the divisions and subdivisions in the order in which they appear and to indicate the page on which the headings are to be found. It furnishes the reader with a rapid device for determining the coverage of the report and gives him an idea of what to expect.

Although the table of contents is in essence the outline of the report, it is not necessarily set up as such. It differs from a formal outline in that letter or numeral designations need not follow outline style; however, entries in the table of contents must exactly reproduce the headings within the report. If no letters or numerals are used for the text heads, none should appear in the table of contents. The table of contents does not list the material that precedes it; that is, it omits mention of the title page and the letter of transmittal.

Table of Contents

List of Illustrations

Most technical reports employ tables and figures (see Chapter 7). A list of them that follows the table of contents shows on what pages they appear. If the table of contents and the list of figures are short, they can be combined on one page, separated, of course, by their headings.

List of Figures

Foreword and Preface

The purpose of the foreword and the preface is to present a more informal and personal communication than is acceptable in the body of the report. Conventionally, the preface is written by the author, whereas the foreword (never under any circumstances spelled *forward*) is written by someone else who is qualified to evaluate the merits of the report. However, this distinction is not always observed, and at times the author writes both sections. Neither preface nor foreword is necessary to understanding the report; consequently, some reports omit them completely and others include only the preface. Unlike many books, reports seldom include both sections. A preface often explains what the author is attempting to accomplish in his report; it may call attention to some unusual aspect or indicate particular problems in dealing with the investigation. Acknowledgments are appropriate in this section. The foreword discusses the qualifications of the author and the effectiveness of the report.

PREFACE

In this Cost Accounting Manual, I have attempted to provide a means whereby the profitability of business can be improved. The manual has been designed particularly for all levels of management and accountant controllers. I have demonstrated the practicability of both the basic and most sophisticated control systems. To ensure that the manual is practical I have included flow diagrams, cost charts, and examples of necessary reports. It is hoped that a study of this manual will aid in a decision on whether to install an entire system or to upgrade an existing system.

FOREWORD

This manual was written by a consultant with a background of 25 years of experience as a contractor—a background heavily oriented to highway construction. In recent years he has become keenly interested in construction cost control. The manual is clearly written and provides valuable details for cost control. It supplies accurate and authoritative information on the subject and can be confidently used as a guide for installing a system of cost control.

Glossary

The purpose of the glossary is to acquaint the reader with meanings of technical terminology, abbreviations, and symbols (if any) used in the report. The glossary is sometimes placed at the beginning of a report as a courtesy to the reader; at other times it is placed in the appendix, where it is out of the way for the specialist but available to those who are not familiar with technical terms. If a glossary appears in the appendix, the reader's attention should be called to its existence either in the table of contents or in the body of the report. If only a few technical terms are used, they are better defined in the body or in footnotes. With many reports there is no need for a glossary.

Glossary of Abbreviations and Symbols

c	cohesion force
H	height
h	hydraulic head
hp	pressure head

N_g	bearing capacity factor
n_f	number of flow paths
P_a	total active pressure
γ	unity weight (density)
γ_s	saturated density
α	contact angle
Δ	change
ϕ	angle of shearing resistance

Glossary (nuclear terms)

Activation	The process of making a material radioactive by bombardment with neutrons, protons, or other nuclear particles.
Deuteron	The nucleus of deuterium (heavy hydrogen). It contains one proton and one neutron.
Dosimeter	A device that measures radiation dose, such as a film badge or ionization chamber.
Excited state	The state of an atom or nucleus when it possesses more than its normal energy. The excess energy is usually released eventually as a gamma ray or photon.
Photon	A discrete quantity of electromagnetic energy. Photons have momentum but no mass or electrical charge.

Proton	An elementary particle with a single positive electrical charge and a mass approximately 1847 times that of the electron. The atomic number of an atom is equal to the number of protons in its nucleus.
Radiation	The propagation of energy through matter or space in the form of waves.

Abstract

An abstract (see Chapter 8) is included in most formal reports. A good abstract is self-sufficient and can be used entirely separate from the report. Heading a report and preceding the introduction, the abstract is single spaced. It sometimes appears on a separate page, sometimes on the title page.

Abstracts accompany the student reports presented in this chapter and in Chapter 11.

Introductory Summary

Some reports include both an abstract and an introductory summary. Unlike an abstract, which is a reduction of the whole report, the introductory summary deals selectively with the most important points of the report. Some points are reproduced fully, some are considerably abbreviated, and others are omitted. The introductory summary is part of the report and cannot stand alone. But it does allow the reader to decide whether he is interested in reading further.

INTRODUCTORY SUMMARY

Of the several types of processes to capture energy from organic wastes, anaerobic digestion appears to be most attractive for swine wastes. It can stabilize the waste while producing bio-gas or methane gas. The concept has been extensively applied in Europe and India during energy shortages. Similar equipment has been used for gas production with domestic wastes.

Anaerobic digestion has the additional attraction of preserving most of the plant nutrients for application to agricultural land.

Primary disadvantages are the management required by sensitive digesters, the high initial investment required for equipment, and the fact that waste still must be disposed of after it is digested.

Research is in progress to make the process more practical. Bacteriologists are investigating new strains of bacteria and culturing techniques. Engineers are investigating digester designs and operation to reduce construction and operational requirements and costs. Investments in such research appear worthwhile with each rise in the cost of energy.*

Body of the Report

All of the preceding elements are prefatory to the text of the report. The text is made up of the introduction, the body, the conclusions, and also the recommendations if they are appropriate. It is followed by a references section and/or a bibliography and perhaps by appendixes.

Footnotes, References, and Bibliographies

If secondary sources are used, they must be acknowledged and documented in footnotes, references sections, or bibliographies. (There are so many different methods of documentation that the subject is treated at length in Appendix A.)

Appendix

The final section is, as the name *appendix* implies, appended material. It furnishes supplementary material not essential to the development of the report that would, if included in the body, interrupt the continuity. There may be one appendix or there may be

*Ralph Lipper, *Reclaiming Energy from Swine Manure*, Kansas State University, 1975. Reprinted by permission.

several of them, one for each piece of supplementary matter. The section should be used with discrimination. It is not a dump heap for extraneous material merely to add bulk to the report. It is, rather, an appropriate place for complete tabulations of data, sample calculations, long mathematical derivations, detailed quotations from authorities that support generalizations found in the body of the report, or copies of letters that add to the validity of evidence. Furthermore, it can contain case histories, copies of questionnaires, samples, and supplementary tables and figures.

Sometimes a figure that is constantly referred to throughout the report is placed in the appendix. A gate-folded map is more easily managed if it is put in the appendix. The reader can then unfold it and refer to it as he reads.

Some companies have adopted a system of extracting the heart of the discussion and presenting it as the body of the report. All other information is relegated to the appendix. This practice has the advantage of shortening a report, but it has the disadvantage of making the report hard to comprehend without the bulk of substantiating evidence. Sacrificing details for the sake of brevity places a burden on both the author and the reader.

Pagination

Pagination follows a conventional pattern. The preliminary elements are paged by lowercase roman numerals, often centered at the bottom of the page. The title page is considered page i, but the number is not printed. The letter of transmittal is page ii, and its number is also not printed. Subsequent pages of the preliminary material are numbered iii, iv, and so on; these *are* printed. Arabic numbers are used throughout the report proper. The first page of the body—probably the introduction—is counted, and the number is, if printed, placed at the bottom center of the page, even when other page numbers throughout are placed at the top center or top right. The appendix is numbered in sequence with the body of the report.

Headings

Reports of any length require headings, and, as already mentioned, they must be *exactly* duplicated in the table of contents. The purpose of the headings is to contribute to readability, to serve as a guide to the subject matter, and incidentally to break up large masses of type. Methods for writing heads are discussed in Chapter 5. The key is consistency. Once a method has been adopted, it must be followed throughout the report.

Sample Student Report

Although some of the conventions discussed in this chapter may seem rather arbitrary, they are useful in meeting the audience's expectations; moreover, following the conventions that have evolved through the years will result in an attractive format and will contribute to the clarity and order of the report.

An example of a formal report follows, with some side comments about it.*

*Courtesy of Donald D. Glower

The title itself would become more informative by the addition of these words: "An Evaluation of the Sanborn Output Computer." The title page contains the identifying material necessary.

THE SANBORN CARDIAC OUTPUT COMPUTER

Project CA-113-756

in contract with

Beachmont Hospital

and

The American Cardiological Association

Submitted by

Donald D. Glower,

Director of Product Development

Hewlett Packard--Sanborn Division Co.

May 23, 19xx

Hewlett Packard--Sanborn Division Co.

175 Wyman Street

Waltham, Massachusetts 02154

May 23, 19XX

Dr. D. C. Andrews
Director, Beachmont Hospital

426 Cooke Avenue
Boston, Massachusetts 02135

Dear Dr. Andrews:

In fulfillment of our contract with your hospital and the American Cardiological Association (Project No. CA-113-756), I am happy to report the completion of our prototype cardiac output computer. I have enclosed the final project report, which should be of service to you when the computer itself is delivered to Beachmont Hospital on May 24, 1974. We at Sanborn are enthusiastic about our product, and we hope you will share our enthusiasm.

Because we are considering full-scale production of the cardiac output computer, please keep in touch and let us know how the computer is performing. We will be only too glad to answer any questions you may have regarding the computer.

Respectfully yours,

Donald D. Glower

Director of Product Development

The letter of transmittal, presented in the proper business letter form, indicates the authorization for the report, the subject, and the date of submission. It has a pleasant tone that is emphasized in the final paragraph.

CONTENTS

The table of contents fails to include pages for the list of illustrations and the abstract. They should appear before the introduction. The divisions conform exactly to the headings used in the report. It would be possible to delete the *the's* used to introduce subsections under "Design of the Cardiac Output Computer" for the sake of brevity. If they are deleted, they must, of course, be deleted from the headings in the text.
[All the appendixes appeared in the original report, but only Appendix D is included in this example.]

iii

ILLUSTRATIONS

The list of illustrations is satisfactory.
[Figures 5 through 11 are not reprinted in this example.]

iv

A preface and a glossary are not needed in this report. The letter of transmittal substitutes for the preface, as is often the case. The author is submitting his report to a knowledgeable audience familiar with the technical terms used.

ABSTRACT

For the first time, a computer has been constructed to calculate noninvasively cardiac output from the pressure cardiogram. This computer, developed by the Sanborn Corporation, analyzes waveforms from either aortic catheters or external carotid transducers. Because of the advanced digital construction, the Sanborn computer can monitor from one to ten patients simultaneously. Hazards to the patient are minimal and may be completely eliminated if the external carotid transducer is used whenever moderate accuracy is sufficient. With aortic catheter input the computer was shown in extensive tests to be more reliable than hand or machine indicator dilution methods, even for patients with highly abnormal pressure waveforms. Nontechnical hospital personnel can operate the computer with significantly less cost and time than are required for indicator dilution methods. On the whole, the Sanborn cardiac output computer is a significant breakthrough in medical technology and should become a step toward controlling heart disease. It should be installed on a trial basis.

Subject

Purpose

Advantages

Results of tests

Conclusions

Recommendation

Abstracts are usually, although not always, single spaced. This is an excellent abstract, giving the subject, purpose, advantages, results of tests, conclusions, and recommendation. It is self-sufficient.

v

THE SANBORN CARDIAC OUTPUT COMPUTER

INTRODUCTION

Although coronary disease is the most pervasive cause of death in the United States, detection and treatment of coronary disease have progressed slowly. In hopes of treating heart disease more successfully, the Sanborn Corporation has developed a computer to measure the critical parameter of cardiac output. To be of greatest benefit to the physician, any such instrument measuring cardiac output must meet four criteria. The device must be (1) accurate to within 10 per cent, (2) minimally invasive and minimally hazardous to the patient, (3) operable by hospital staff and adapted to hospital use, and (4) minimally expensive.

Background

Criteria

Of the cardiac output devices existing today, almost all fail to meet these criteria: indicator dilution devices are invasive; impedance cardiographs are highly inaccurate; and the electromagnetic and ultrasonic cardiographs are costly, highly invasive, and extremely sophisticated (Benchimol et al., 1965; Friedberg and Donoso, 1963; Kubicek et al., 1969; Piller, 1970). Nonetheless, D. A. McDonald et al.(1968) proposed an innovative method to derive cardiac output from the pressure cardiogram. Basically, McDonald's method is based on the formula

Literature sources

$$CO = \frac{K \times FD}{1 - E/BB}$$

1

where CO = cardiac output

K = calibration constant

BB = beat-to-beat time interval

E = ejection time

FD = flow differential, the difference between the area under the pressure curve during systole and that during diastole

As the first device to use McDonald's method, the Sanborn computer has encountered much success. The cardiac output computer derives from the pressure cardiogram all the key parameters of McDonald's equation (ejection time, beat-to-beat interval, and flow differential) and then substitutes the parameters into the formula for evaluation. In the end, McDonald's equation has resulted in a cardiac output computer with exceptional accuracy, safety, and economy. The Sanborn computer is therefore a substantial breakthrough in medical technology and the struggle against coronary disease.

Success

Thesis sentence

The introduction orients the reader by giving background and purpose of the investigation as well as the criteria. The sources of literature mentioned support the validity of the evidence and aid in establishing confidence in the mind of the audience. The last paragraph is a sales pitch, not always included in the introduction, but effective here.

2

DESIGN OF THE CARDIAC OUTPUT COMPUTER

In the design of a computer to calculate cardiac output by McDonald's method, the computer was divided into four basic stages as shown in Figure 1: (1) an input stage to obtain the pressure cardiogram, (2) a processing section to derive from the pressure waveform the parameters in McDonald's formula, (3) a section to calculate cardiac output from the parameters, and (4) an output stage to display the calculated cardiac output. Appendix A contains complete circuit diagrams of all four sections. Each of the four sections is carefully designed to meet four basic criteria originally set forth.

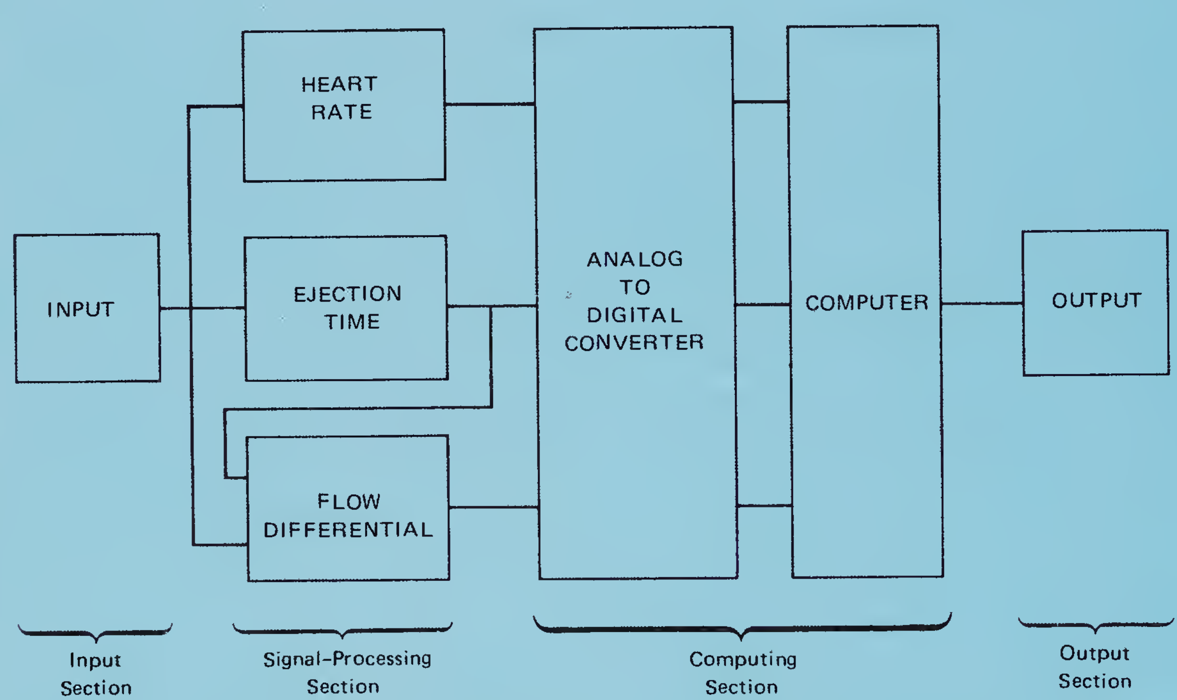


Figure 1. Block diagram of the cardiac output computer.

<u>The Input Section</u>

To comply with the original criteria, the computer must obtain all input with minimal risk to the patient. Although the normal procedure of placing a catheter in the patient's aorta does involve some risk, catheteriza-

3

tion is the only reliable means of obtaining a pressure waveform from acutely ill patients. In cases where catheterization is unnecessary, a pressure transducer placed externally on the carotid artery provides the least invasive input. The Sanborn computer is therefore designed to accept either an aortic catheter or a carotid pressure transducer as input.

The Signal-Processing Section

From the pressure waveform the computer next determines the three parameters necessary to solve McDonald's formula: heart rate, ejection time, and the flow differential. The pressure waveform is first differentiated and sent through a low-pass filter before heart rate and ejection time can be/are determined. As shown in Figure 2, the beginning of each heart-beat is detected as a large, positive spike in the differentiated pressure waveform. The computer then obtains the time interval between beats for use in a later stage. Ejection time is determined as the time between the beginning of any beat and the incisura, the most negative peak in the differentiated pressure waveform. In order to determine the flow differential the computer integrates the pressure waveform over each beat. The difference between the integral of the systolic pressure and that of the diastolic pressure is then the flow differential.

4

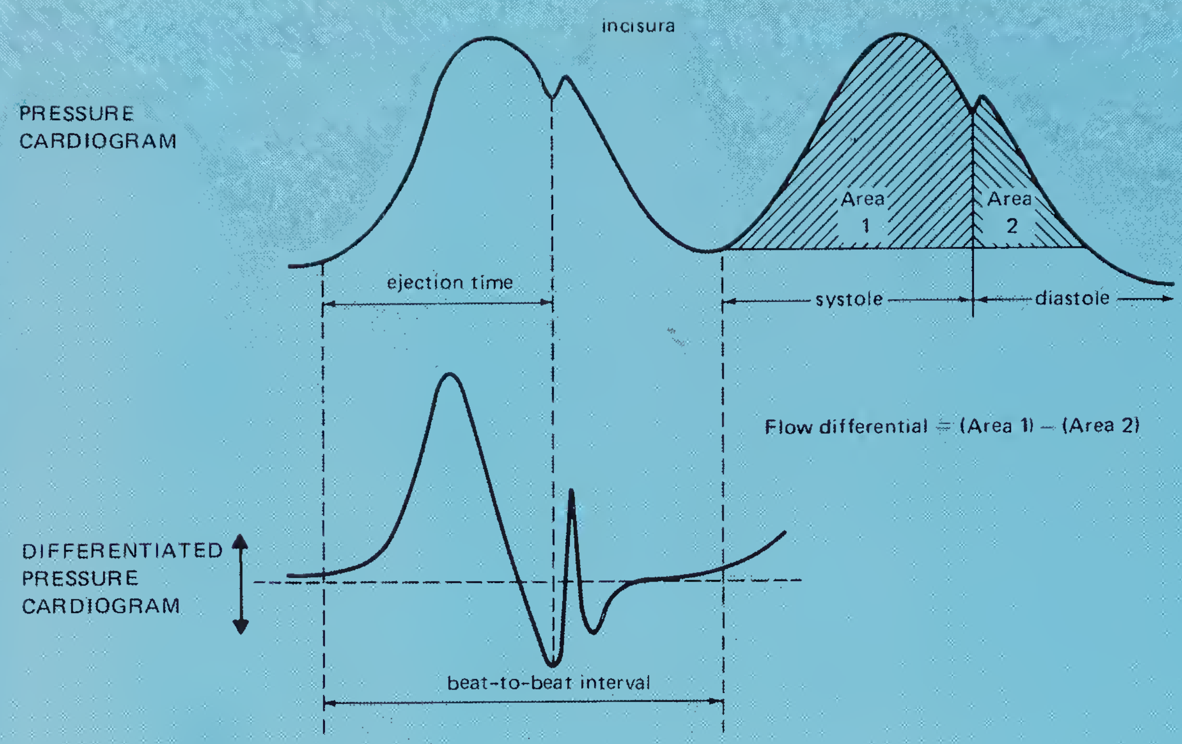


Figure 2. Pressure waveform parameters.

The Computing Section

In solving McDonald's formula for cardiac output, the Sanborn computer uses the digital techniques of any large, programmable computer. The ejection time, the beat-to-beat interval, and the flow differential are all passed through analog-to-digital converters and then fed to a central processing unit. The central processor follows the fixed program shown in Figure 3 to calculate cardiac output on a beat-to-beat basis. Such computations involve extensive circuitry, including circuits to sequence each calculation step, buffers and accumulators to store calculated values, and various multiplication and addition units to actually perform the calculations. As a result of such complexity, the digital computing unit accounts for over one fourth the total cost of the computer.

5

Figure 3. Computer program to solve McDonald's equation.

STEP 1:	Calculate the reciprocal of the beat-to-beat time interval	$\frac{1}{BB}$
STEP 2:	Multiply result by ejection time	$\frac{E}{BB}$
STEP 3:	Subtract result from 1	$1 - \frac{E}{BB}$
STEP 4:	Calculate reciprocal of result	$\frac{1}{1 - E/BB}$
STEP 5:	Multiply result by the calibrated flow differential	$\frac{K \times FD}{1 - E/BB} = CO$

Despite their high costs, digital computing methods have distinct advantages over analog methods. The single processing unit of the Sanborn computer can handle input from one to ten patients whereas analog methods would require each patient to have his own input and computing units. For ten analog devices the cost would far exceed that of an equivalent digital system. Moreover, digital computing techniques are inherently more accurate than their analog counterparts. For these reasons the computing section of the Sanborn computer is exclusively digital.

The Output Section

To accompany the digital computing circuitry, the Sanborn computer uses a digital display of heart rate and cardiac output. This digital display can be clearly seen and accurately read from a distance of 25 feet, whereas an analog meter or chart recorder provides less accuracy, even when viewed at a distance of 1 foot. In

6

addition to the digital displays, heart rate, cardiac output, and ejection time are all available in analog form to be recorded on paper or magnetic tape. With such a tremendous variety of outputs available, the cardiac output computer is ideally suited for monitoring either a single patient in surgery or an entire ward of patients, in each case with maximum accuracy and convenience.

CONSTRUCTION OF THE COMPUTER

The total cardiac output computer consists of three basic units: the input unit, the central processing unit, and the display unit. The central processor contains all computation circuitry and may handle up to ten pairs of input and display units. As shown in Figure 4, all circuits are attractively housed so that input and display units can be stacked on the central processor or placed at a great distance away. Thus each display unit can be placed at the patient's bedside, or all display units can be placed together to allow simultaneous monitoring of several patients. The entire computer weighs only 40 pounds and is quite portable.

7

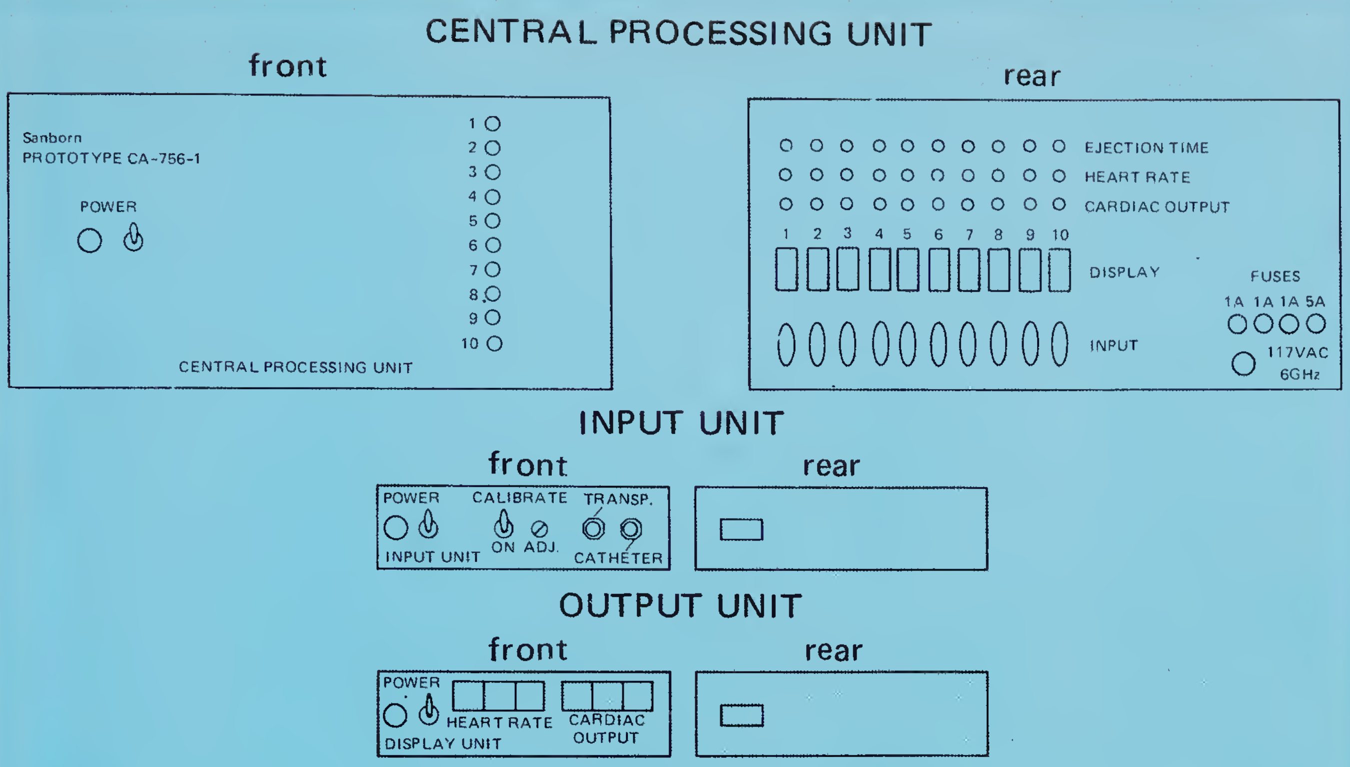


Figure 4. Computer housing.

Internally, all circuits are 100 per cent solid state for extreme reliability. Advanced microcircuitry is extensively used to maintain overall light weight and small size. All circuits are neatly assembled and arranged in individual boards (as shown in Appendix B), again for reliability and for ease of repair. The use of one highly regulated power supply for all units eliminates shock hazards due to long and numerous power cables.

In terms of construction costs the prototype computer involved significant expenses, yet on a mass production basis the Sanborn computer may provide substantial economy. Discounting the costs of development, the central processing unit, one input unit, and one display unit cost $800, $130, and $95, respectively. A complete breakdown of the costs appears in Appendix D. These costs refer to the experimental prototype; mass or commercial production of the computer could reduce these

8

figures by over 50 per cent. To the credit of the Sanborn computer, ten comparable ratemeters and ten cardiac output machines would cost over $10,000 while sacrificing accuracy, ease of operation, and the patient's safety.

PERFORMANCE OF THE COMPUTER

In order to evaluate the performance of the cardiac output computer, three aspects of the computer were tested: (1) accuracy, (2) safety to the patient, and (3) facility of operation. All three aspects were examined when the computer was placed in actual hospital use at both Beachmont and Regency General Hospitals in Boston. Over a period of 6 weeks, 122 patients were examined with the cardiac output computer, 78 of whom had acute heart ailments.

In 38 cases the computer's accuracy was assessed by a comparison with commercial ratemeters, hand determinations, and several indicator dilution devices. As summarized in Table A, the Sanborn computer measured cardiac output with a 6 per cent reproducibility, slightly better than the 7 per cent reproducibility of hand and machine dilution methods. Although the computer readings averaged about 10 per cent higher than the dilution readings, this deviation is insignificant in light of the uncertain accuracy of dilution methods. When tested on patients with highly abnormal pressure cardiograms, the computer proved to be more reliable and accurate than the indicator dilution method. In several of the abnormal cases, the Sanborn computer was able to give reasonable results where dilution methods were ineffective.

9

TABLE A. Comparative Accuracy of the Sanborn Computer

	Cardiac Output		Heart Rate		
	Accuracy	Reliability	Accuracy	Reliability	Cost
Cardiac output computer	A) 10% B) 11% C) 15%	A) 6% B) 7% C) 14%	1.5% ———	1.2% ———	$2950 ———
Hand indicator dilution method	standard	A) 7% B) 7%	———	———	———
Beckman cardiodensitometer	A) 10%	A) 8%	———	———	$795
Waters X-302 densitometer	A) 8%	A) 7% B) 9%	———	———	$845
Graphical heart rate determination	———	———	standard	0.5%	———
Waters CT200W cardiotachometer	———	———	1.1%	0.9%	$429
Phipps #70-781 cardiotachometer	———	———	2.9%	2.5%	$219
Neilson #2750 ratemeter	———	———	1.3%	1.0%	$285

A) signifies a random patient cross-section

B) signifies acutely ill cardiac patients

C) signifies noninvasive use of the carotid pressure waveform

The computer's heart rate circuitry also performed accurately. Deviations from the results of hand graphical analysis were under 1.5 per cent and compared quite favorably with other ratemeter deviations.

In terms of safety to patients, the Sanborn computer was again superior to present dilution methods. Although no figures can be given, aortic catheterization with the computer generally involved less risk than dilution methods that require placement of an irritating probe within the patient's heart. In addition, the Sanborn computer essentially eliminated any risk whenever an external pressure transducer was used. The main drawback to the external transducer, however, was that cardiac output readings were less accurate for patients with thick or fatty skin. At best, external transducers provided 15 per cent accuracy. Nonetheless, despite inaccuracies in cardiac output, the external transducer averaged 2.5 per cent accuracy in heart rate measurements and produced reasonable heart rates in all but a few cases.

In order to test the computer's ease of operation, five nurses and two interns were trained to operate the computer and were given instructions similar to those in Appendix C. All seven obtained good results with about 30 minutes of training, whereas mastery of indicator dilution techniques may require several days. While dilution methods could at best provide a reading in 15 minutes two or three times a day, the cardiac output computer provided readings every heartbeat after only 15 minutes of preparation. In addition to ease of use, the computer's adaptability to the hospital environment was tested. The computer was examined in numerous situations including the operating room, a single intensive care unit, multiple care units, and part of a coronary ward. Readout units were placed both individually at the patient's bedside and collectively at a nurses' station. In all situations no difficulties were encountered, and hospital staff was pleased with the computer's performance.

On the whole, tests show the Sanborn computer to outperform the most reliable hand and machine indicator dilution techniques. In addition to comparable accuracy and greater reliability, the computer demonstrated significant time savings to hospital staff and a substantial decrease in risk to the patient.

The headings in the body of this report follow a consistent system. Subordinate head could have been used in some of the sections; for instance, "The Computing Section" could have been divided into method used and costs; "Construction of the Computer" into the basic units and construction costs; "Performance of the Computer" into tests, results, accuracy, safety, and ease of operation. The report might have been improved if the discussion of costs had been collected under one heading, because costs will be an important consideration for the hospital.

CONCLUSIONS

Innovative use of McDonald's formula and unique suitability to the hospital environment ensure that the Sanborn cardiac output computer surpasses all available devices in meeting the four originally established criteria.

1. Accuracy. As a result of its advanced digital circuitry, the computer was found in extensive tests to be more reliable over a greater range of cases than

12

either hand or machine indicator dilution techniques.

2. Safety. Because McDonald's method requires only aortic carotid pressure as input, the Sanborn computer involves less risk to the patient than dilution, impedance, electromagnetic, or ultrasonic techniques. With the carotid pressure transducer, the computer provides for the first time a totally noninvasive means of computing cardiac output.

3. Facility of Operation. The cardiac output computer can easily be operated by nontechnical hospital personnel and still produce continuous results in less time than present dilution devices. Moreover, the computer is carefully adapted to serve the hospital's needs, whether in the operating room or in a general ward.

4. Cost. At one third the cost of comparable equipment, the Sanborn computer can monitor up to ten patients with greater safety and accuracy than any other device at any price in the current market.

Thus the cardiac output computer not only satisfies all criteria for hospital operation but also remains the only device presently capable of doing so. Moreover, future refinements and quantity production may still provide tremendous increases in computer economy and flexibility. The Sanborn cardiac output computer is therefore a significant and innovative breakthrough in medical technology and a positive step toward control of coronary disease.

The "Facility of Operation" paragraph is not a clear-cut conclusion; rather, it represents the results of tests supporting the major conclusion. It should probably not be listed as a conclusion.

13

RECOMMENDATION

Based on the conclusions that the Sanborn cardiac output computer is accurate, safe, easy to operate, and less expensive than comparable equipment, it is recommended that Beachmont Hospital install the computer on a trial basis.

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KUBUCEK, W. G., KARNEGIS, J. N., PATTERSON, R. P., WITSOE, D. A., MATTSON, R. H. 1969. Development and evaluation of an Impedance Cardiac Output System. Aerospace Medicine 37.

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14

APPENDIX D: DEVICE COST ANALYSIS

	Cost in Construction of Prototype	Cost in Large Quantities	Estimated Production Costs	Total Cost of Mass-Produced Unit
CENTRAL PROCESSING UNIT				
Integrated Circuitry	$390	$200		
Power Supply	50	30		
Hardware	150	90		
Components	210	100		
	$800	$420	$400	$ 820 x 1 = $820
DISPLAY UNIT				
Digital Numerals	$ 35	$ 20		
Integrated Circuitry	40	20		
Hardware	15	10		
Components	40	18		
	$130	$ 68	$ 20	$ 88 x 10 = $880
INPUT UNIT				
Integrated Circuitry	$ 40	$ 20		
Hardware	15	10		
Components	40	20		
	$ 95	$ 50	$ 50	$ 90 x 10 = $900
Carotid Pressure Transducer	$ 25	$ 15		$ 15 x 20 = $300
Catheters	$ 5	$ 1.50		$1.50 x 100 = $150
				$3,050

Total estimated cost of mass-produced unit		$3,050
Cost of competitive ratemeter	$219	
Cost of other cardiac output devices	$795	
Cost of ten ratemeters and ten cardiac output devices		$10,140
Net savings with the Sanborn computer		$ 7,090

CHAPTER 13

Articles

Writing for Publication

Technical people publish articles for several reasons. As professionals, they want to tell members of the technical community what they have learned in their work. They make their research useful to others. Publishing articles also helps them to advance within their corporations or institutions and carve out their own scholarly territory. Articles in company magazines and in professional and technical journals help answer these desires. Some professionals also discuss their research and scientific issues of public interest in popular and semitechnical publications that appeal to persons outside their disciplines.

Writing articles probably seems far off to the student. But this is not necessarily so. He may contribute an article about some aspect of his academic training, his hobbies, or his work to a student newspaper or magazine. Such writing is good practice for publishing later.

In addition, writing articles helps the student by requiring him to tailor materials for real audiences. If he can write so that people outside his discipline understand him, his fellow students and teachers will understand him better—and he will come to understand his subject better himself.

This chapter offers advice to the technical person who decides to write an article. Indeed, one characteristic that distinguishes articles from most proposals and reports is that the decision to write often comes from the author himself rather than from a supervisor or client (although a boss may urge his people to publish *something*). An article submitted for publication will compete with swarms of other manuscripts, and a prospective author needs to know how to outrun the competition. This chapter surveys the variety of publications one might write for and discusses the preparation of a manuscript. Two forms of articles students might try their hand at are examined in detail: the review of literature for a technical or semi-technical publication and the popular science article. Because students rarely write technical papers for a professional journal, such work is only briefly discussed. Those interested in this form would do well to consult John Mitchell's *Writing for Technical and Professional Journals* and the handbooks and guides to authors published by leading professional societies (see Appendix B).

Variety of Publications

Different publications appeal to different audiences. The breadth of material covered and the technicality of treatment vary. Publications range from the highly specialized to the popular.

TECHNICAL

The most technical are the professional journals and technical magazines that foster the exchange of information among specialists in the same field. Professional societies—such as the American Chemical Society, the American Medical Association, the Society of American Foresters, the American Society of Mechanical Engineers—sponsor journals. In addition, commercial publishers produce technical magazines such as *Product Engineering* that concentrate on describing money-saving industrial ideas.

The technical article (often called a paper) in a professional journal is a thorough, detailed account of a specialized topic. It may be based on a report, but the approach is shifted from what one would say to a sponsor or client to what would attract fellow specialists. The content must be cleared through the author's company for general dissemination. Reports having only local implications are seldom suitable for publication. The article must be of broad interest and convey new and timely information. It may be more theoretical than a report. Whereas a report may center on the description of a procedure, the article may condense that description to concentrate on how the results support, refute, or extend established theory or confirm a new experimental approach. Some articles are tutorial; they discuss how to do something in the laboratory, plant, field, or professional practice. Often only one aspect of the work discussed in a report is described in an article. Published papers are shorter than most reports (papers average 3000 words or 10 to 12 typewritten pages). Thus, details are condensed; and several case studies may be combined to make one example. Sample instructions for one technical journal are shown in Figure 13-1.

Figure 13-1. Sample instructions for authors of papers for a technical journal. (From *Metallurgical Transactions.* Copyright © American Society for Metals, 1977).

INSTRUCTIONS FOR AUTHORS

METALLURGICAL TRANSACTIONS will publish contributions on all aspects of research and significant engineering advances in materials science and metallurgy. This includes the extraction and refining of ferrous and nonferrous metals and subsequent conversion and use as engineering materials. All manuscripts will be judged by qualified reviewers according to established criteria for technical merit. *Submission of a manuscript is representation that it has neither been copyrighted, published, nor submitted for publication elsewhere.* Prior publication is a basis for rejection. There are two classes of papers:

Technical Publication—TP: Manuscripts should represent completed original work embodying the results of extensive field, plant, laboratory, or theoretical investigation, or new interpretations of existing problems. Material must be considered to have significant permanent value. In addition to technical acceptability, material should be presented clearly and concisely.

Communication: This class provides more rapid publication of short items. Abstracts and divisional headings are not used. The maximum length for a Communication is 1000 words of text, accompanied by whatever figures and tables may be required to support this text. These fall in the following categories:

a) theoretical or experimental work of immediate current interest;
b) discussions of Technical Papers and Communications. These should contribute to the original article by providing confirmation or additional interpretation. They will be referred to authors for reply. Discussion and authors' reply will be published concurrently;
c) announcements and summaries of computations and computer programs or other compilations which are available on request from the author or a specified agency.

MANUSCRIPT

1. Send to: *Metallurgical Transactions*
   Carnegie-Mellon University
   Schenley Park
   Pittsburgh, Pa. 15213
2. Submit three copies, each complete with abstract, tables, and figures. All copy (abstract, text, footnotes, references, figure captions) should be typed double-spaced on one side of 22 × 28 cm (8-½ × 11 in.) paper, with a margin of at least 2.5 cm (1 in.) all around. *High quality micrographs* are required for review purposes; Xerox-type copies are not acceptable.
   a. A separate list of figure captions should be included (double-spaced) in addition to the caption appearing with each figure.
   b. All tabulated data identified as tables should be given a table number and a descriptive caption. Tables should be numbered consecutively, using Roman numerals.
3. Figures (halftones and line drawings) and tables should be designed for final printing in single column 8.5 cm (3-¼ in.) width. Double column 18 cm (7 in.) treatment will be used only when required by the complexity of the material. Intermediate sizes will not be used.
   a. Line drawings. Should be no larger than 22 × 28 cm (8-½ × 11 in.). Lettering should be large enough to be 2 mm (1/16 in.) after reduction. Glossy photocopies of larger drawings are satsifactory.
   b. Photographic material. One mounted set of glossy prints with captions should be furnished for the printer's use. These should be protected by cardboard to avoid creases and markings. Staples or clips should not be used. If necessary, indicate suitable framing, position, and proportion on a working copy.
   c. Color printing of photographic material can be arranged. This will involve an additional charge of $100 per page of color, and the publication schedule will depend on the total demand. Authors should correspond with the editor regarding specific papers.
   d. *Printer's copy of all figures (drawings and halftones) should be retained by the author until requested by the editor, after the paper is approved for publication (see items 3a and 3b).*
   e. Original drawings and photographic material will be returned to the author as soon as the printer no longer needs them.
4. The abstract is the author's summary of a scientific paper and is included in the review procedure. It should indicate newly observed facts, conclusions, and the essential parts of any new theory, treatment, apparatus, technique, etc. It should be concise and informative and only in exceptional cases exceed 200 words.
5. References should be double-spaced and listed on a separate sheet. For proper format, see Styling of References which appears on the reverse side of these instructions.
6. If the paper depends on unpublished work, three copies of the unpublished material should be included to assist the referees in their evaluation.
7. On the printer's copy, symbols should be clearly identified, i.e., "Greek omicron," "One and ell" and "oh and zero" should be differentiated by a marginal note to avoid ambiguity.
8. Special artwork required for suitable reproduction or extensive alteration of proof resulting from errors or carelessness in the original manuscript will be charged to the authors.
9. There are no facilities for translating or making editorial revisions of foreign contributions. All publication is in English, and papers must be submitted in proper form.
10. The policy of *Metallurgical Transactions* is to use the International System of Units (SI). For current guidelines, see National Bureau of Standards Special Publication 330. (For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.)
11. Avoid the use of trade names and proprietary information whenever possible. Such use can occasionally be justified if this is the best way to specify a particular material or process.
12. A series of papers dealing with separate aspects of a subject should be cross referenced. Divisions, such as Part I, Part II, etc., are not recommended as they complicate the review procedure and abstract listings. If such divisions are considered essential, they should be justified by the author at the time of submission and are subject to approval in review.

SEMITECHNICAL

Less specialized but still concentrating on science, the social sciences, and technology are publications that may be called semitechnical. A leading one is *Scientific American*. It publishes articles on a broad range of scientific and engineering subjects for technically trained readers as well as for informed nonscientists who want—and need—to keep up to date. The authors are established researchers who report their own original work or review the literature on a subject of current interest. Semitechnical articles blend the materials of the technical paper with some of the special techniques, interest-getting devices, and more personal approach of the popular account. The aim is to arouse the reader's curiosity as well as to inform him, engage his enthusiasm, and entertain him. The article may be either narrower or broader than a technical paper the author would write about the same investigation. That is, it may deal with only one case study or aspect of a broad problem, or it may discuss a specialized technique in the large context of its implications or applications. The introduction is often longer than one for a technical article, because the audience is likely to require more background information. Uncommon technical terms are either avoided or are defined in the article. Mathematical treatment is restricted to basic calculations. Illustrations—photographs, drawings, graphs—are usually abundant. Some important business and financial publications, such as *Fortune*, and the bulletins of agricultural and engineering experiment stations and the house organs of some companies or industries might be considered semitechnical.

POPULAR

Appealing to an even wider circle of readers are popular science magazines and hobbyist guides such as *Science Digest*, *Psychology Today*, *Popular Science*, *Popular Electronics*, and *Popular Mechanics*. Museum publications such as *Natural History* (published by the American Museum of Natural History) and *Smithsonian* (published by the Smithsonian Institution) appeal to an educated audience interested in areas outside their specialties—in topics like energy conservation, preservation of wildlife, space exploration, and archeology. Articles on science news also appear in general interest publications such as *The New York Times Magazine*, *The New Yorker*, and *Reader's Digest*. Popular articles tend to stress current—and controversial—topics like solar energy, nuclear safety, turbo trains, and government-sponsored day care. The topics go in and out of fashion. The articles aim to inform, convince, or advise with large doses of entertainment. They are usually more sprightly than thorough.

Preparing the Manuscript

SELECTING A PUBLICATION

After the writer is sure of what he has to say and has checked to see that his facts and interpretations are beyond challenge, he decides what audience to address and compiles a list of suitable publications. Who could profit from his information? fellow specialists? fellow students? specialists in other fields? the general public? Browsing the library might assist him in compiling the list, or he can check *Writer's Market*, an annual publication that lists magazines, professional journals, and book publishers. For each publication it gives the editor's name and address and describes the audience and type of article desired.

To determine suitability, the writer should examine several issues of prospective periodicals. He should read any specific instructions to authors. To supplement direct advice, he should examine tables of contents and skim sample articles in several issues of each magazine to determine

1. The range of subjects included
2. Editorial viewpoint
3. Categories of contributions (sometimes called departments)
4. Typical length of articles
5. Frequency of use of technical terms
6. Prevailing tone (serious? chatty? humorous?)
7. Average, maximum, and minimum length of sentences and paragraphs
8. Format of articles (type and length of titles, subtitles, abstracts, biographical information about the author)
9. Use of graphics

One further step the potential contributor can take in selecting a publication is to write to the editor of the first magazine or journal on his list. In the letter he comments on his background and describes the article he intends to write to see if the editor is interested. If not, the writer has saved time in adjusting his material to that one audience and can move on to the next publication on his list. If the editor is interested, the writer can tailor his material with confidence to the specifications of one magazine. The editor might even offer some hints.

TAILORING MATERIAL

Basic to any presentation is the need for clarity—for simple, direct expression in a well-organized text. But writing for publication involves special efforts. The author faces stiff competition. He must select, arrange, and express his material to fit the publication he has selected. The broader the audience, the less substance the article can present and the more necessary are interest-getting devices. Of course, the audience for a technical paper needs less courting than a popular one. The technical paper is shaped largely by the material, the popular article by the reader.

Whatever the publication, the article must have an inviting title and a good first or "lead" sentence. Leads are critical to attract the reader who may give the author only two or three sentences to arouse his interest. Having built momentum, the lead must then introduce a discussion paced to hold attention. The ending is another critical point, especially in popular accounts that may not have the built-in endings of technical articles (conclusions from the work or a statement of future work). It is important to know when to quit.

Headings, as in reports, help to make an article readable. Their number is determined by the content, although some editors suggest headings every sixth paragraph. More popular accounts often have more headings.

SUBMITTING THE MANUSCRIPT

Before submitting his manuscript, the author should review the regulations set by the publication concerning preparation of the typescript and return of rejected material as well as matters of style (punctuation, abbreviations, symbols, units of measurement). The author should always keep a copy of his manuscript.

The Review Article

One increasingly significant form of article is the review. Reviews, called "reviews of literature" or "critical reviews," appear in both technical and semitechnical publications. They may be collected as well in special review journals such as *Chemical Reviews* and *Nutrition Reviews.* The *Handbook for Authors* of the American Chemical Society defines a review as follows:

> Reviews integrate and correlate results from numerous articles and notes which are relevant to the subject under review. They seldom report

new experimental findings. Effective review articles have a well-defined theme, are usually critical, and may present novel theoretical interpretations. Ordinarily, they do not give experimental detail, but in special cases (as when a technique is of central interest) experimental procedures may be included. An important function of reviews is to serve as a guide to the original literature; for this reason adequacy of bibliographical citation is very important.[1]

Reviews are frequently addressed to nonspecialists who seek an overview of a topic or discipline. Writing a review is a good way for the student to master the literature on a topic. (A selection from a student review is included in exercise 2 at the end of the chapter.) It requires him to select, read, and criticize pertinent printed materials (see Chapter 3).

The major goals of the review are authority of opinion, completeness, coherence, and adequacy and clarity of documentation. To be complete, a review must treat all available published information on a topic. It indicates which researchers are working on what problems, with what success. Because engineers, for example, are legally responsible for knowing all relevant knowledge in a field when they select a material or complete a design, such reviews provide a valuable service. Reviews are also useful in drawing together information from various disciplines—economics, law, engineering, science, psychology—to focus on problems, such as the management of environmental quality, that necessitate broad understanding. Completeness in a review is not clutter. The writer must be selective about what he displays as evidence. Irrelevant information—no matter how hard it was to come by, how interesting it may seem, or how clever a researcher it proves one to be—must be discarded.

Brief reviews of applicable studies often introduce reports of original research. They show that the researcher is not duplicating earlier work. They reveal the scope of his reading, disclose how his project fits in with former projects, and describe what he is doing that is new.

The writing of review articles presents special problems of fitting together materials from disparate sources. The review needs a smooth and consistent style; it should not seem to be a series of clippings pasted together. A point (a "well-defined theme") and a plan, as with any writing, are essential. Like abstracts, which are either informative or descriptive, reviews either interpret the information collected from the literature or describe the history of the literature. The review may be general or specific.

The following passage is taken from a general review of dolphin research in the Soviet Union. It is an informative review; the author summarizes major findings from her readings. The style used for references is that commonly used in the biological sciences (see Appendix A).

> The Soviets envision a variety of roles for the dolphin, such as carrying messages from underwater habitats to the surface, herding fish when man makes the transition from fishing to fish farming, helping to locate seafloor mineral deposits, searching for sunken ships and assisting in rescue operations. Soviet scientists also believe the secret of the rapid and safe dives of the dolphin could greatly extend man's diving capabilities. Other areas of special emphasis in Soviet dolphin research are the application of dolphin echolocation and swimming hydrodynamic principles to sonar and marine vehicle design, respectively. A Soviet research institute (Savchenko, 1971) has investigated the concept of a "flapping-wing"-type engine based on dolphin propulsive principles, and a Leningrad inventor has designed a hydroplane (Anon, 1972) for which he got the idea while observing dolphins in motion.*

The next passage describes the literature. It is taken from an article that reviews the literature in order to assess the feasibility of one particular method to determine labor costs in a regional medical library.† The superscript numbers are reference numbers.

> Most cost studies in the literature are little more than estimates; they lack consistency, precision of reporting, and comparability, a fact noted by several authors.[3,6,7,8,9,10] The difficulties in identifying and defining cost elements, in separating input from output costs, and in localizing costs to particular process steps have been discussed.[1,3,6,8] The scarcity of cost information in libraries and information systems has been noted in recent reviews.[2,3,11] While materials and equipment costs are relatively easy to deal with, a simple, general method for determining labor costs is clearly needed.

The review of literature may be organized logically, as in the preceding passages where a generalization is followed by more detailed statements. Or it may follow the chronology of research. Contribu-

*Ruth M. Linebaugh, "Soviet Dolphin Research: An Analysis of the Literature from 1900 to the Present," *Marine Technology Society Journal*, 10 (1976), 16. Reprinted by permission of the Marine Technology Society.

†Carol C. Spencer, "Random Time Sampling with Self-observation for Library Cost Studies: Unit Costs of Interlibrary Loans and Photocopies at a Regional Medical Library." Reprinted with and by permission of *Journal of the American Society for Information Science*, May-June 1971, page 153. Copyright 1971 by the American Society for Information Science, 1155 16th St., N.W., Washington, D.C. 20036.

tors may be introduced in either descending or ascending order of importance. They may also be pitted against one another. This plan is shown in the following passage from a review that evaluates the social and psychological impact of five major inventions.

> Melvin and Robinson (19) argue against the notion that most technological advances were the result of the work of anonymous "little men," craftsmen and technicians often innocent of basic scientific development and training. They think that to insist upon the importance of such craftsmen "serves to reinforce the belief in the autonomy and purity of science seen as a concept-generating activity. . . . Ruling out any significant interaction between technologists and scientists until the late nineteenth century, whatever the validity of such a belief, serves to protect a particular historiographic viewpoint," a viewpoint which has tied to it "a particular kind of scientific community" (p. 78). They further claim that these views on science and technology did "not evolve. . . in a vacuum" (p. 80). Their opinion is in direct contrast to that of Kuhn, perhaps the most outstanding historian of science writing today. Kuhn (20) thinks that the polarization between technology and science may spring from subterranean roots, "for almost no historical society has managed successfully to nurture both at the same time" (p. 50).*

This example shows a solution to one special problem in achieving coherence in reviews: the use of direct quotations. The author quotes extensively; each quotation, however, is syntactically incorporated into the text, which logically and grammatically bridges both the beginning and the end of quoted matter. (Note that direct quotations are enclosed within quotation marks, and note as well the proper use of punctuation around page references.)

Quotations can be used effectively to call attention to a particularly significant interpretation, to summarize with special finality a line of reasoning, to present the accurate text of a law or regulation, or to open a discussion on a point of familiarity with the audience, if both the audience and the writer are acquainted with the authority quoted. Overused, quotations make an article a piece of patchwork. They indicate an author who, out of laziness or modesty, let his own thinking be trampled by his sources. It is the writer's responsibility to rework others' material into his own context, for the new audience.

Long quotations should not be used unless they are necessary. When they must be used, long quotations should be introduced by a line of text and then set off from the text by indention on the left and right and extra space above and below. In material prepared for publication, long quotations are double spaced in the typescript

*Courtesy of June Z. Fullmer.

(in a document to be submitted to a class, quotations are generally single spaced and set off from the text by triple spacing before and after). No quotation marks are necessary; the spacing and indention indicate quoted material.

Another difficulty in writing reviews is selecting the proper tense. The past tense should be used to describe what was done; the present implications of that activity are described in the present tense. Theories that remain current are expressed in the present tense. The past tense is used only to emphasize the lack of currency in an interpretation that has been corrected or the time at which a case study was conducted or a theory developed (see Section A.13.1 in the Handbook).

The Popular Science Article

NEED FOR POPULAR UNDERSTANDING

Frequently, both a sense of public duty and enlightened self-interest require technical people to make the implications of their findings clear to the general public. What they do may affect significantly the way people live and think. And popular opinion sometimes places boundaries on what engineers and scientists are allowed to do: where a nuclear reactor may be located, whether the Cambridge city council will approve a permit for a Harvard laboratory.

Someone who knows his subject well should be able to present at least its main points clearly to any audience. Doing so is a good test for the student. (For a popular science article written by a student, see exercise 4 at the end of this chapter.) But there are problems.

COMMUNICATIVE ACCURACY

The chief problem in writing a popular account is summarized by one science writer:

> The would-be popularizer is always confronted by the dilemma of incomprehensible accuracy or comprehensible inaccuracy and the fun of his work lies mainly in the solution of that problem.[2]

Warren Weaver of the Rockefeller Foundation, in an editorial in *Science*, defines a concept in science writing he calls "communicative accuracy":

> This concept rests upon the fact, not always recognized, that the effective accuracy of a written statement depends primarily upon the interpretation given to it by the reader. A statement may be said to have

communicative accuracy, relative to a given audience of readers or hearers, if it fulfills two conditions. First, taking into account what the audience does and does not already know, it must take the audience closer to a correct understanding. The better an example of communicative accuracy it is, the more gain in understanding it will achieve—but the basic point is simply that it must gain ground in the right direction. Second, its inaccuracies (as judged at a more sophisticated level) must not mislead, must not be of a sort which will block subsequent and further progress toward the truth. Both of these criteria, moreover, are to be applied from the point of view of the audience, not from the more informed and properly more critical point of view of an expert.[3]

Thinking from the point of view of the audience is essential for solving a second problem in popular accounts: enticing the reader. Some technical subjects are too specialized or mathematical to be converted into an account readable by—and of interest to—a person of limited (or no) scientific background. But much scientific work has the makings of a good article. The writer has to judge what will be attractive and select and arrange his materials to court the reader. He can

1. Wrap a scientific development in a story rather than simply recite the facts.
2. Appeal to the reader's fundamental interests: money, security, safety, health, recreation (and, of course, sex). Promise (and deliver) practical rewards.
3. Stress the startling dimensions or conflict or human interest in his work.
4. Introduce himself and his work—that is, weave a narrative around himself.
5. Relate the unknown to what the reader is already familiar with by extended comparisons and analogies. Define key terms.
6. Move quickly through a series of items in a question-and-answer format. This is particularly effective in conveying advice—about homes, cars, plants, children.
7. Be concrete and specific rather than abstract and theoretical.
8. Where appropriate for the publication, accompany the article with a full range of visuals—photographs, charts, drawings.

Let us look at some good examples of these appeals in titles, lead sentences, and organizational patterns. The writer must pay particular attention to his tone in a popular article. He should manipulate carefully the connotations of words to achieve an appropriate emotional level. He may be folksy, conversational, authoritative, humorous, or serious, but never patronizing or pretentious. These last two qualities destroy the effectiveness of any writing. The technical writer must remember his own humanity.

TITLES

In a popular article the title serves as bait. It does not necessarily have to be informative—mainly attractive, eye-catching. It may make a direct appeal:

How to Fat-Proof Your Baby

Genetic Profiles Will Put Health in Our Own Hands

What You Should Know Before You Buy a Big Bike

Do You Have a Cancer Personality?

How Much Is It Worth to You Not to Go to Houston?

Or it may whet the reader's curiosity. Figure 13-2 is a table of contents from *Natural History* and shows how the magazine uses short titles that state the topic, often generally (and wittily), expanded with more information in a tag line. *Smithsonian* uses full-sentence titles to draw the reader with a display of the article's slant. Note also the interest-getting devices in these two titles from *Smithsonian*:

Truckers, the new folk heroes, deliver the goods—and their CB lingo—to frigid Alaska pipeline project. [slang]

Bugs bit what bullets bypassed in bygone battles. [alliteration]

The following titles from popular articles written by students display interesting plays on words:

How Will Wildlife Manage?

Fertilizer Production: A Growing Market

From Hoof to Hook: A Look at a Modern Slaughterhouse

Winterproof Your Home for Savings and Comfort

Figure 13-2. Title page from *Natural History*. (Reprinted, with permission, from *Natural History* Magazine, January, 1976. © The American Museum of Natural History, 1976.)

2 Authors

8 The Bald Eagle Bicentennial Blues *David R. Zimmerman*
America's national bird has little cause for celebration.

23 A Naturalist at Large *Richard M. Klein*
A Nation of Moonshiners

32 This View of Life *Stephen Jay Gould*
Darwin and the Captain

38 Slow Exodus from Mesa Verde *Douglas Osborne*
Why, after centuries of occupation, did the Indians abandon their pueblos?

46 The Image Makers of Nepal *Alexander Duncan*
Each mold produces only a single fine metal casting.

54 Black Bears of the Smokies *Michael R. Pelton and Gordon M. Burghardt*
The cubs, due to be born in the next few weeks, are about the size of a rat.

64 Human Locomotion *Adrienne Zihlman and Douglas Cramer*
To understand human evolution, follow the action of the pelvis.

70 The Importance of Being Feverish *Matthew J. Kluger*
We've been studying fever for at least 2,400 years, and still don't know its actual function.

76 At Random *Christopher L. Hallowell*
The Fencing of America

80 Sky Reporter *Stephen P. Maran*
Missing Matter

86 A Matter of Taste *Raymond Sokolov*
The Drinking Man's Pear

92 Celestial Events *Thomas D. Nicholson*

94 Book Review *Michael J. Bean*
The War Against Wildlife

98 Additional Reading

101 Announcements

The appeal of the title is further strengthened by the lead, which draws the reader into the text itself. The lead may strike a familiar chord, or it may amuse, startle, or intrigue. It may set up a good story. Here are some effective leads:

> Most people don't much like garbage; they want it taken away—far away—preferably by somebody else and as quickly as possible.[4] [familiar chord]

> In the mid-1860s, when construction of New York's Central Park was under way, the *Herald Tribune* editorialized on the folly of the undertaking, prophesying that it would "be nothing but a great beer garden for the lowest denizens of the city," that decent citizens could not safely venture there, that real estate bordering the park would be adversely affected, and that only the grog shops would benefit from its presence. The park, of course, was a success.[5] [knocking down an argument]

> Necessity is *not* the mother of invention—only of improvement. A man desperately in search of a weapon or food is in no mood for discovery; he can only exploit what is already known to exist.[6] [knocking down an argument]

> Cambridge, Mass., has made the question whether to pursue research on recombinant DNA city business.[7] [unusual statement]

> Nearly three decades ago, Dr. Caroline Bedell Thomas of Johns Hopkins University set out on an intriguing search to identify personal characteristics—both physical and emotional—that might be linked to the development of various diseases later in life.[8] [generalization and appeal to authority]

> Back in 1891, when electric lights were first installed in the White House, President and Mrs. Benjamin Harrison, like many other Americans, were reluctant to turn them on or off for fear of getting shocks. In fact, they always had someone else do it for them.[9] [anecdote]

> At 7:17 a.m. local time on June 30, 1908, something frightful occurred in the Tunguska area of central Siberia.[10] [startling statement]

> Marriages may still be made in heaven, but the equations have now been worked out by Gary S. Becker, professor of economics at the University of Chicago.[11] [humorous twist on a cliche (and appeal to authority)]

> When President Ford sent to Congress in October legislation to reduce Federal regulation of air travel, the airlines squealed like a landing gear tire hitting a runway. But the Civil Aeronautics Board was as quiet as a Whisper jet in flight.[12] [simile]

> On a chill, gray midmorning in Houston, Texas, two 18-wheel trailer trucks (one pulling a wide-loaded step-deck with a mysterious-looking, bungalow-sized steel box labeled "Arctic Inspection Unit") eased through a downtown interchange and headed north on I-45, into an approaching cold front.[13] [sets up a story]

The organization should draw the reader through the article. Several plans are possible. One may be described as a pyramid, where the author starts with one fact or a series of facts and broadens the discussion beyond the facts to describe their significance. After speculating about how, say, a discovery has altered previous interpretations and opened new paths of research or applications, he may then further broaden his statement of the significance of the initial facts.

A second pattern is the narrative—the story. Its essence is persuasive description (see Chapter 6). The writer himself may enter the story, especially at the beginning and end:

> I began to suspect there might be a big story hidden in the woods somewhere after casually visiting two lumberyards and two sawmills and asking how they were fixed for walnut. The reaction was such as you might imagine if a fellow walked into a jewelry shop and asked the proprietor if he could see some of his Hope diamonds.[14]

A narrative may turn into a good mystery. Berton Roueché's articles in the "Annals of Medicine" series in *The New Yorker* are masterly detective stories. They successfully integrate technical information into an absorbing tale. Most follow a set pattern (often imitated). The introduction relates a case history, followed by an account of the causes, treatment, and problems of a particular disease. The conclusion focuses again on the central character. Here is the opening paragraph of Roueché's "One of the Lucky Ones." The detailed description sets up clues that turn out to have been crucial to the diagnosis of the disease—in the best Sherlock Holmes manner—as carbon tetrachloride poisoning.

> Among the more obvious ailing suppliants who appeared at Mount Sinai Hospital, on upper Fifth Avenue, on the afternoon of Tuesday, February 15, 1949, was a man I'll call Arnold Schneider. Schneider was only thirty-seven years old, but that day he could have passed for sixty-five or seventy. His back was bent, his gait was slow and shuffling, and his hands, his face, and the whites of his eyes were a ghastly lemon yellow. He felt as wretched as he looked. He had a blinding headache, he told the examining physician, there was a burning pain in the pit of his stomach, and he was dizzy, diarrheic, and nauseated—violently nauseated. He hadn't had a bite to eat since Sunday. The very thought of food was enough to double him up. To the best of his recollection, it was Sunday night, at supper, that his trouble had begun. Nothing had tasted right. Also, he had felt tired and his bones had ached. His wife suggested that he probably had a touch of the flu. He thought so, too. So, to be on the safe side, as soon as they had cleared the table and done the dishes he went straight to bed. A few hours later, around midnight, he had an attack of cramps, and vomited. That

seemed to help, and Monday morning he felt a trifle better. Enough, at least to get up. But on the way to work—he owned a half interest in a cleaning and pressing shop on West Ninety-sixth Street, just down the street from his flat—he had another seizure, and it was all he could do to get back home. Since then, he had been in almost constant misery. What really worried him, though, was his urine. It was dark brown, almost black. He had never heard of such a thing. This morning was the first time he had noticed it, and it had sent him, as rapidly as he could drag himself into his clothes and around the corner, to the nearest doctor. The doctor had sent him to the hospital. Schneider reached in his pocket and brought out an envelope. Here was a note from the doctor. The examining physician smiled a reassuring smile, glanced at the note, and clipped it to an admittance form. Apart from identifying its author as a man of conventional prudence, the message told him nothing that he hadn't known since the patient entered the room. Schneider, as his color alone made pitifully plain, had jaundice.[15]

The article traces the medical detective work. Along the way it attends to other relevant matters: the sources and occurrences of occupational disease, the effects of and attempts to control severely toxic substances. The list of substances is gradually narrowed through coal-tar distillates to carbon tetrachloride. The article ends in a dialogue that returns the reader to the story line.

To keep his article moving, Roueché takes advantage of interest-getting devices: vivid action verbs, startling statements, quotations, statistics interpreted to show their human interest, dramatic details. In other settings humor or questions (especially in the introduction and at the opening of paragraphs) are effective.

The writer should also vary paragraph length and sentence length and adjust headings to encourage reading. In *The New Yorker*, paragraphs tend to be long. Newspaper paragraphs often average only one or two sentences.

CONCLUSION

At the end the author makes a graceful exit. The conclusion may restress the main point or may complete the narrative that brackets a more technical discussion. It may evoke laughter or offer good advice. An author who is sure of himself might end with a question, but this can be risky. Usually, it is better to ask the question in the beginning, and then use the article to answer it. Often the writer ends with a look to the future.

[at the end of a story on Arctic-bound truckers—if retirement catches up with the trucker]

He and his wife Geraldine are going to buy a motor home and fix it up with a hi-fi stereo and a good CB radio. Then he will hit the road with her and shake some iron, and say into his mike: "We gone!"[16]

[at the end of an article on the evils of noise]

But the final decision [about banning noise sources] will probably require even more than the intensified work of the anti-noise forces. It will also rest, no doubt, with the individual who *likes* noise. He must get over the notion that loud is good.[17]

Signing off is almost as hard as signing in. It is important not to reduce the punch of a good article with a slow ending. The ending should be a bang, not a whimper.

NOTES

1. American Chemical Society, *Handbook for Authors*, Washington, D.C., 1967, p. 18.
2. Edward Slossen, as quoted by Robert H. Grant and Kenneth D. Fisher, "Scientists and Science Writers: Concerns and Proposed Solutions," *Federation Proceedings* (Federation of American Societies for Experimental Biology), 30 (1971), 819.
3. "Communicative Accuracy," *Science*, 127 (1958), 499.
4. *The New Yorker*, April 28, 1975, p. 29.
5. Tanya Edwards Beauchamp, "Renewed Acclaim for the Father of American Landscape Architecture," *Smithsonian*, 3 (December 1972), p. 69.
6. Cyril Stanley Smith, "Aesthetic Curiosity—The Root of Invention," *The New York Times*, August 24, 1975, p. 2-1.
7. Sara Jane Neustadtl, "Genetic Engineering: The People's Choice," *Technology Review*, 79 (1976), 10.
8. Matt Clark, "Personality and Disease," *Newsweek*, September 15, 1975, p. 72.
9. Paul Brodeur, "A Reporter at Large—Microwaves I," *The New Yorker*, December 13, 1976, p. 50.
10. Walter Sullivan, "A Hole in the Sky," *The New York Times Magazine*, July 14, 1974, p. 11.
11. Israel Shenker, "Can Two Really Live as Cheaply as One?" *The New York Times*, December 16, 1973, p. 3-3.
12. Julius Duscha, "A New Man Regulating the Airlines," *The New York Times*, January 11, 1976, p. 3-7.
13. David Snell, "Truckers Roll their Subculture into the Arctic," *Smithsonian*, 7 (June 1976), p. 67.
14. Hugh Moffett, "Pursuing the King of the Walnuts," *Smithsonian*, 3 (March 1973), p. 78.
15. *The Incurable Wound*, Little, Brown, Boston, 1957, pp. 68-69.

16. Snell, p. 76.
17. David Dempsey, "Noise," *The New York Times Magazine*, November 23, 1975, p. 31.

EXERCISES

1. Write a memo to a fellow student comparing two articles, one from a technical journal and one from a semitechnical or popular one, that discuss roughly the same topic. Determine the audience being addressed; describe the form of the article (abstract? headings? visuals? question-and-answer?); comment on the style (length of sentences? length of paragraphs? use of technical terms? degree of abstraction? extent of discussion? specificity vs. generalizations?); and assess the readability of each piece. How do the treatments differ?

2. The following passage is taken from a student report titled "Industrial Air Pollution." Discuss the techniques of the review of literature shown in the passage. What is the organizing principle?

   Sources of Sulfur Dioxide

   The reaction of hydrogen sulfide in the atmosphere, combustion of sulfur-containing fuels, and processing of ores which contain sulfur all produce sulfur dioxide. Robinson and Robbins (3) estimate the worldwide annual emissions of sulfur dioxide as follows: coal combustion, 102 million tons; petroleum combustion, 22.8 million tons; petroleum refining, 5.7 million tons; and smelting, 15.7 million tons. These categories were further broken down as shown in Table I.

   The Stanford Research Institute's figures are not well corroborated. The Air Conservation Commission of the American Association for the Advancement of Science (4), using statistics from roughly the same time period as the Stanford group, estimate that the annual worldwide emission of sulfur dioxide totals about 80 million tons: 50 to 60 million tons from coal; 11 million tons from crude oil refining; about 15 million tons from copper, lead, and zinc smelters; and a much smaller contribution from the burning of wood and solid wastes, such as paper, cardboard, and rubber tires. Dr. Leslie Chambers (5) estimates the latter contribution to be only 2 to 8 pounds per ton of burned material.

   The major trend common to both sets of figures is the ranking of the emitters, from greatest to smallest, as coal combustion, petroleum refining and combustion, and smelting.

3. Write a popular article based on material presented in a technical report you have submitted to a technical class or an English class. Obviously, you can't include everything, but try to adjust the material for the audience of one publication. Examine the publication, then fit your presentation to meet its needs. Think of a good title and lead sentence. Label, in the right-hand margin, the interest-getting devices you use.

4. The following popular article was written by a student majoring in microbiology. It is based on a formal report titled "Amniocentesis: A Low-Risk

Procedure for Determining Chromosomal Abnormalities." What device does the author use to adapt this information to a popular audience? What is the organizational pattern? Can you supply a better title?

GENETIC DEFECTS: A LEADING CAUSE OF BIRTH DEFECTS*

Ellen was 30 when Susie was born. It was a normal pregnancy with no complications, but Susie was not a normal baby. It was apparent to the doctors that Susie suffered from Down's syndrome, commonly called mongolism. This disease is characterized by an extra twenty-first chromosome. Down's syndrome is one of the many diseases caused by chromosome defects.

Susie will never lead a normal life. She is severely retarded and physically deformed. Life expectancy for children suffering from Down's syndrome is very low. Susie probably won't live past her tenth birthday.

Susie is not alone. One out of every 200 children born suffers from some chromosome abnormality. Many pregnancies are naturally aborted as a result of genetic malfunctions. Each of us potentially carries five to ten genetic faults. If two people carrying the same genetic fault reproduce, this fault can be passed on to a child, causing a genetic defect.

Not all genetic defects are carried by the parents. Many occur that have no apparent source. Geneticists and doctors are working to discover the causes behind these defects. Researchers in every country are seeking the answers to genetic defects. Major universities spend thousands of dollars every year to support projects in genetic research.

Within the past 10 years at least four universities have opened genetic counseling centers. Sarah Lawrence College in New York has one of the first genetic counseling programs in the country, where college graduates are trained for the counseling centers. These centers, staffed by qualified people, offer counseling, medical services, and help for future children. Doctors are referring more and more families with genetically afflicted children to these centers. One of the centers' major functions is to provide early detection of abnormalities in any future children.

How is this done? Will it prevent future children from suffering defects like Susie's?

A simple, low-risk, painless procedure is used during pregnancy to determine if the baby will be afflicted. The process, called amniocentesis, requires the insertion of a hollow needle into the fluid surrounding the baby. This fluid is then tested for abnormalities.

Amniocentesis is almost 100 per cent accurate. At least 20 different chromosomal abnormalities have been identified using this technique. One of the advantages of amniocentesis is that it can be performed as early as the fourteenth week of pregnancy. This is early enough for a therapeutic abortion to be performed if abnormalities are found. In this way families like Susie's are offered a solution to future genetically afflicted children.

*Courtesy of Merry Pierson.

Not all genetic defects can be identified by amniocentesis. Other processes are being used. But not all genetic defects can be identified during pregnancy. These defects receive special attention from researchers, doctors, and geneticists. How can we overcome these genetic defects? What is being done to prevent birth defects caused by genetic factors?

Other methods of determining genetic defects are being sought. Doctors and geneticists are finding new treatments for these defects. Genetic counseling programs, like the one at Sarah Lawrence College, will provide help to parents with genetically afflicted children. With continued research and public support, there soon may be alternatives to genetic defects.

CHAPTER 14

Correspondence

Correspondence is what keeps the wheels of business and industry turning. At least 80 per cent of business is conducted partially or completely by mail. Letters are a means of carrying on business efficiently, and they are written for various purposes: to furnish information, to get action, to influence people, and to furnish permanent records. Writing letters is an expensive business. According to recent studies, the cost of a business letter has jumped from $2.44 to $3.79 in the last 10 years and there is every indication that the cost will continue to rise. Recognizing not only the cost but also the prime importance of effective letters, many companies have initiated training courses and have published pamphlets to educate their employees in the art of writing letters. Moreover, many excellent books are devoted to the numerous types of letters used throughout business and industry.

There are just about as many types of letters as there are reasons for writing them. No attempt has been made in this chapter to cover all types of letters; rather, the chapter is limited to the forms of business letters, the characteristics of letters, and the types of correspondence that may concern students in their academic careers: inquiry, invitation, gratitude, transmittal, application, and follow-up.

Conventional Practices

BUSINESS LETTER

Business letters follow certain conventional practices and usually include the following elements.

Heading. Where stationery does not contain a letterhead, a personal heading is needed that gives the address of the sender and the date. It is single spaced, about 12 spaces from the top and a little to the right of the vertical center of the page. The right-hand margin should be at least 1 inch.

Inside Address. The inside address is used to identify the name and address of the recipient. Single spaced, it starts flush with the left margin, which should be at least 1½ inches. The address is typed two lines below the date line, which appears at the right.

Salutation. The salutation is a greeting that makes the letter more personal. There is some tendency today to omit the salutation, but most companies prefer to include it because it is a strong attention getter. It is placed flush with the left-hand margin two lines below the last line of the inside address. It is followed by a comma or colon (the colon is more formal) but never by a semicolon.

Attention Line and Subject Line. If an attention line is used, it usually appears between the inside address and the salutation and may be placed in one of three positions: left, right, or center. The subject line can appear either above or below but not beside the salutation.

Body. The body contains the letter's message. The introductory sentence or paragraph should gain the attention of the reader quickly and favorably and remind him of any previous correspondence relating to the present situation. The message is next and presents facts, reasons, and explanations. The final paragraph closes the letter and usually implies that some kind of action or decision on the part of the recipient is expected.

Complimentary Close. Custom dictates the use of a complimentary close, although some companies are disregarding it, and it is never used if the salutation has been omitted. It is placed two spaces below the last line of the body of the letter. The first word is capitalized; the other word or words begin with lowercase letters. It is generally followed by a comma.

The complimentary close should agree with the salutation in tone.

Somewhat Formal	*Less Formal*
	Sincerely,
Yours very truly,	Sincerely yours,
Very truly yours,	Yours truly,
Very sincerely yours,	Regards,

"Cordially" may be used when the writer is well acquainted with the recipient. "Respectfully" or "Respectfully yours" implies that the person to whom the letter is written is of high rank.

Signature. The typed name appears five spaces below the complimen tary close, and the name is signed immediately above the typed name.

If a letter is more than one page long, the second and subsequent pages should be written on stationery matching that used for the first page but without the first page's letterhead. These following pages should be headed with the *recipient's* name (left margin), the page number (centered or right margin), and the date (right margin).

Mr. J. J. Johnson	2	November 12, 1976
	or	
Mr. J. J. Johnson		Page 2 November 12, 1976

MEMORANDUM

The form of the memorandum differs from that of a letter. It is headed flush with the left-hand margin, but there are variations:

To: Date:

From:

Subject: [often indicated by "Re:" for *in reference to* or *regarding*]

It is usually written in block form. Paragraphs are not indented but are indicated by double spacing. There is no complimentary close, but a name and title may be typed to the right, six spaces below the body of the memorandum.

Styles of Letters

There is some choice in the matter of the style or the form of the letter. One may choose to use the indented form or semiblock or full block. There are other forms, but their uses are limited to special letters, generally those dealing with sales. One should be cautious about using innovative and unusual forms. More than 200 years ago, Alexander Pope said in his *Essay on Criticism*: "Be not the first by whom the new is tried nor yet the last to lay the old aside." The advice is still good. Any one of the three forms suggested is acceptable. Of course, when a person is working for an industry the form used by the company should be used and the letter should conform to company practices.

The following examples illustrate the different forms or styles.

INDENTED

Summer and Lee Streets
Parkersburg, West Virginia 26101
May 23, 19xx

Mr. H. V. Smith, Engineer
XYZ Company
40 Wacker Drive
Chicago, Illinois 60630

My dear Mr. Smith:

This letter exemplifies the indention form in which the first line of every paragraph is indented. The letter is single spaced, but double spaced between paragraphs. At one time this form was very popular, probably a carryover from handwritten letters. Today it is still used by some companies, although in general it has been replaced by the semiblock or full block forms.

At one time, business letters contained a great deal of jargon, no doubt as a result of the popularity of a nineteenth-century publication called Webster's Complete Letter Writer, which offered numerous patterns of different types of letters. Because they were patterns with blanks to be filled in, they seldom dealt in specifics and they abounded with such phrases as "We beg to advise," "The contents were duly noted," "Your order will arrive in due course," "As to your esteemed favor," "Please find enclosed herewith," and "We beg to remain."

Such phrases are now considered wordy and are unacceptable in modern letters.

Yours truly,

John H. Doe
Consultant on Correspondence

Summer and Lee Streets
Parkersburg, West Virginia 26101
May 23, 19xx

Mr. H. V. Smith, Engineer
XYZ Company
40 Wacker Drive
Chicago, Illinois 60630

Dear Mr. Smith:

This is called the semiblock or modified block form of a business letter, a very popular form today. It is single spaced; paragraphs are not indented but are indicated by double spacing.

No matter what form a letter takes, it must be appropriate to the situation; it must be accurate, clear, concise, and complete. Accuracy means that the information is correct and honestly presented. Clarity requires understandable language dependent on the reader. Conciseness demands compactness; however, enough words must be used to cover the subject effectively. For a letter to be complete, the reader must be told all he wants to know.

The recognition of such elements will result in more effective correspondence.

Yours truly,

John H. Doe
Consultant on Correspondence

P. S. A postscript should not be attached unless it is part of a sales letter. It is not an afterthought as we might find in personal correspondence; rather, it is added to emphasize a point or draw attention to a special offer. It can be indicated by "P.S." or "PS."

FULL BLOCK

Summer and Lee Streets
Parkersburg, West Virginia 26101
May 23, 19xx

Mr. H. V. Smith, Engineer
XYZ Company
40 Wacker Drive
Chicago, Illinois 60630

Dear Mr. Smith:

This is an example of a full block form, and this pattern is a recent addition to letter forms. As you can see, all information is aligned on the left side of the page, including the complimentary close and signature.

Some people object to the form on the basis that the letter does not look balanced. When it is used with a letter heading, however, it appears to be symmetrical. Of course, this form has the advantage of being fast to type, therefore less expensive than the other two forms.

Sincerely yours,

John H. Doe
Consultant for Correspondence

MEMORANDUM

INTEROFFICE MEMORANDUM

TO: Al Keane
Dick Murray
DATE: November 14, 19xx
FROM: Judy Staler

SUBJECT: December Network News

As we discussed earlier this week, I will need your marketing report for the December issue of Network News today.

If you plan to make a contribution but for any reason cannot provide us the information today, please let me know and we will try to make other arrangements. If I do not hear from you, I will assume you have nothing for December's issue.

As I mentioned, December's issue will be a "goodbye 19xx" issue. We would therefore like some information that is in keeping with this theme. One suggestion might be the top salesman of the year, the top office of the year, growth, etc.

Judy Staler
Assistant Editor

Characteristics of Effective Letters

FOLLOW A PLAN

Before writing a letter, the writer must know what message he intends to convey; he must gather the facts. He should visualize his audience, because a good business letter does not merely transmit information but rather begins or continues a relationship between the writer and the reader. Of course, the reader must understand the message, but the letter should accomplish more; it should arouse the reader's interest and elicit a positive response from him.

A good letter follows a plan, gets off to a fast start, shows a "you" instead of an "I" or a "we" attitude, and employs the proper tone. These elements combine to make a letter warm and personal.

A letter, like any other piece of writing, must be planned. This does not mean that each letter should be outlined, but it does mean that the writer should, before starting his letter, think about it or jot down the major points he wants to make. Before composing his letter, he must of course gather the facts; then the facts must be ordered in logical sequence. They cannot be scattered throughout the letter. If they are, they will produce a garbled message. It is estimated that about 6 per cent of written letters are so poorly organized that a second letter must follow in order to clarify what the writer intended in the first letter.

The following letter was written by a high-salaried executive who obviously did not plan or even think about the letter. No doubt, he dictated it and did not proofread it before he signed it—a dangerous practice.

> We received a telegram from you requesting 116 cases of the above product. However, I knew this was an error and should have been 16 cases.

We didn't have sufficient amount in stock to cover this order, and therefore shipped you 71 cases. I know you cannot use this many, and would appreciate your shipping 55 cases back to the warehouse. Please forgive this error but honestly it wasn't our fault.[1]

Such unplanned correspondence is expensive both in time and in money. Even more important, it can destroy the confidence and good will of a customer. An unplanned, disorganized letter is better not written at all.

GET TO THE POINT IMMEDIATELY

A planned letter gets to the point immediately. If the writer has not organized his facts and ideas, he usually fumbles at the beginning while he tries to decide what he wants to say. Nothing exasperates the recipient more than to have to plow through several say-nothing paragraphs in order to discover the message (see Figure 14-1).

The message should get off the ground in the first few sentences.

> Your letter of April 10 informed us that you had not yet received your purchase order. We are sorry for the delay. Unfortunately, the order was directed to our Newark plant instead of our Boston plant. However, our Boston plant has now processed the order, which you should receive within the next 2 days.

EMPLOY THE "YOU" ATTITUDE

Because consideration of the audience is basic to all business letters, it is not surprising that such letters are improved by the predominance of the "you" attitude rather than the "I" attitude. This does not mean that a letter should eliminate all first person references, but where possible the writer should acknowledge the recipient's position with regard to the situation described. If he writes

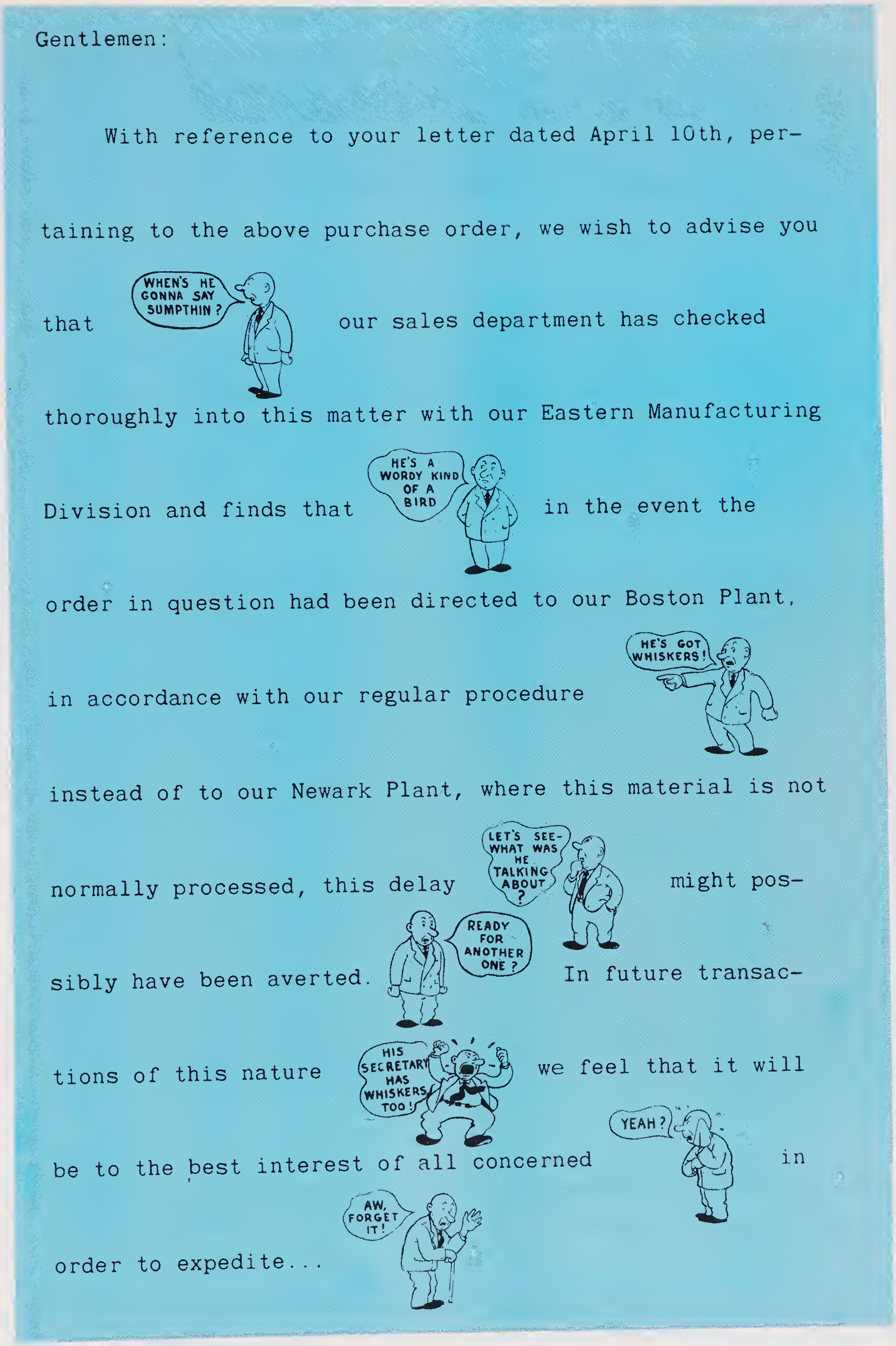
> We were delighted to receive your subscription to *Holiday*. We have placed the order with the subscription editor.

he is emphasizing the "we" (plural of "I" attitude), but the sentence can easily be revised to put the emphasis on "you":

> Thank you for your subscription to *Holiday*. You will receive your first copy at the beginning of the month.

The following example illustrates the same point:

> We have received your letter of April 15 and we have referred it to our shipping department, and they tell us that we sent the order on April 18.



Gentlemen:

With reference to your letter dated April 10th, pertaining to the above purchase order, we wish to advise you that our sales department has checked thoroughly into this matter with our Eastern Manufacturing Division and finds that in the event the order in question had been directed to our Boston Plant, in accordance with our regular procedure instead of to our Newark Plant, where this material is not normally processed, this delay might possibly have been averted. In future transactions of this nature we feel that it will be to the best interest of all concerned in order to expedite...

Figure 14-1. A bad letter. (From *Letters—Have You Read Yours Lately?* Johns-Manville Company. Reprinted by permission.)

The more thoughtful writer would have written:

> The merchandise that you inquired about in your letter of April 15 was sent to you on April 18.

Such changes in the sentences may seem minor, but it must be remembered that psychology plays a great part in constructing an effective letter.

WATCH THE TONE

A letter written with adequate appreciation for its intended audience will usually achieve a proper tone; that is, the words chosen to carry the message will not only be unmistakably clear in meaning but also be suitable for conveying the more subtle aspects of a communication. Choice of words should be carefully monitored to ensure a friendly tone; certain words produce a negative reaction:

Complaint unwarranted	Your complaint about the damaged merchandise seems unwarranted, but we will give it our immediate attention.
Mistake	This is to correct the mistake you made in the amount of the check you sent us.
Claim	We have your letter in which you claim that the pump was damaged.
Assume or presume	I assume that you are a man of intelligence because of the position you hold.
Disgrace	The last issue of The Engineer is a disgrace to the University, its staff, and its student body in general.

The wrong word can easily alienate the recipient. If two or three such words appear in the same letter, they will certainly affect his response. Imagine the recipient's reaction to the following:

> It is unfortunate that you did not receive the pump handle that you allege was missing from your order. Our packaging division contends that the handle was carefully packed in the bottom of the box. No doubt you should make a careful check for the handle.

The words *unfortunate*, *allege*, and *contends* are unwise choices within the context of the letter. Moreover, the last sentence practically accuses the customer of carelessness. It is common knowledge that words are not merely words; one cannot always rely on dictionary definitions. The dictionary does not indicate a word's emotion-evoking qualities. (See Chapter 4 for a discussion of denotation and connotation.)

CONSIDER THE AUDIENCE

Consideration for the audience demands that a letter be written in natural, understandable language and be concise and specific. "The exigencies of the situation make it necessary that the government decrease its monetary expenditures" is a prompously unnatural way of saying, "The financial crisis makes it necessary to cut government expenses." Using more words than are necessary is also discourteous. Why say in 31 words what can be said in 12 words? "This is to acknowledge receipt of your message and is a thank you for your letter of May 10 with reference to the above subject, which offers us a discount on your merchandise," instead should read, "Thank you for your offer of a discount on your merchandise."

Information offered in a letter should be specific and concrete. Not "Salesmen will visit your area soon," but "Our representatives will visit your Chicago office on February 1." If only vague information is available, consider not mentioning it at all.

Types of Letters

The following letters make use of the preceding principles and illustrate possible patterns for types of letters that may concern students.

LETTERS OF INQUIRY

Letters of inquiry are a type that students often need to write. Such letters range from a very simple request for the price of an apparatus to a complex request for the details of financing a project. Letters of inquiry contain clear and concise statements of the information desired.

- What is wanted?
- Who wants it?

- Why is it wanted?
- How will it be used?

Usually, letters requesting a favor close with an expression of appreciation.

Because letters of inquiry are written to get a response, they should be made easy to answer. One way to do this is to list questions and number them. Of course, questions should be kept to a minimum and the request should be reasonable.

Simple requests usually do not list questions. For instance,

> I have a family of eight children ranging in age from 3 to 16. We are living on a very low budget and need some suggestions for nutritious meals. Would you be kind enough to send several menus for lunch and dinner with their estimated costs?

If several items of information are requested, it is advisable to list them:

> As a student at Eastern University, I am doing research on the different concentrations of sulfur dioxide from stack gases. Would you be kind enough to answer the following questions?
>
> 1. What percentage of sulfur dioxide is removed by the equipment you produce?
> 2. What is the cost per pound of processed sulfur dioxide for operation?
> 3. Is adsorption or absorption applied in the extraction process?
>
> Any further information in the form of published reports or brochures will be greatly appreciated.
>
> I hope to complete my report by November 21, and, in consideration of your time and effort, I shall be glad to forward a copy to you, if you are interested.

All letters of inquiry are written in business letter form, as illustrated in the following:

221 Hague Avenue
Champaign, Illinois 50121
July 10, 19xx

Professor J. J. Johnson
Department of Entomology
University of Illinois
Urbana, Illinois 60435

Dear Professor Johnson:

I saw a strange-looking insect in my garden yesterday. It was slender, but large for an insect--about an inch long. It was a rather violent green, had greenish gossamer wings, and a tiny head with prominent black eyes. It appeared to be able to turn its head in a complete circle. As I watched the creature, it rose on its hind legs and folded its front legs. Could you identify it from this description?

1. What is the name of the insect?
2. Is it destructive to plants?
3. If so, which plants?
4. What kind of spray should I use to destroy it?

I would appreciate any information you can send me.

Sincerely,

Care should be taken in writing an inquiry letter. The following letter is ineffective:

For a final report to be written in a marketing course this term it is required that brochures and other information pertinent to the general approach to sales and general financial status of your company be sent to me at the above address not later than one week after receipt of this letter.

The following questions should be answered.
1. What is your company's philosophy on advertising?
2. How much do you spend on advertising in each and all media?
3. Is your advertising effective?

An annual report will help, but opinions and details will make the report receive a better grade.

Thanking you for your time,

This letter violates a number of letter-writing principles. The tone is demanding, partly as a result of the use of the passive and partly because of the use of words such as *required*. Apparently, the student had heard somewhere that *I*'s should not be used in a letter, which, of course, is not true. His outdated participial ending implies overconfidence that the company will send all the material requested. In this case, although the letter writer did receive the information, it was accompanied by a letter pointing out several of his problems and showing some annoyance on the part of the recipient:

> We are forwarding part of the information you requested in a rather discourteous manner. Some information has been withheld because it is classified, and some cannot be released because of company policy. We hope, however, that enough material has been furnished to aid you in writing your report.
>
> May we suggest that you work on the content and tone of your correspondence? When you request a favor, do your homework. Limit the questions. Allow time for a response. Be courteous. This advice may assist you in college and in your career.

LETTERS OF INVITATION AND GRATITUDE

Some students may have to write a letter of invitation to a speaker for one of their academic meetings. Such letters are not difficult to write, but care must be taken to include the essential information.

The letter of invitation should

- Include a statement that will influence the addressee to accept.
- State definitely what the invitation involves. Either name the subject of the talk or give the general interest of the audience.
- State how much time is to be allotted for the talk.
- Indicate size and type of audience, date, place, time of the meeting, and whether a fee is to be paid and expenses are to be reimbursed.
- Mention provisions for entertainment, if any.
- Assign a date for an answer.

If the speaker accepts the invitation, a thank-you letter should be sent to him after the meeting.

Following are two typical letters of invitation and an example of a thank-you letter:

1621 Camelot Street
Peakburst, New Jersey 07755
April 27, 1976

Professor John Thomas
Department of English
University of Notre Dame
Notre Dame, Indiana 46556

Dear Professor Thomas:

I am writing as program chairman of the Melville Society to ask if you would be interested in presenting a talk at our annual meeting in New York City during the Modern Language Association convention in late December 1976.

We are contemplating two general themes for the meeting: "Self and Society" in Melville and the America of Melville's day and "Melville and Science (or Technology)."

Your work on <u>Moby Dick</u> and the Calvinist tradition and on scientism and puritanism in the "Lightning-Rod Man" led me to believe that you may be researching something that would fit our theme and that you might want to talk about.

If you are interested, please let me know the general design of what you might say and a title. The talk should last about 20 minutes. Since we need to line up the program by June 1, could you please reply by May 15? We will select the final theme based on responses to our solicitation.

I hope to hear from you soon--and to listen to you in New York. Please let me know if I can supply further information about the meeting or the society.

Sincerely,

Dorothy C. Anderson

November 21, 19XX

Professor Edwin T. Lyle
Department of History
Case Western Reserve University
University Circle
Cleveland, Ohio 44106

Dear Professor Lyle:

I am writing on behalf of a group of faculty members in the departments of history, English, and metallurgical engineering who hope to bring to Ohio State this winter and spring several distinguished scholars to lecture on various aspects of the relationship between science and technology and society. We would be honored if you would accept an invitation to speak to us.

We would ask you to present one public lecture attended largely by faculty members and advanced students with varying interests and backgrounds; we would be pleased to know of several topics appropriate to such a group that you would be willing to speak on. In addition, we would like to have you speak to or meet informally with one or two small classes, probably in history or metallurgical engineering, to share with students your ideas on general issues and problems in science and technology.

In addition to paying your expenses we can offer an honorarium of $100.

If you are willing to join us, please let me know of several possible topics you might speak on and of dates for two days (preferably Thursday and Friday) when you would be free to come to Ohio State between 14 January and 14 March or 8 April and 30 May.

I hope you will be able to accept our invitation, and I look forward to hearing from you about specific topics and dates.

Sincerely,

Sandra Winchester

Capital University
2199 East Main Street
Columbus, Ohio 43209
June 2, 1975

John Weller
Reports and Graphic Arts
Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201

Dear John,

Dolores and I would like to put in writing what we have mentioned to you and detailed at length to others: that the seminar could not have succeeded without your consistent work, good sense, and attention to particulars. That it was such a success makes us all glad. It results largely from your leadership.

The seminar, I think, made us all aware of the tremendous energy--and sheer intellectual (and other) muscle--stored up in the Central Ohio Chapter. Now that we've carried off this one seminar under your chairmanship, we look forward to working together on many more projects.

Please do give your thanks, too, to Ruth for her grand hospitality at your home.

This year has certainly been a good one for the Society for Technical Communication. Thanks to you.

Sincerely,

Ethel Poling
Instructor of English
Co-Chairman, Seminar Committee, Central Ohio Chapter STC

LETTERS OF TRANSMITTAL

The letter of transmittal is a covering letter for a formal report. Sometimes written as a memo, it is more often submitted in business letter form. The length of such letters varies considerably. The basic function of the letter is to announce transfer of the report to the recipient, and, in doing so, a short letter may state only the subject and its authorization, but longer letters may include a number of items. They may

- Mention the report by name.
- Give the authorization for the work.

- Discuss briefly the contents of the report.
- Indicate difficulties that were encountered.
- Include major conclusions and recommendations.
- Acknowledge any assistance rendered.
- Offer to answer any questions about the project.

Ohio Department of
Natural Resources
Division of Planning
P.O. Box 1310
Columbus, Ohio 43210

Mr. Donald Hough, Director
Carroll County Regional Planning Commission

Mr. David Norman, Director
Tuscarawas County Regional Planning Commission

Gentlemen:

As part of our cooperative undertaking to provide for the future of the Conotton Creek Watershed, I am pleased to transmit to you the analysis of the Conotton Creek Subwatershed.

This report represents the end of an intensive 6-month study conducted by the Mined Lands Restoration Unit of the Ohio Department of Natural Resources. The publication contains the methods used to evaluate both mined and nonmined lands within the watershed, as well as planning objectives and goals that you formulated to guide the study.

The report will prove useful to the Regional Planning Commission for long-range mined land restoration planning and for land-use planning decisions. Implementing the study will materially contribute to the goal of improving the quality of life in that region.

It has been a pleasure to cooperate with you on this project.

Sincerely,

John Doe, Chief
Division of Planning*

*Courtesy of Ohio Department of Natural Resources.

November 21, 19xx

Mr. Dominic Ferro
Richmond Heights Service Department
22620 Chardonview Drive
Richmond Heights, Ohio 44143

Dear Mr. Ferro:

The accompanying report entitled Effective Street Striping is submitted in accordance with your instructions of October 26.

The purpose of this report is to present information about street striping and to recommend the best types of paint and an effective method of application. The information was obtained from testing done during the last month. An effort has been made to cover each important aspect, such as the paint product used, thinner amounts, spray pressure, and thickness and drying time needed.

I wish to acknowledge the assistance given me by Mr. Edward J. Potter.

I sincerely hope that this report will meet with your approval. I am available to answer any questions you may have. I am also available for future work.

Respectfully yours,

John D. Franco

LETTERS OF APPLICATION

Any student—indeed, nearly every person between the ages of 16 and 65—knows the importance of writing an effective letter of application. He knows that he cannot write a careless letter full of misspelled words, erasures, strikeovers, and blurred typing. If the student sends such a letter, its recipient may assume, rightly or wrongly, that he performs all tasks with a similar disregard for quality and finish. And one never has a second chance to make a first impression. The tone of the letter cannot be apologetic or egotistical. The content must be well organized and specific. A letter of application should

- State the specific job wanted.
- Give specific information on qualifications. Offer facts, not the judgments of the writer.

- Request an interview.
- Include a résumé, a summary in outline form of personal data, education, work experience, and references.

Like all other letters, the letter of application consists of an introduction, a body, and an ending. The introduction usually opens with a reference to the source of knowledge about the job.

Introductory Sentences.
Reference to an Advertisement.

I saw your advertisement for an auditor in *The Wall Street Journal*, Monday, May 14, 1976, and feel that my working experience and education would qualify me for such a job.

Reference to an Individual.

Professor J. J. Jones, my finance instructor, has suggested that I apply to you for the opening in your credit department.

Question or Summary. If no source is available, the letter could start with a question:

Do you have an opening in your department for a computer programmer? If so, I would like to apply for it.

Or it could start with a summary sentence:

Having spent my last four summers as a playground director with your department, I would like to apply now for a permanent position as a director of one of your recreation centers.

Body. The body consists of specific information expanding on some points included in the résumé. It may emphasize scholastic achievement: special training, honors, subject of and work on a thesis. Or it may emphasize some area of work experience. Emphasis on college activities and offices held indicates an ability to get along with people.

Judgments of the applicant's abilities or characteristics should not be offered. "I am conscientious and hardworking" carries no conviction, but specifics do: "I have maintained a point hour of 3.8 out of a possible 4.0 in chemical engineering, and have worked at a part-time job as a laboratory assistant for the department during the last 3 years." "I am 22, and I like people and get along very well with my fellow students" might as well have ended with "I am 22." Facts will more convincingly convey the idea of getting along with people. "I am president of my senior class and have held two offices in my fraternity: secretary and treasurer. I am now chairman of the program committee for ACE Day, which entails working with a committee of 25 students and 10 professors."

Accomplishments should be emphasized, not by judgments, but by specific details:

> My interest in designing children's furniture was triggered by my visit to the Furniture Mart in Chicago 3 years ago, where I saw several pieces of children's furniture designed by your company. I then switched my major from architecture to design and have been thoroughly satisfied with my choice. I have written three articles on designing children's furniture. One (copy enclosed) was published in the February 1976 issue of *Child's World.* Moreover, I sold one of my designs for a children's playbox to the Child Craft Company.

Concluding Sentences. The purpose of the letter is to obtain an interview, so a request for an interview concludes the letter:

> If you are interested in my qualifications, I would appreciate having an interview at your convenience. I am available any Tuesday or Thursday, the days I do not have class meetings. I can be reached at the above address or by telephone (691-2356).

Résumés. Sometimes called a "vita," a résumé usually accompanies a letter of application. It is an abbreviated record of the applicant's qualifications—a short, condensed autobiography presented in outline form. Name, address, telephone and social security numbers appear at the top of the résumé, which usually consists of a summary of personal data, education, and experience. The information is arranged for easy reading to give the recipient a chance to ascertain the facts quickly. Listings are usual and abbreviations are acceptable, because résumés should not exceed two or three pages—one is best. Education (with dates) is listed chronologically, but experience (with dates) is listed from present to past. A résumé must be accurate in every detail.

Following are two letters of application accompanied by résumés.

Cross Laboratories
Seattle, Washington 98116
March 6, 19xx

Hazel B. Benton
Acting Director
Health Sciences Library
376 West 10th Avenue
Seattle, Washington 98116

Dear Ms. Benton:

As a medical information specialist at Cross Laboratories and a frequent user of the Health Sciences Library, I am acquainted with the excellent reference service your library provides. I was pleased to receive your recent announcement of an opening on your staff for a reference librarian.

In my former position as a library assistant at Cross Laboratories I performed a variety of library tasks. In addition to acquisitions, cataloging, and reference work, I maintained a computerized information storage and retrieval system for in-house research reports. I left this position to obtain my M.L.S. degree at the University of Maryland. As a documents assistant at the Health Sciences Library in Baltimore I provided reference assistance to medical students and allied health professionals. I obtained further experience in collection development and reference work at the Women's Information Center, which was developed by students at the library school. My present position in the Medical Department at Cross Laboratories allows me to provide in-depth reference service tailored to the special information needs of the physicians and researchers on the staff.

Computerized searching of the health care literature has added a new dimension to reference service. My library school course work included data processing for librarians as well as MEDLINE training.

My qualifications are outlined on the enclosed résumé. My present work frequently brings me to the Health Sciences Library, and I would be pleased to meet with you for an interview at your convenience.

Sincerely,

Mary Jane Jones
Medical Information Specialist

Enclosure

RESUME

Mary Jane Jones
1927 Northwest Boulevard
Seattle, Washington 98116
206-7549 (home)
206-5281, ext. 398 (office)
Social Security 301-16-234

Personal Data: 29 years old (born November 30, 1945)
Married, no children

Education: University of Washington
B.Sc. in psychology, 1970
University of Maryland
M.L.S., 1974

Medical and Reference Courses	Grade (4.0 basis)
Reference and bibliography	4.0
Medical literature	4.0
Special libraries and Information Centers	4.0

Experience: 7/74 to the present
Cross Laboratories Medical Department
Medical information specialist serving as liaison between staff physicians and the library

1/74 to 5/74
Women's Information Center, University of Maryland
Student assistant librarian answering telephone and walk-in reference questions

7/73 to 1/74
Health Sciences Library, University of Maryland
Documents assistant providing reference service for a health-related government documents collection

1969 to 1972
Cross Laboratories Library, Seattle, Washington
Library assistant performing literature searches for medical staff

Professional Memberships: Medical Library Association
American Society for Information Science

References: Supplied on Request

2338 Kensington Drive
Bloomington, Indiana 46714
September 4, 19XX

Mr. R. H. Dawson
Scientific Research Staff
Ford Motor Company
P.O. Box 2053
Dearborn, Michigan 48121

Dear Mr. Dawson:

From both Professor Richard C. Jones at Indiana University and your advertisement in the August issue of the IEEE Spectrum, I have learned of your opening for a reliability engineer. I feel that I could fit your needs quite well, as my training has been concentrated in reliability testing. In fact, I owe much of my knowledge to Professor Jones, who has been a reliability consultant at your firm.

Presently, I am a student at Indiana University and will graduate with a B.S. in electrical engineering this December. I am in the top 10 per cent of my class.

My last three summers were entirely devoted to reliability testing of electronic components at the Western Electric Company in Columbus, Ohio. Much of my work involved detection of failure in solid state circuitry and location of defects within a system.

In terms of theoretical ability, I have had experience with mathematical models and am well schooled in the physics of solid state devices, which you emphasized in your advertisement.

I have enclosed a résumé for your convenience and will be able to start work any time after classes end December 14. On September 16-20 and November 21-25 I will be in Detroit and will gladly meet with you for an interview at your convenience. If you find the dates unsuitable, please contact me, as arrangements can easily be made. I hope to meet with you soon.

Sincerely yours,

Donald D. Matson, Jr.

Enclosure

RESUME

Donald D. Matson, Jr.
2338 Kensington Drive
Bloomington, Indiana 46714
812-488-5033
Social Security 801-10-003

Personal Data:	22 years old (born June 22, 1951)
Education:	Upper Hills High School (Bloomington, Indiana), 1969 Indiana University B.S.E.E. expected December, 1973 Accumulative Grade Point: 3.95 (4.0 basis) Important Courses: Strength of Materials and Failure Theory Electronic and Solid State Devices Physical Theory of Electron Devices Solid State Design and Fabrication Modeling of Linear Systems Calculus through Linear Algebra Statistics
Honors and Awards:	Undergraduate Research Scholarship, 1972 Honors student (for maintenance of grade point) Phi Eta Sigma (freshman honorary fraternity) First place in Rasor-Bareis Math Contest
Activities:	Treasurer of Amateur Radio Club (holder of advanced class amateur license) Bridge Club Math Tutor
Experience: 1973, 1972, 1971 (summers)	Researcher at Western Electric Columbus, Ohio, in system and component reliability under Mr. Warner E. Miller
1972, 1971, 1970	Assistant instructor in engineering graphics under Professor L.J. Markum
1970 (summer)	Counselor for NSF engineering program
1969, 1968, 1967 (summers)	Aide to graduate students doing research in electrical and mechanical engineering
References:	Supplied on Request

Thank-You Letter. Sending a thank-you letter to a company after an interview or an inspection trip is the courteous thing to do and it sometimes pays dividends:

> Thank you for giving me the opportunity to visit your plant in New Jersey. It was a very pleasant and informative experience and everyone I met seemed eager to answer any questions I had.
>
> I appreciate the time you took from your busy schedule to escort me through the plant. I am looking forward to hearing from you again.

Letter of Acceptance. Letters of acceptance are not difficult to write:

> I am glad to accept the position of junior electrical engineer that you have offered me. I shall do my best to prove myself to be a loyal and progressive employee.
>
> As you suggested, I shall plan to be in Knoxville on Friday, June 15, so that I can take up my duties the following Monday.

Letter of Refusal. The tone of the letter of refusal should be pleasant; the main reason for the refusal should be stated briefly and politely, and, of course, a sentence of appreciation should be included:

> As a result of our interview on April 20, you were kind enough to offer me a position in your mechanical engineering department, and I appreciate it.
>
> For the past few days I have given the matter serious consideration, but have finally decided to turn down your offer. After talking with you, I have been offered a position here in Chicago. Because both my husband and I are from Chicago, we feel that we will be happiest in this area.
>
> I enjoyed being able to talk with you while in New York and carried away some very pleasant memories of your courtesy.

A Revised Letter

Because letters supply a permanent record, the writer should carefully reread every letter and revise it if necessary. Letters should not be written in an ornate style; they should be direct, clear, accurate, and concise. Students often feel that English teachers are picayune in correcting manuscripts, but once these students are in industry they will find that their bosses can often outdo English teachers in their demands for effective writing. The following letter was written by an engineer, revised by his boss, and finally rewritten.* As the saying goes, "Good papers are not written; they are rewritten."

Original.

Mr. Robert J. Orton, Project Representative
Spinney, Coady, Parker Associates
443 North Walnut Street
Springfield, Illinois 62702

Re: SMEAA Drilled-Pier Work

Dear Mr. Orton:

We have received a copy of your October 27, 1977 letter to Mr. Ron Vancil of Reilly Construction Company concerning the coring time required to penetrate *the boulders being* ~~boulders~~ encountered at *the* ~~the above~~ site. *Your letter* ~~By that letter~~ ~~you~~ indicated you would like our recommendations pertaining to *this situation* ~~the above problem~~.

~~As you remember~~ In our original foundation report for this project, we discussed the *probability?* ~~possibility~~ of encountering boulders in the buried bedrock valley *which* ~~that~~ *is filled with glacial till and* crosses the southern portion of your site. The initial drilled-in-pier work has been concentrated in this area and boulders are being encountered. The contract *for this work* was set up *intentionally so that* ~~so that any~~ boulder-coring time would be paid as an extra. We concurred with this approach in *the* preparation of the specifications. If the risk *associated with removal of boulders had* ~~of penetrating boulders had~~ to be assumed by the drilled-in-pier contractor in his *per-*foot~~age~~ *bid* price, ~~and since all the drilled-in-pier contractors are familiar with the Springfield profile where you might have a thick section of glacial till containing boulders~~ then very high per-foot prices *would have* ~~will~~ result*ed*. However, ~~the way~~ the contract was set up *so that* the risk was reduced (*to* ~~for~~ the contractor) *resulting in* ~~and~~ favorable unit prices. ~~resulted~~. ~~In the long run~~ This

What if encountered in other places?

Which wording, possibility or probability? (See report)

*Courtesy of Hanson Engineers, Inc.

equitable approach results in ~~usually considerably less dollars spent than is the risk had to be assumed by the drilled-in-pier contractor~~ *the proper expenditure instead of both the contractor and the owner being subjected to an undefinable reconstruction risk*.

We have inspected and reviewed *the approach that* ~~equipment~~ the contractor ~~has available and find~~ *is using and believe* that the crawler type rig and ~~the~~ *its* support equipment ~~is~~ *are* adequate to penetrate the boulders. Other than the method they are using about the only thing that could be done would be to bring in a much larger auger rig than presently being used. However this would have to be done at a considerable extra cost and I'm sure would require renegotiation of the contract.

Let's stay out of this.

Careful ~~I believe at this time that the problem is going to have to be lived with, however, as soon as~~ *When* the contractor ~~gets~~ *moves* out of *area of* the buried bedrock valley, ~~we do not expect this problem to continue~~ *the extent of boulder removal should diminish*. ¶ ~~I would also like to point out~~ *We should point out* that ~~up to this point~~ the estimated length of piers ~~are~~ *is* some 3 or 4 ft shorter than ~~that on which the contractor bid and their will be a sizable deduct on this work~~ *the base bid length. If this continues there should be a footage deduct on this work, which might then*. ~~At this time assuming very favorable drilling conditions are going to be encountered on the north half of the site it appears that the deduct will more than~~ offset ~~any~~ *the* extra *time* required for boulder coring.

Please contact me if you have any questions.

Very truly yours,

HUBBLE ENGINEERS, ~~Inc.~~ *Incorporated*
John M. Tolton
Vice President

Revision.

November 6, 1975

Mr. Robert J. Orton, Project Representative
Spinney, Coady, Parker Associates
443 North Walnut Street
Springfield, Illinois 62702

Re: SMEAA Drilled-Pier Work

Dear Mr. Orton:

We have received a copy of your October 27, 1975, letter to Mr. Ron Vancil of Reilly Construction Company concerning the coring time required to penetrate the boulders being encountered at the SMEAA site. You indicated in your letter that you would like our recommendations pertaining to this situation.

In our original foundation report for this project, we discussed encountering boulders in the buried bedrock valley, which is filled with glacial till and crosses the southern portion of the site. The initial drilled-pier work has been concentrated in this area, and boulders are being encountered. The contract for this work was set up intentionally so that boulder-coring time would be paid as an extra. We concurred with this approach in the preparation of the specification. If the risk associated with removal of boulders were to be assumed by the drilled-pier contractor in his per-footage bid price, then very high per-foot prices would have resulted. However, the contract was set up so that the risk to the contractor was reduced, resulting in favorable unit prices. This equitable approach results in the proper expenditure, instead of the contractor and the owner being subjected to an undefinable preconstruction risk.

We have inspected and reviewed the approach that the contractor is using and believe that the crawler-type rig and its support equipment are adequate to penetrate the boulders. When the contractor moves out of the area of the buried bedrock valley, the required extent of boulder removal should diminish.

We should point out that the estimated length of piers is some 3 to 4 feet shorter than the base bid length. If this continues, there should be a footage deduct on this work, which might offset the extra work item required for boulder coring.

Please contact me if you have any questions.

Very truly yours,

HUBBLE ENGINEERS, INCORPORATED

John M. Tolton
Vice President

Letter Reports

Many reports, especially short ones of six or seven pages, are submitted in letter form. The letters are somewhat formal and make use of headings for easy readability.*

Hubble Engineers Incorporated
March 30, 1976

Mr. M. G. Johnson
Division Engineering Manager
Illinois Bell Telephone Company
529 South Seventh Street
Springfield, Illinois 62721

Re: Report of Investigation and Recommendations
Structural Damage to Beams
IBT Dial Office
Centralia, Illinois

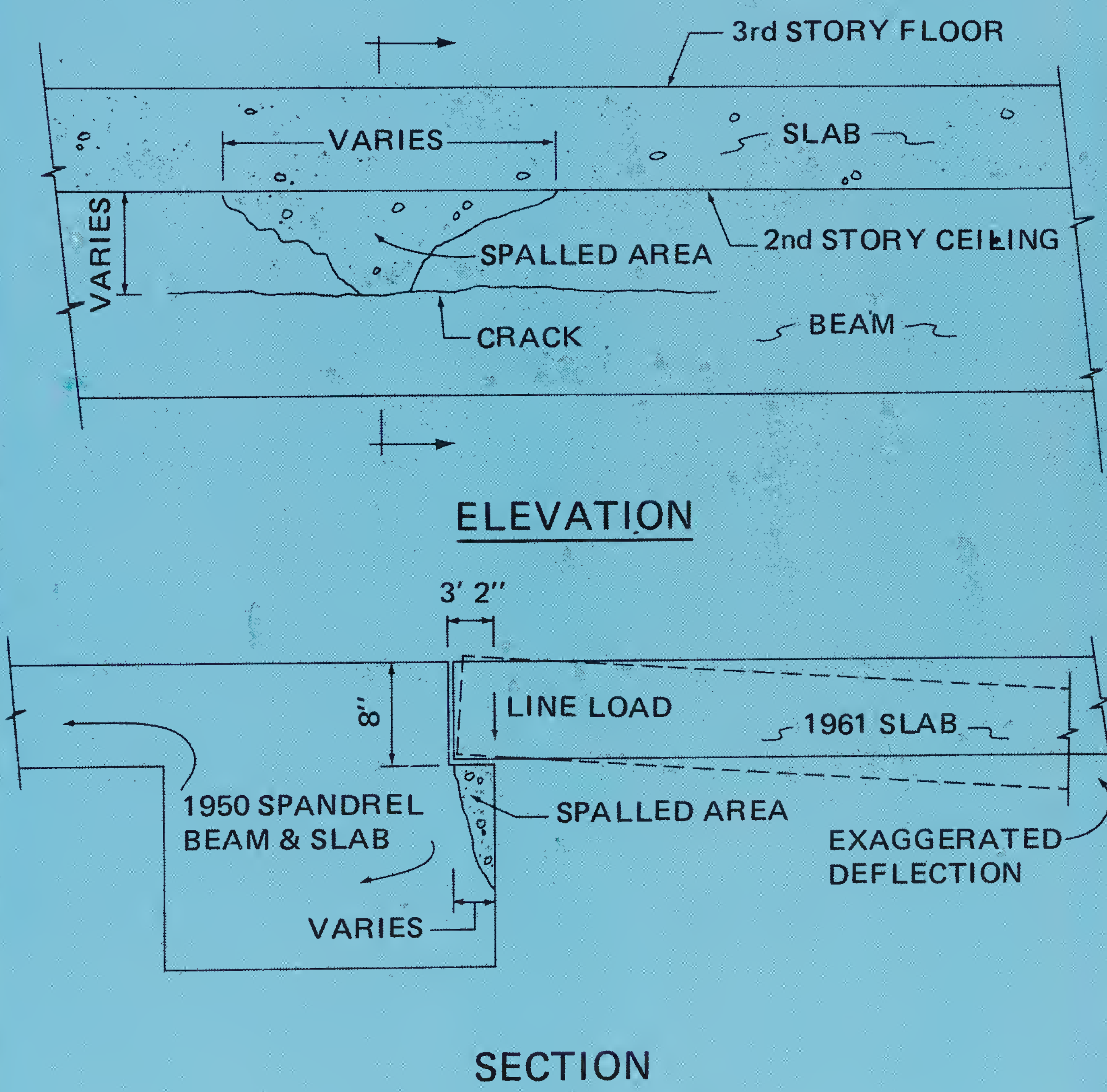
Dear Mr. Johnson:

This letter summarizes our investigation of structural damage to beams at the Centralia, Illinois Dial Office and presents our recommendations for repair.

*Courtesy of Hanson Engineers, Inc.

DISCUSSION:

On 26 February 1976, the writer accompanied Mr. James Kline (IBT) on an initial inspection trip. During this inspection, cracking and spalling (chipping or crumbing) were observed from the second story level on the west side of the ceiling beams (third story floor beams) along column line F between rows 1 and 3. The following sketch illustrates the type of distress observed. During this visit, Mr. Kline made arrangements with Stover Bros. Construction Co. to have the cracked and loosened concrete removed to reveal the full extent of the damage.



TYPICAL DISTRESS

SCALE—1" = 1'-0"

As-built records, provided by IBT, were then examined by our personnel. They showed that the cracks and spalls observed on the initial inspection were located along the interface of a lateral building expansion that occurred in 1961 (original construction was in 1950--dates as shown on as-built plans). A list was compiled of all locations within the building where lateral expansions have occurred and, therefore, where similar distress might be expected.

On 2 March 1976, the writer and Mr. Kline made another inspection of the structure, which included the areas listed below. At each of these locations, a lateral expansion has taken place (either in 1961 or in 1970):

Point	Beam	Span
Basement	West side line F	Between rows 1 and 6
First Floor	West side line F	Between rows 1 and 6
Second Floor	West side line F	Between rows 1 and 4
	North side row 4	Between lines F and D
	West side line D	Between rows 4 and 6
Third Floor	South side row 3	Between lines A and H

No cracking or spalling was observed at the basement or third floor level. However, at the first floor level, cracking and spalling were observed along the entire length of the beam, except between rows 2 and 3 where the beam was plastered over. Cracking and spalling were also observed at the second floor level along line D in both spans. The two spans along row 4 had only very slight cracking (cracks extending about 1.0 inches below bottom of slab).

At the second floor along line F, between rows 1 and 4, the contractor had removed the loosened concrete. The worst spalls were observed to be in the span between rows 2 and 3. The spalls in this span extended, in some locations, 3 to 3.5 inches back into the beam and extended 5 to 11 inches down from the bottom of the slab. Spalling was nearly continuous along this span. Spalls were not as deep and were more localized in other areas.

CONCLUSIONS AND RECOMMENDATIONS

Based on our observations and on reviewing the details of the ledge beam in the plans, it is our opinion that the concrete has failed under a line load on the outside edge of the ledge caused by deflection of the slab (see sketch). Although there are some localized areas where a significant portion of the support ledge has broken off, we do not believe that there is any immediate danger of total loss of floor support at the building expansion interfaces.

The nature and functions of this facility place severe restrictions on the type of work that can be done without resulting in extensive interruption of IBT operation. On the first floor, most of the damaged beam is in the operators' room and is concealed by a suspended ceiling. This room is staffed continuously, and noise and dust due to repair work must be minimized. On the second floor, working space is extremely limited by closely spaced racks of switching equipment. Workmen must crawl across the top of the racks, about 12 feet above the floor, to reach the damaged beam. This leaves only about a 3-foot working space. Duct work further limits or prevents access in many areas. Furthermore, the switching equipment is quite sensitive to dust.

Because of these limitations, and the opinion that the structure is not in a critical condition at this point, we consider it acceptable to patch the areas of broken-out concrete with epoxy grout. This repair is not considered as a remedy to the basic problem, but it will rebuild the ledge to at least its original integrity. We also must emphasize that the long-term effectiveness of this type of repair is questionable. If further slab deflection occurs, additional areas of cracking and spalling may develop. If the slab deflections become excessive, it is possible that concrete just beyond the limits of the patched areas could fail and that the patches would then loosen and fall off.

In our opinion, even though the effectiveness of such a procedure is uncertain, the epoxy repair should be attempted at this time. The alternative, which would be to construct additional ledge support for the slab, would necessitate moving the switching equipment, which would cause a disruption of activity in the operators' room.

On 9 March 1976, Mr. Kline and Mr. Richard Bond (IBT) met with Mr. Jeff Wilkens (Sika representative) and the writer at our office. The possible use of an epoxy grout was discussed, and the product "Sikadur Lo-Mod Gel" mixed with "Colma Quartzite Aggregate" was selected as a material having workability suitable for the required patching (see attached specifications).

On 11 March 1976, Mr. Kline, Mr. Wilkens, Mr. Jack Marsh (Stover Brothers Construction Company), and the writer met at the Centralia Dial Office. The extent of the damage was again assessed by these parties. Following that inspection, the following areas were designated to be patched:

1. First Floor: west side of line F, except between rows 2 and 3.
2. Second Floor: west side of line F, rows 1 to 4, and west side of line D, rows 4 to 6.

The north side of row 4, between F and D, is not in need of repair at this time. However, precautions should be taken to prevent injury to personnel by providing some means of catching any future spalling concrete before it falls to the floor. This could be accomplished by placing plywood across the top of the racks under the beam.

The repair procedure is to be as outlined below:

1. All areas to be patched should be thoroughly wire-brushed.

2. A bond breaker (such as plastic tape) should be used to prevent bonding of epoxy to the slab.

3. Epoxy should be mixed thoroughly and proportioned exactly according to product directions.

4. Epoxy grout should be applied in layers not to exceed about 1.0 inch.

All areas listed previously as possible locations of similar spalling should be inspected closely at frequent intervals (perhaps monthly) by maintenance personnel. Any sign of additional cracking or spalling at any location should be reported immediately to your office.

It is entirely possible that additional areas will crack and spall. Also, as discussed, additional excessive slab deflections could cause the patches to fail. If this happens, it will probably be necessary to resort to extensive repair procedures.

Please contact us if there are any questions concerning the contents of this report or if any further problems develop.

Very truly yours,

HUBBLE ENGINEERS, INCORPORATED

Michael Ramsey

Approved by ____________________
Robert R. Tillson
Vice President

Robert Louis Stevenson once wrote:

The difficulty is not to write,
but to write what you mean,

not to affect your reader,
but to affect him precisely as you wish.

And these principles are true of effective letter writing, as they are of all writing.

NOTE

1. American Business Communications Association, *Bulletin*, February 1955, p. 10.

EXERCISES

1. Write a letter to the university asking for information on continuing education courses. Request such items as descriptions of the courses, names of the instructors, time offered, cost, and credit toward a degree.
2. If you have decided on a subject for your final report, write a letter to a company or an organization requesting the information you need.
3. Write a letter to a recording company requesting a description of its latest country music album.
4. As the secretary of a professional society, write a letter inviting a speaker to participate in one of your programs.
5. Assuming that the speaker accepted your invitation and participated in your program, write a thank-you letter to him or her.
6. Compose a letter of transmittal to accompany your decision-making report.
7. Write a critical analysis of the following letter of application:

   I would like to apply for a job with your company. I have had a good education and have taken practically every course available in electrical engineering. Therefore, I feel that I could handle any problem that you have in that area. I realize that it is important to get along with people and I assure you this is one of my strong points. I'll be visiting my brother in Chicago during the month of September and will be glad to come to your office for an interview.
8. What changes would you make in the following opening and closing paragraphs of letters of application?

   Opening paragraphs:

   I saw your ad in last week's paper for a computer programmer. I feel that I have all of the qualifications needed.

   I am the right man for you as you will see when you read this letter.

   I'm sorry to take up your time, but I need a job, and I'd like to join your company. I'm sure you'd never regret making me an offer.

   I have searched every where for a job commensurate with my abilities. You are my last resort and for that reason I have outlined for you the reasons I need a job.

Closing paragraphs:

Thanking you very much for reading my letter and for considering my qualifications.

I am anxious to obtain an interview and am available at any time.

Please answer as soon as possible because I want to make arrangements for interviews with other companies.

As you can see from my letter, I haven't had much practical experience, but I learn fast and am not afraid of hard work. So please tell me when I can come and talk to you.

9. Criticize the tone of the following letter and account for its tone.

Dear Mr. Follett:

You are mistaken in your statement about overcharges for the trip to Hawaii. You claim that we charged extras not listed. We can only assume that you did not read all the information, which is unfortunate because we specifically stated in the final section that the cost of the trip did not include tips nor did it include the cost of the trip to the outer islands.

So far we have had no complaints from other passengers. We are sorry that you failed to note the final statement in the brochure, but we feel that we are in no way at fault.

Very sincerely,

10. Rewrite the following letter using a direct, no nonsense style. Concentrate on including all pertinent information and excluding all unnecessary wordiness and multisyllabic affectation.

Dear Mr. Dawson:

I am writing to acknowledge with sincere gratitude receipt of your lines of recent but unspecified date, pertinent to the eventuality of securing a teaching position in our English Division commencing in September 19xx, and to inquire by way of response whether you would be gracious enough to fill out the enclosed Curriculum Vitae form and report it to me at your early convenience. While I am not currently at liberty to give you assurance that we will experience a vacancy in your area of professional specialization in the period of time posited, I assure you that your credentials will receive every comparative consideration consistent with our needs and requirements. Ultimately, indeed, I shall shortly petition the Chandler Hall Teacher Placement Service at Noonan University to forward your proffered dossier. At such time as I and the Advisory Senior personnel constituting the hiring committee of the Department of English Literature have had leisure to view all papers germane to your application, you may expect to hear from me again. Thanking you for your aforementioned inquiry, and looking forward to hearing from you further regarding the matter at hand, I am

Cordially yours,

SECTION IV

MECHANICS

CHAPTER 15

Handbook

This Handbook describes how to avoid the most common usage errors in technical and scientific writing and surveys the conventions of punctuation, abbreviation, and capitalization. It also lists frequently misused or confused words. Conventions change. Principles of usage come into and go out of fashion. This guide adheres to current practices.

It is not exhaustive, nor does it repeat all matters covered in grammar books. For a more detailed discussion of the principles of style, see Chapter 4. For greater specificity in the use of conventions, consult the style guide of the leading journal or professional society in a field. Several style guides and handbooks are listed in Appendix B.

The three sections of this Handbook are

A. Common errors in sentences.

B. Conventions of punctuation, abbreviation, capitalization, and numbers. (Entries are in alphabetical order.)

C. Frequently misused words.

[Page numbers in brackets in this Handbook refer to the section of Chapter 4 that discusses the item in more detail.]

A. Common Errors in Sentences

The following 13 errors are the most common offenders in scientific and technical reports. They cause ambiguity in the message and indicate an author who is unaware of standard grammatical principles.

A.1 Faulty Agreement (of subject and verb) [pp. 74–75]

The verb must agree in number with the subject of the sentence; a single subject takes a single verb, and a plural subject takes a plural verb.

- *wrong*: The most important influence on the children are the different learning centers in the classroom.
- *right*: The most important influence on the children is the different learning centers in the classroom.

However, some words that end in *s* take a singular verb: *dynamics*, *news*, *chaos*, *mathematics*, *politics*, and so on.

- *right*: The thermodynamics of this reaction is interesting.

A.1.1 Connectives like *together with*, *as well as*, *in addition to*, and *along with* do not affect the number of the subject.

- *wrong*: A list of the products, along with the names of their suppliers, are provided.
  [The subject is *list*, a singular; *products* and *names* are plural but are not the subject of the sentence.]
- *right*: A list of the products, along with the names of their suppliers, is provided.

A.1.2 When two subjects of different number control the same verb, the number of the verb agrees with the nearer subject.

- *right*: Neither the engineer nor the technicians are responsible.
- *right*: Neither the technicians nor the engineer is responsible.

A.1.3 Either a singular or a plural verb is correct in mathematical expressions.

- *right*: Two times two is four.
- *right*: Two times two are four.

A.1.4 An equation is always singular, regardless of the number of terms on either side.

- *right*: If we assume that $x + y\ (3a/b) = 46$ is valid, then. . . .

A.1.5 The following singular pronouns require singular verbs (and singular possessive pronouns; see A.2): *another*, *anybody*, *anyone*, *anything*, *each*, *either*, *everyone*, *everybody*, *everything*, *neither*, *nobody*, *nothing*, *one*, *somebody*, *someone*, *something*.

- *wrong*: Each of the quantities have their effects on the resistance of the conductor.

- *right*: Each of the quantities has its effects on the resistance of the conductor.

A.1.6 A collective noun takes a singular verb when the group is regarded as a unit and a plural verb when the members of the group function as individuals.

- *right*: The number of specimens is large.
- *right*: A number of experiments were run.

The word *series* is often a problem. It is a singular that should not be used in the sense of *several*.

- *right*: The series of examinations was not regarded as difficult.
- *poor*: A series of 15 specimens was examined.
- *better*: Fifteen specimens were examined.

A.1.7 With percentage figures or fractions, the verb agrees in number with the noun in the modifying prepositional phrase.

- *right*: Ten per cent of the reagent was recovered.
- *right*: Half of the trees suffer some blight.

A.2 Lack of Agreement (of pronoun and antecedent) [pp. 75–76]

A pronoun must have a clear antecedent (the word for which it stands) and must agree with it in number.

- *faulty agreement*: A monkey eats bananas, but they eat other food, too.
- *right*: A monkey eats bananas, but it eats other food, too.
- *right*: Monkeys eat bananas, but they eat other food, too.

A.2.1 The pronouns *he* and *she* stand for some noun preceding them. Unfortunately, there is no third person (or possessive) pronoun or pronominal adjective that includes both genders; thus it is permissible to use the masculine pronoun to refer to both men and women. Use of the alternatives *he/she*, *he or she*, *his/her*, and *s/he* is awkward if the pronoun must be repeated frequently in a lengthy report. Consistently using the plural represents one solution, but this is also awkward. In this text we have used the pronoun *he* throughout to refer to the technical writer, although we are perfectly aware that scientists and engineers can be either women or men.

A.3 Comma Fault or Comma Splice

Two independent clauses forming a sentence must be linked with a comma and a coordinating conjunction or with a semicolon or a colon (see B.5). A comma used alone, without a coordinating conjunction, does not adequately separate and balance the clauses.

- *comma fault*: It was a fair test, we did well on it.
- *right*: It was a fair test, and we did well on it.
  It was a fair test; we did well on it.

A semicolon, not a comma, must be used between main clauses joined by a conjunctive adverb (*however*, *thus*, *indeed*, *nevertheless*, *therefore*, *moreover*, *consequently*) (see B.17).

- *comma fault*: The results were unfavorable, nevertheless we proceeded with the experiment.
- *right*: The results were unfavorable; nevertheless, we proceeded with the experiment.

A.4 Dangling Modifier [pp. 79-81]

A dangling modifier is usually a verbal (participle or infinitive), often at the beginning or end of a sentence, that cannot logically modify the subject of the sentence. Danglers are particularly prevalent when the main verb of a sentence is passive (see A.9). The subject of the sentence must be capable of the action in the modifier.

- *wrong*: Working 8 hours a day, 6 days a week, 20 working days have been completed.
- *right*: The technician completed 20 working days of 8 hours each, 6 days a week. [See B.12.3.]
- *wrong*: After thinning the stand, the following trees were designated as crop trees.
- *right*: After the stand had been thinned, the following trees were designated as crop trees.
- *right*: After the stand had been thinned, we designated the following trees as crop trees.

A.5 Expletives (overused)

Expletives are forms of predication (see pp. 73-79 and A.10) that disguise the subject and weaken the verb: *it is*, *there is*, *there are*. Overreliance on these reduces the vigor and precision that good writing requires. Expletives are sometimes unavoidable: "It is raining today." They are sometimes justifiably used to avoid a passive: "It is useful to make a distinction" seems stronger than "A distinction can be usefully made." But expletives too often appear simply because they are easy;

recasting the sentence to bring forth the proper subject, attached to a good verb, requires some thought and effort.

- *poor*: There are three kinds of birds that have been discovered by researchers in this environment.
- *better*: Researchers have discovered three kinds of birds in this environment.
- *poor*: It was found in these studies that the equipment was inadequate.
- *better*: These studies revealed that the equipment was inadequate.

A.6 Fragment

A fragment is a group of words that fails to state a complete thought, although it looks like a sentence because it begins with a capital letter and ends with a period or question mark.

- *fragment*: But only if all variants are considered. [This is a dependent clause that must be attached to a main clause to make sense—and a sentence.]
  right: But only if all variants are considered will the project succeed.

- *fragment*: The reason being conventional tillage is destroying the soil's structure. [This needs a main verb; *being* is a verbal.]
  right: The reason is that conventional tillage destroys the soil's structure.

- *fragment*: Work undertaken on developing a silvicultural system of management for a 50-acre forest. [only a subject (with many modifiers); no verb]
- *right*: Work has begun on developing a silvicultural system of management for a 50-acre forest.

A.6.1 A fragment can sometimes be used for emphasis, but the writer must recognize his intent: "One would think that if Plan A would work, so also would Plan B. Not so."

A.7 Misplaced Modifier [p. 81]

A modifying element should appear next to the word it modifies. If not, it is misplaced (see C: *Only*). Note the difference between "All the loans were not paid" and "Not all the loans were paid."

- *misplaced modifier*: Angel fish are normally intolerant of anything that moves while breeding, but they seem to accept me.

[As the sentence stands, *while breeding* seems to modify *anything*, later defined as *me.*]

- *right*: While breeding, angel fish are normally intolerant of anything that moves.

- *misplaced modifier*: In response to the request of Newberry community organizations that Creative Children's Programs develop a day care center on September 22, 1977, we submit this report.
- *right*: In response to the request of September 22, 1977, that Creative Children's Programs develop a day care center for Newberry community organizations, we submit this report.

A.8 Lack of Parallelism [pp. 82-85]

Items in a series should be expressed in similar grammatical form and should be logically equal (see B.5.4 and B.14.4 for punctuation of lists).

- *parallel*: Is your pond overgrown with weeds, filling up with sediment, not pleasing to look at, putting out a foul odor, covered with green scum, leaking, or just plain not working?

Sometimes a preposition or conjunction needs to be repeated before coordinate elements to produce clarity and emphasis or to follow idiomatic usage.

- *parallel*: He was first in peace, first in war, and first in the hearts of his countrymen.
- *parallel*: He neither fled from nor succumbed to temptation.

A.8.1 Both parts of a comparison should be tied down, and like objects should be compared.

- *poor*: Farm buildings constructed of FRP have many advantages over the more common types of construction like wood or steel.
- *right*: Farm buildings constructed of FRP have many advantages over those constructed of more common materials like wood or steel.

- *incomplete comparison*: Large windows offer more light.
- *complete*: Large windows offer more light than small ones.

A.9 Misuse of the Passive [pp. 76-77]

Unless he has a good reason, a writer should keep verbs in the active voice. The passive is useful where the doer is unimportant or where responsibility or blame should not be assigned:

"It was decided that the coffee break be eliminated." The passive may also be necessary to maintain a consistent point of view: "Such terms are important for engineers; as a consequence, they are carefully used by report writers." Or it may be required to maintain parallel structure: "Brick lasts longer, is cheaper in the long run, and is not affected by moisture" (rather than "moisture does not affect it"). But the active is more vigorous, more natural, and clearer than the passive. It also avoids the trails of prepositional phrases that haunt the passive.

- *poor*: Belugas are exploited in Alaska by Eskimos of coastal villages from the Kuskikwim River to Point Barrow.
- *better*: Eskimos of Alaskan coastal villages from the Kuskikwim River to Point Barrow exploit the belugas.

A writer may use the passive to avoid the first person pronoun, a form forbidden by some companies and instructors. But such use of the passive contributes to jargon and other forms of obscurity, and fails to assign proper responsibility.

- *poor*: The case of specimens was dropped as it was being removed from the refrigerator.
- *better* [at least more honest]: I dropped the specimens as I was removing them from the refrigerator.

A.10 Faulty Predication [pp. 74-75]

Predication is a general term referring to the relationship of the verb and the object to the subject. A falsely predicated sentence may include any number of dislocations of that relationship.

- *nonsense*: The need for effective fertilizers is required.
- *sense*: Effective fertilizers are needed.

A.11 Smothered Verb [pp. 77-79]

The real action of the sentence should not be hidden in a noun, noun phrase, adjective, or extended verb phrase. The action should be expressed with a simple finite verb.

- *smothered*: The clipping should be done whenever the plant reaches a height of 8 inches.
- *better*: The plant should be clipped when it is 8 inches high.

- *smothered*: A description of a reference reactor station of this type is given in Hammond's report.[6]

- *better*: Hammond[6] describes a reference reactor station of this type.

- *smothered*: Whenever diminishing energy seemed to overtake him, he rested.
- *better*: Whenever his energy diminished, he rested.

A.12 Stacked Modifiers [p. 88]

In an effort to be concise, technical writers often stack nouns (called nominative adjectives or noun adjuncts) and adjectives in line in front of a noun. At the least, such groupings should be hyphenated (see B.10); at best, the words can be spread for ease of understanding.

- *stacked*: hydrofluorinator off-gas solids removal data
- *unstacked*: data on the removal of solids from off-gas hydrofluorination

- *stacked*: instrumentation application range study
- *better*: study of the range of application of the instrumentation

- *stacked*: cycle dependent fatigue crack propagation behavior
- *unstacked*: ?

A.13 Unnecessary Shifts in Tense

The tense of a verb shows whether an action is in the present, past, or future.

- *present*: She speaks.
- *past*: She spoke.
- *future*: She will speak.

Added to these are the perfect tenses, which allow the writer to express a prior action or condition that continues.

- *perfect*: She has spoken. [action in the past that extends to the present]
- *past perfect*: She had spoken. [action in the past before another action]
- *future perfect*: She will have spoken. [action in the future before another action]

A.13.1 Technical writers are sometimes puzzled about when to use present or past tense. The present records references to stable conditions—to things that exist. It is used for generalizations, for theoretical discussions, for instructions, for repeated actions.

- *present*: Water boils at 100 C.
- *present*: John Maass is the author of *The Victorian Home in America.*
- *present*: When the specimen is placed in the solution, it dissolves. [not *will dissolve*, unless a specific instance is being discussed]

The past tense records observations and completed events or procedures.

- *past*: The patient died.
- *past*: John Maass wrote *The Victorian Home in America* in 1972.

In a review of literature (Chapter 13) the past tense shows what was done; the implications of that activity are given in the present. Current information is given in the present; the writer should use the past tense only if he wishes to indicate that the results are outdated or that the research was done at a particular time.

- *present*: Percy's results add significantly to our understanding of the thermodynamics of this process.

A.13.2 A writer may use more than one tense in a sentence or a paragraph, but the shifts should be logically consistent. The writer must maintain a consistent point of view. The following passage, from a report on the cold-crushing strength of ceramics, aims to describe the test procedure—what the author did. But the shifts in tense cause confusion.

> The test specimens *were* then crushed separately using a Riehle hydraulic crushing machine. After the specimen *is* placed in the machine, the bearing block *is* brought to rest on top of it. The center of the sphere of the bearing block *must be* kept in contact with the top bearing surface of the specimen and in the vertical axis of the specimen. The spherical bearing block *should be* thoroughly lubricated to ensure accurate adjustment, which should be made by hand under small initial load. [Italics added.]

The first sentence is in the past tense; the second is in the present tense; the third and fourth move into the conditional to offer instruction and shift the point of view of the paragraph. To keep the same point of view, the author should maintain a consistent use of the past tense.

B. Conventions of Punctuation, Abbreviation, Capitalization, and Numbers

B.1 Abbreviations

Abbreviations save space and typing time, but if overused they may make a report unintelligible. Decisions about which and how many abbreviations to use depend on the context and the reader's ability to comprehend them. Certainly, only those terms that readers will readily understand should be abbreviated—and one report may have many readers. If there is any doubt, write the term out. Otherwise your reader may be in the position of the farmer who shot a crow and read the tag on his leg that said "Wash. Biol. Surv." The farmer remarked that he washed the crow, boiled it, and served it, but it still tasted awful. If there is any doubt, write the term out.

B.1.1 Standard abbreviations are used after numbers denoting a definite quantity.

- The tensile strength is 40,000 psi.

The degree of abbreviation depends on the reader.

- fps or ft/sec, in.^{2} or sq. in.

For standard abbreviations, see the style guides listed in Appendix B.

B.1.2 Most abbreviations are used in the singular only (except *Figs.*, *vols.*, *Nos.*, *eqs.*, *refs.*, Drs.).

- 3 ml, *not* 3 mls

B.1.3 In general, periods are omitted for units of measurement unless the abbreviation spells a word (e.g., *in.* for inch) or might be confused with an identical abbreviation (some companies may insist on periods with all abbreviations).

- IU (International Unit)
- I.U. (immunizing unit)

Periods are also used after certain other abbreviations.

- Dr., Ltd., Co., e.g., Ms.

B.1.4 The name of a unit of measure that follows a spelled-out number is spelled out.

- about eight milligrams

B.1.5 A long word or phrase that is used frequently in a report (and for which there is no standard abbreviation) may be abbreviated in subsequent mentions if the full phrase is explained when it first occurs.

- Fiberglass-reinforced plastics (FRP) may be the answer to painting problems on the farm.

B.1.6 Commonly accepted abbreviations for the names of organizations, societies, or government agencies may be used as long as the first mention gives the full title.

- *first mention*: International Commission on Radiological Protection (ICRP)
- *first mention*: ICRP (International Commission on Radiological Protection)

No periods are used; the letters are typed consecutively (ASTRM, AMA).

B.1.7 Students as well as professionals need to be aware of the shift toward use of *le Système International* (SI) for units of measurement. This system includes both metric units and other standards (for example, degrees Kelvin rather than degrees Fahrenheit for temperature, newtons for force). The student should familiarize himself with SI units and use them consistently in a report.

B.1.8 The dimensions need not be repeated in a series of numbers with dimensions (some companies may require repetition; check style guide).

- a 10 × 15 in. plate
- −10 to +20 C

B.2 Apostrophe

B.2.1 An apostrophe (') is used to form the possessive. In singular nouns it follows the word and comes before an *s*: for example, *John's*, *the machine's*, *the nation's*. In plural nouns ending in *s* the apostrophe appears after the *s*: for example, *the machines'*, *the nations'*. Generally, when a singular noun ends with an *s*, an apostrophe and another *s* are added; this occurs usually with proper names: *Andrews's*, *Jones's*.

B.2.2 Some scientists and engineers insist that an inanimate object cannot possess something; a biologist who objects to *the leaf's color* may instead write *the color of the leaf* or *the leaf color*. But the possessive is generally accepted.

B.2.3 Joint possession is shown by an apostrophe and *s* added to the last member of the group; separate possession is indicated by an *s* added to each member.

- Meyrick and St. Pierre's results received great acclaim.
- Meyrick's and St. Pierre's procedures differed markedly.

B.2.4 An 's indicates the plural of words or letters spoken of as such.

- Mind your *p*'s and *q*'s.

B.2.5 An *s* is used *without apostrophe* to form the plural of a date or an all-capital abbreviation.

- During the early 1970s
- ECGs

B.3 Brackets

B.3.1 Brackets are used as parenthetic marks within parentheses ([ ]), except in mathematical expressions, where the order is reversed [()]. They are often needed in reviews of literature and in bibliographical entries.

- Decorative details (noted by Jones [*Rev. Art.*, 1973]) were widely used.

B.3.2 Brackets indicate additions within quoted matter; what appears within the brackets is understood to be the remarks of the quoter and not of the person quoted.

- "Going along the route [i.e., westward] brings you to Great East Lake."

Most typewriters have brackets; if not, brackets can be drawn in with black ink on the final manuscript. Do not use double parentheses as substitutes for brackets.

B.4 Capitals

Capitalization must be consistent, conventional, and spare; then it conveys meaning. For example, it is not consistent to capitalize *Civil Engineers* in one place in a report and refer later to *ceramic engineers* in lowercase letters.

A writer should capitalize the following kinds of words:

B.4.1 The first word of a sentence.

B.4.2 The first word of a direct quotation when the quoted material begins a sentence.

- The researcher said, "It can't be done."

Indirect quotations are not capitalized.

- The research said that it couldn't be done.

B.4.3 All letters in report titles and the first letters of important words in some section headings (see Chapter 5; usage varies).

B.4.4 The first word in a numbered or lettered vertical list (except in a list after an equation). No caps are used in lists run in as part of a sentence (see A.8 and B.14.4).

B.4.5 Proper nouns. These include the names of languages, people, races, political parties, religions, religious sects, states, countries, geographic regions, as well as branches of the government and the military, organizations, and departments.

- Atlanta is the leading city of the South.
- the English language
- the Department of Defense

The report was produced by the Department of Metallurgical Engineering at The Ohio State University.
[Note: Some companies and organizations capitalize *The* preceding their name; they may also capitalize a common noun used with a restricted meaning.]

- the Company
- the Laboratory

B.4.6 Registered trademarks, whether used as nouns or adjectives.

- a Xerox copier [the common noun is not capitalized]

Some trade names have become part of the language and are not capped: e.g., *bessemer*, *diesel*, *portland cement*, *fallopian*, *pasteurized*.

B.4.7 Certain technical terms and units of measurement derived from proper nouns: *Btu*, a *Faraday* cell.

B.4.8 Common nouns (or abbreviations) when they identify an item by letter or number.

- Table A
- Fig. 11 [but page 10]

B.4.9 The name of a genus in biological designations, with or without a species name, but not when used as the vernacular name. The name of the species is not capitalized. Class, order, family, and tribe names are capitalized (see B.11.4).

genus → *Liphyra brassolis*
species → (species name)

B.5 Colon

B.5.1 The colon is used to introduce a quotation (written either on the line of text or below the introductory line), an informal table or unnumbered figure, an example, or an equation.

B.5.2 The colon separates two main clauses when the second contains an illustration, amplification, or explanation of the first.

- The engineer had to meet one condition: he had to understand there were some things he could not manipulate.

B.5.3 The colon is used after the greeting in a formal letter.

- Dear Professor Folsom:

B.5.4 The colon introduces a list, especially after an anticipatory phrase (*the following*: or *three items*:)

- He needed three tools: a compass, a calculator, and intelligence.

but *not* if the sentence is continuous without it:

- He needed a compass, a calculator, and intelligence to complete the examination.

B.6 Comma

The comma is a mark of both separation and enclosure that clarifies the grouping of words in a sentence. It cannot force badly ordered words into sense, but it can aid in emphasis, like the gestures one uses in talking. The tendency today is to use as few commas as possible. *Use a comma for the following purposes:*

B.6.1 To separate two independent clauses in a compound sentence when the second begins with a coordinating conjunction (see A.3).

- It was not well done, but we believed it anyway.

B.6.2 To set off an adverbial dependent clause at the beginning of a sentence.

- After they had eaten, the men left the building. [The comma prevents misreading.]

B.6.3 To separate elements in a list when more than two are given.

The methods were considered faulty, misleading, and dishonest.

In technical writing a comma is usually used before the final conjunction (*and*, *or*, or *nor*) to show that the final item is of equal value to each other item and not part of a set of the last two items.

B.6.4 To separate two or more adjectives that modify a noun independently. No comma is needed if the first adjective modifies the second as well as the noun.

- a sudden, violent storm
- a bright blue sky

To test: a comma is needed if it is possible to insert an *and* between the two modifiers or transpose them and retain the meaning of the phrase. The final adjective should not be separated from the noun with a comma.

- *wrong*: a sudden, violent, storm

B.6.5 To separate the year from the rest of the date and the state from the city.

- June 12, 1976, [but: 12 June 1976]
- Chicago, Illinois,

No commas are used when the month and year are given without the day.

- Results of a survey made in November 1977 were inconclusive.

B.6.6 To introduce a brief quotation on the line of text (see B.16.2).

- Jones said, "That's a foolish approach."

B.6.7 To indicate the omission of a word or phrase.

- His knee required 25 stitches; his elbow, 28.

Use a pair of commas for the following purposes:

B.6.8 To enclose parenthetical interrupters.

- It is impossible, of course, to achieve perfection.

B.6.9 To enclose nonrestrictive clauses or appositives.

- Emmanuel Rudolph, a lichenologist, presented the lecture.
- The soybean, which is high in protein, may be used to complement an animal's diet.

Such clauses and phrases may be considered parenthetical; they add information, but they do not limit or "restrict" the noun or pronoun they modify.

- *nonrestrictive*: Tables of reciprocals, which may be found in most handbooks, should be consulted.
restrictive: The tables of reciprocals that were needed in making these computations contained typographical errors.

[Note: in rigorous usage the pronoun *that* begins a restrictive clause and *which* a nonrestrictive one, but the distinction often is blurred even in formal writing.]

B.6.10 To enclose academic degrees, titles, and so on.

- Christopher S. Andrews, DVM, was in charge.

A comma should not be used in the following instances:

B.6.11 After an introductory *but* or *yet*, unless the word is followed by a parenthetical expression.

- *wrong*: But, it is difficult to offer a variety of toys.
- *right*: But, of course, it is difficult to offer a variety of toys.

B.6.12 To separate the subject of the sentence from the verb; only a double comma, indicating a nonrestrictive element, may separate.

- *wrong*: The combination of tensile stress with a stress-raiser at the weld, greatly reduces the effective strength of the weld.
- *right*: The combination of tensile stress with a stress-raiser at the weld greatly reduces the effective strength of the weld.
- *right*: Tensil stress, especially if it is combined with a stress-raiser at the weld, greatly reduces the effective strength of the weld.

B.6.13 With a compound verb (the comma separates the subject from the second verb).

- *wrong*: The device collates, and staples material.
- *right*: The device collates and staples material.

B.7 Dash

The dash (—) is a relatively informal mark that may be used in some writing as a substitute for a semicolon between two independent clauses.

- Don't ask why—just do it.

It can also be used to set off interrupting or qualifying material in much the way parentheses are used.

- At the time—we are speaking about 1957—no antidote was known.

B.8 Ellipsis Points

B.8.1 Ellipsis points (three periods separated by spaces) indicate omissions from quoted material.

- They claim that these views on science and technology "did not evolve. . .in a vacuum."
- *original*: "They did not evolve, in spite of what other authorities might say, in a vacuum."

If the omitted material completed the sentence, four periods are used—three for the ellipsis, the fourth as the final mark of punctuation. No ellipsis points are needed if the content of the quotation indicates omission.

- She characterized her coscientists as "seekers of trivia."

B.8.2 In a table, ellipsis points may indicate that no data are available or that one category of data is not applicable.

B.9 Exclamation Mark

The exclamation mark calls attention to a startling statement. It is rarely used in technical writing but might occur occasionally in an informal memo.

- We overran our budget for the third time!

Exclamation points are generally undesirable, often the mark of immaturity in the writer and the writing.

B.10 Hyphen

The hyphen (-) connects words bound together as compound nouns, verbs, or adverbs or as compound modifiers of a noun or pronoun.

- dry-wall construction

- three-fourths full
- in-between state

The hyphen is never used between an adverb ending in *-ly* and a second word.

- badly managed proposal

There is a sensible tendency to eliminate hyphens in many compounds and join them as one word.

- semicolon
- threeway switch

A current dictionary (like *Webster*'s) or company style manual can help a writer determine how to hyphenate. Usage varies; one authority calls the problem of hyphenation "hyphen horrors." The goal is to clarify what modifies what (see A.12). Phrases hyphenated before a noun or pronoun are not hyphenated when they appear in the predicate.

- an up-to-date system.
- The system is up to date.

B.10.1 The hyphen indicates that a word is divided and carried over to the next line (words may be divided between syllables only).

B.11 Italics

Italics is a type style. Although emphasis can be gained by italicizing, this practice should be limited. Words to be set in italics should be underlined in typing.
The following are generally italicized:

B.11.1 Titles of books, reports, periodicals, and newspapers.

- *The New Yorker* is a weekly magazine.

Titles of chapters of books and of articles are not italicized; they are set off by quotation marks (see B.16.2).

B.11.2 Words being defined and words, letters, and figures when discussed as such (sometimes quotation marks are used).

- In this report *preschooler* will refer to a child between 3 and 5 years old.

B.11.3 Foreign words that have not been assimilated into English (a dictionary usually indicates foreign phrases that are italicized).

- *quid pro quo*

[Usage varies with "et al."; check a style guide.]

B.11.4 Scientific names of genera, subgenera, species, and subspecies (not the names of groups of higher rank than genera).

- *Liphyra brassolis*
- the family Leguminosae

B.12 Numbers

Technical writing frequently deals in quantitative concepts. Numbers and figures should be treated consistently.

B.12.1 A sentence should not start with a figure.

- *wrong*: 28 engineers worked on the project. [Write out *twenty-eight* or rephrase.]

B.12.2 Arabic numerals should be used for quantities greater than ten (there is some variation in this limitation).

- There were 1200 animals in this zoo, but only nine of them were monkeys.

B.12.3 Figures should be used to indicate two or more numbers in a series.

- She bought 6 oranges, 3 apples, and 15 peaches.

But if one figure follows another, one should be written out.

- He owned four 6-bedroom houses.

B.12.4 Approximations or indefinite measurements should usually be written out.

- He earned about fifty dollars a day.

B.12.5 Arabic numerals should be used in illustrations and tables no matter what quantities are expressed.

B.12.6 Figures that run into millions or over should generally be written out. Instead of $12,000,000, the sum should be written $12 million.

B.12.7 Numerals should be used for days but not months in dates and in decimals and percentages.

- 0.3 g
- May 16, 1977 [Do not abbreviate as 5/16/77 in a report.]
- They reported an incidence of 5 to 10%.

B.13 Parentheses

Parentheses () are used in the following instances:

B.13.1 To set off certain matters in bibliographical citations.

- *Manual of Professional Practice* (New York: Macmillan, 1973)

B.13.2 To set off parenthetical remarks or definitions within a sentence.

- This form of construction (poured concrete) is commonly used.
- Recent (1970-1976) journals . . . .

B.13.3 To set off bibliographical citations in reviews of literature.

- Jones (1918) first called attention to the problem.
- The problem was noticed early in the century (Jones, 1918).

B.13.4 To enclose the numerals in a numbered list when the list is within the lines of text and to enclose the numbers that designate equations (see B.14.4).

B.13.5 To direct the reader.

- The relationship is clear (see Fig. 1).

B.13.6 To identify the location of an institution, organization, or publication that includes a place name.

- Swarthmore (Pennsylvania) Sanitation Board

B.13.7 To enclose a translation.

B.13.8 To group mathematical expressions.

B.14 Period

B.14.1 A period indicates the end of a declarative or an imperative sentence.

B.14.2 No period is used after titles, headings on separate lines of type, headings in tables, or date lines in letters.

B.14.3 Abbreviations that might be confused with a word should be followed by a period (see B.1.3).

B.14.4 No period is used after items in an enumerated list unless the items are complete sentences. The last item of a vertically arranged list *is* followed by a period to complete the main sentence (see B.4.4.).

- The client's program required
  1. Efficient use of energy
  2. Maintenance-free materials
  3. Low long-term costs
  4. Easy access and use for the handicapped.

B.14.5 A period is used within parenthetical expressions only when the expression forms a complete sentence.

- Continued operation at 650°F is a sure route to failure. (Reference 5 provides a detailed discussion of this boundary condition.)

A period is placed outside the parenthesis in a sentence ending in a parenthesis.

- Temperature is critical (Fig. 1).
- The investigation was inconclusive (Adams, 1977).

B.15 Question Mark

A question mark terminates an interrogatory sentence.

- Did the soil test prove anything?

B.16 Quotation Marks

B.16.1 Quotation marks indicate material derived from another source.

- He stated, "The level of pollution is undesirable."

In American English double marks (") are used for quotations and single marks (') for quotations within quotations.

- Jones noted that "the results formerly called 'spurious' are now enshrined as laws."

The British reverse this pattern and use single marks first and double marks for material quoted within quotations. An omission in quoted material is shown by ellipsis points (see B.8).

B.16.2 The placement of punctuation marks with quotation marks frequently causes problems for the writer and typist. The rules are simple and should be learned and followed consistently:

1. Periods and commas belong *within* quotation marks, even though they are not part of the material being quoted.

- The pesticide, Dr. Breen insisted, is "a contaminant that will upset the entire ecology of this region."
- Dr. Breen labeled the pesticide a "contaminant," but other researchers found it harmless.

2. Question marks, exclamation marks, semicolons, and colons belong *outside* quotation marks except when they appear in the quotation itself.

- The experiment was called a "disaster"; still, we think we learned from it.

3. If a quotation extends over more than one paragraph, each paragraph should begin with a quotation mark; the quotation is closed with a quotation mark at the end of the last paragraph only.

B.16.3 Quotation marks enclose titles of radio and television programs, movies, songs, and parts of published works (articles and chapters of books) (see B.11.1).

B.16.4 Quotation marks rather than italics (see B.11.2) are sometimes used to call attention to a word being defined or being introduced as a new term. They also indicate terms being used in an unusual sense or context. The marks are needed only the first time the word appears.

- In this report "preschooler" will refer to a child between 3 and 5 years old.

Such a device should not be overused; otherwise, it becomes annoying. The marks may indicate an author either unwilling to take responsibility for the words he uses or deliberately trying to drag in colloquial or otherwise inappropriate language.

- *poor*: Nuclear power, with its attendant technological and biological risks, is so critical that to have a "bust" is immoral.

B.17 Semicolon

B.17.1 A semicolon separates two independent clauses in a compound sentence when no connective word is used (see A.3).

- This method of accounting proved satisfactory; the year-end results were widely approved.

B.17.2 A semicolon is used between main clauses joined by a conjunctive adverb.

B.17.3 A semicolon separates elements in a list when there is punctuation within the elements.

- Three chemicals were investigated: butadiene, which is used in synthetic rubber; cyclohexane, a constituent of nylon; and hydroxydimethyl oxide.

B.17.4 A semicolon is *never* used after the greeting in a letter.

- *right*: Dear Professor Staehle:
- *right*: Dear Roger,

C. Frequently Misused Words

Chapter 4 discusses the need for precise and appropriate words. Because technical terms have no real synonyms, a writer ought not to be afraid of some repetition. An alternative term may introduce a more or less different meaning—with confusing results for the reader.

This section deals with words frequently misused in technical and scientific reports. Unconscious humor may result when a writer uses the wrong term:

- Fortunately, each aspect of my topic has been *smothered* by recent technical journals. [The student meant *covered*, although the other is a real possibility.]

More significantly, the wrong term can confuse the reader.

- One of the more *visual* problems that has emerged from the Arab oil embargo is our dependence on particular sources of energy. [The writer probably means *obvious* or *visible*, but the statement is unclear.]

The writer should maintain the same meaning of a word within a sentence or section of a report.

- A system in which oil is injected near the pump inlet is effective where the cold *fluid* is reasonably *fluid* and can flow or be drawn to the region of the pump inlet without being warmed. [The first *fluid* is merely a synonym for *oil*; the second refers to a property of the oil.]

- Thus the matrix *effect* is, in *effect*, bypassed.

The following list is intended to clarify the differences in meaning of words that are often confused with each other.

Adapt/Adopt/Adept

Adapt means to modify: "We adapted the engine to fit our needs."

Adopt means to take over: "We adopted their methodology."

Adept, an adjective, means skillful: "He is adept at calculating the ratios."

The sentence

He is adept at adopting and adapting others' research methods.

means that he is skillful at taking over and modifying the techniques of others.

Advice/Advise/Inform

Advice is a noun meaning a suggestion.

Advise is a verb meaning suggest.

Inform is a verb meaning tell.

- We want to inform management that we took the advice of the engineer, although the supervisor advised us not to do so.

Affect/Effect

Affect is most often used as a verb meaning to influence: "Temperature *affects* ductility."

Effect is ordinarily a noun: "Temperature has a critical *effect* on ductility."

Affect is used as a noun in psychology and psychiatry to mean the feeling accompanying an idea. It is a generic term for feeling, emotion, or mood.
Effect can be used as a verb meaning bring about, cause to occur, or produce as a result: "He *effected* a change in the plan."

Allusion/Illusion

An *allusion* is a reference to something: "He made an *allusion* to earlier work in the field."
An *illusion* is a false image: "He entertained the *illusion* that he could complete the job quickly."

Alternate/Alternative

Alternate as an adjective means either occurring by turns or every other one; the adjective *alternative* means available as a substitute.

- The committee will meet on alternate Tuesdays for the next three months.
- As the bridge was closed, we had to find an alternative route.

Among/Between

Among implies more than two objects or persons.
Between is used for only two.

- Little distinction could be made among the three candidates.
- We must choose among four possibilities.
- The difference between them [must be two] is great.

Assure/Ensure/Insure

Assure means to guarantee, to make every effort to do something or avoid something: "I can *assure* you that we took every precaution in this test."
Assure refers to persons.
Insure or *ensure* means to try to make secure: "We *insured* against failure by running every known test."
The meanings appear to overlap in some cases: "Quality was *assured* by careful scrutiny" differs almost imperceptibly from "quality was *insured* [or *ensured*] by careful scrutiny."

Case

Case is frequently overused in technical writing. Phrases containing it contribute to jargon. Often, a more direct statement can be made, with increased precision.

- *poor*: In the specific case of fuel being injected into a combustion chamber by an atomizer, the result is significantly better.
- *better*: When fuel is injected into a combustion chamber. . . .

- *poor*: In most cases these units are components of the total waste management system.
- *better*: Most of these units are components of the total waste management system.

Frequently, the expression in brackets can be substituted for that on the left.

- In case [If]
- In many cases [Often]
- In this case [Here]
- In all cases [Always; All]
- In the case of motors we [For motors we]
- In the case of gases this does not apply. [This does not apply to gases.]

The word *case* can be used accurately to indicate a medical or legal problem. But in other contexts it should be avoided.

Cite/Sight/Site

Cite is a verb: "He *cited* sufficient evidence to persuade us."
Sight is a verb or a noun referring to vision: "We *sighted* the craft 3 miles out." "His *sight* is excellent."
Site is a noun: "The *site* for the building was well chosen." (It is sometimes used as a verb meaning to place or locate: "The house was sited to match the topography.")

Complement/Compliment

A *complement* is something that completes; it is necessary to make the thing whole. It implies harmony or mutual compatibility: "Grover's work on bears *complemented* Kermit's on humans."
A *compliment* is an expression of praise: "They *complimented* us on the project."

Continuous/Continual

Continuous means without interruption; *continual* means steady but with brief interruption.

- They worked continuously. [They did not stop.]
- They worked continually. [They worked steadily but stopped briefly.]

Continuous action is unceasing action; *continual* action is steady but liable to occasional pause.

Criterion/Criteria

Criterion is singular; *criteria*, plural. A criterion is a rule or test by which something may be judged; criteria are a number of these rules.

- We have one criterion by which to judge the results.
- The criteria used in this report are well known to all scientists.

Data/Datum

Data is a plural and requires a plural verb: "The data are. . . ." *Datum*, rarely used, is a singular. Some authorities now accept *data* as a singular collective, but in the absence of specific instructions to make it a singular the writer should regard it as a plural.

Due to the Fact That

This phrase can always be shortened at least to *due to*, although *due to* often reaches epidemic proportions in technical reports. Often, *because* is more precise. Reserve *due to* for use only after forms of the verb *to be*.

- Because of turbulence, the plane could not land.
- The delay in landing was due to turbulence.

Etc.

Etc. is the abbreviation for the Latin *et cetera*, meaning "and so forth." It should be avoided in technical reports because it often reveals an author who is too lazy (or uninformed) to complete the series. Instead, use an introductory phrase (*such as, for example*) to indicate that a selected list follows—or, better, use specifics. But if *etc.* must be used, remember that no *and* should precede it—that would be redundant.

Factor

Factor, a word borrowed from mathematics, is a catchall. Whenever possible, a more specific word should be substituted.

- *poor*: My purpose is to find the factors that cause yellowing in Mylar.
- *better*: My purpose is to find the major causes for yellowing in Mylar.

- *poor*: The Factors for Estimating the Cost of School Buildings and the Importance of Insulation
- *better*: The Importance of Insulation to Costs in Heating School Buildings

Farther/Further

Farther refers to physical distance: "The plant is now *farther* away." *Further* refers to an abstract conception (like time): "We were even *further* away from our conclusions."

Fewer/Less

Fewer refers to numbers, *less* to amount or degree.

- Fewer words should be used.
- The farmer marketed less produce than he did last year.

- He has fewer scruples than I thought.
- He has less integrity than I thought.

Hopefully

Hopefully is currently number one on many editors' lists of misused adverbs. It is often attributed wrongly to actors incapable of hoping. It is now a vogue word adapted from the German adverb *hoffentlich* that affirms the desirability of something that may not occur. In English it should be translated as "it is to be hoped that" or "we hope."

- *wrong*: Hopefully the plane will clear the fence.
- *right*: [the plane can't hope] We hope the plane will clear the fence.

Imply/Infer; Implication/Inference

To *imply* is to suggest; to *infer* is to reach a conclusion from evidence. A writer *implies*; a reader *infers*.

- *right*: You implied that the research design was faulty.
- *right*: They inferred from our conclusions that more research was necessary.

An *implication* is thus something given; an *inference* is something taken.

- *right*: The implication was clear.
- *right*: No inference was drawn.

It's/Its

It's is the contraction for *it is*: "*It's* a difficult experiment" means "it is a difficult experiment." *Its* is the possessive form of the pronoun *it*: "*Its* top was loose" means that the top of the item (the antecedent for the pronoun *it*) was loose.

-ize

The suffix *-ize* is properly applied to a few words (*minimize*, *materialize*). But in the attempt at elegance that often ends up in jargon a writer sometimes uses it to create new words (neologisms) where standard ones would be more precise and simpler (see also *-wise*). For example: *legitimate* becomes *legitimize* or *legitimatize* and *use* becomes *utilize*; finish becomes *finalize*, which could mean many things.

Like/As

Like is a preposition; *as* is a conjunction. *Like* is used with a noun or pronoun that is not followed by a verb.

- *right*: It looked like a new element.
  As is used before phrases and clauses:
- *right*: The chemicals reacted as we expected them to.
- *right*: The chemicals, as we expected, exploded.

When the verb is omitted in an elliptical construction, *like* is ordinarily used in place of *as*, although the latter would appear if the verb were used.

- *right*: He takes to it like a duck to water.
- *right*: He takes to it as a duck would to water.

Only

The adverb *only* is a slippery commodity; the meaning of a sentence can change radically when *only* moves around.

- John only calculated the risks.
- Only John calculated the risks.
- John calculated only the risks.

Like any other modifier, it should be placed next to the word it modifies.

Per cent/Percentage

Per cent is a noun meaning "hundredths of." It is used only after figures.
Percentage is a noun meaning a "given part or amount in every hundred." It is not used after a figure.

- More than 90 per cent of the population voted for him.
- The great percentage of people trust physicians.

Person/People; Personnel/Personal

A *person* is a singular human being. *People*, a collective noun, refers to a national or ethnic group. *Personnel* are the persons working for a given organization at a given time.

- *right*: Three persons attended. [not people]
- *right*: The American people are aware of the problem.
- *right*: Our personnel are highly qualified.

Note that *people* is not the plural of *person*.
Personal is an adjective meaning one's own.

- *right*: This is my personal property.

Phenomenon/Phenomena

Phenomenon is singular: "This *phenomenon* is difficult to explain." *Phenomena* is plural: "These *phenomena* explain the basis for the theory."

Precede/Proceed/Procedure

Precede is a verb meaning to go before.
Proceed means to go forward or take action. It should be noted that the noun form of *proceed* is spelled *procedure*.

- Outlines precede an effective report.
- The engineer proceeded to make a literature survey.
- The procedure in testing was somewhat superficial.

Principal/Principle

Principal, used as a noun, has two meanings: (1) money on which interest is paid or earned; (2) the supervisor of a school. As an adjective, *principal* means primary or most important.

The noun *principle* refers to a tenet or belief: "A *principle* of law was at stake."

Quality

Quality is a noun; it should not be used as an adjective.

- *wrong*: We want a quality environment.
- *right*: We want an environment of the best quality. [Or, better, define what *quality* means.]
- *wrong*: quality forest
- *right*: forest of good quality

Reason Is Because

The phrase is an obvious redundancy. It means the reason is that the reason is. Use "the reason is that" (or simply "because").

- *wrong*: The reason is because the evidence does not support the conclusion.
- *right*: The reason is that the evidence does not support the conclusion.

Respectfully/Respectively

Both words are adverbs. *Respectfully* denotes a feeling one has for another. *Respectively* means singly in the order designated. The two words should not be confused in the complimentary close of a letter (see p. 346).

Type

Type is a word often used to postpone or stretch information. Frequently, it can simply be eliminated from a sentence.

- An example of a general ~~type of~~ magazine is *Popular Science*.
- The article never lists references together in any ~~type of~~ order, but mentions the source in the text.
- Rock, gravel, or any other coarse ~~type of~~ substrate. . . .

Using/Use/Utilize

Forms of the verb *to use* grow wild in most technical writing. Whenever possible, the writer should select another—perhaps more precise—term. An easy (but false) way both students and professionals solve the *use* problem is with *utilize*. These terms are roughly synonymous, although various authorities ascribe to them various connotations. *Utilize* is really just jargon for *use*—another *-ize* word introduced for elegant variation. Avoid it (and also avoid *employ*). Whenever possible, *with* should replace *using*, and sentence structure should be adjusted to eliminate extra *use*'s.

- *poor*: The alternative to using multiplexing is to use a separate communication line for each unit.
- *better*: The alternative to multiplexing is a separate communication line for each unit.

- *poor*: Using an axe he chopped down the cherry tree.
- *better*: He chopped down the cherry tree with an axe.

-wise

Words coined by adding the suffix *-wise* should always be suspect: "*Moneywise*, it was expensive" means simply "it was expensive." "*Workwise*, we had a busy day" means "we were busy at work." "*Jobwise*, the prospects are dim" means "I don't have [can't get?] a job."-Wise words are offensive to both logic and the ear.

poor: Angel fish are nearly impossible to distinguish sexwise.
better: It's hard to determine the sex of angel fish.

How to Document an Article or a Report

Acknowledging Sources

In reports, proposals, journal articles, and student papers, original materials and interpretations are balanced against evidence drawn from published sources. Writers cite authorities to bolster a line of reasoning and to show that their thinking is informed and up to date. All proprietary information—the special property of one researcher or shared by only a few researchers—requires referencing: direct quotations, opinions and predictions, statistics not derived by the writer, visuals not drawn by the writer, original theories, case studies, and unique research procedures. To fail to acknowledge sources is dishonest and illegal. But more than a matter of basic courtesy and professional honesty, such acknowledgment provides the credentials for the information presented. Anonymous information is useless in science and engineering; information can be considered reliable only if it can be tested. The person who is responsible for it, the conditions under which it was developed, and the context for its interpretation must all be known.

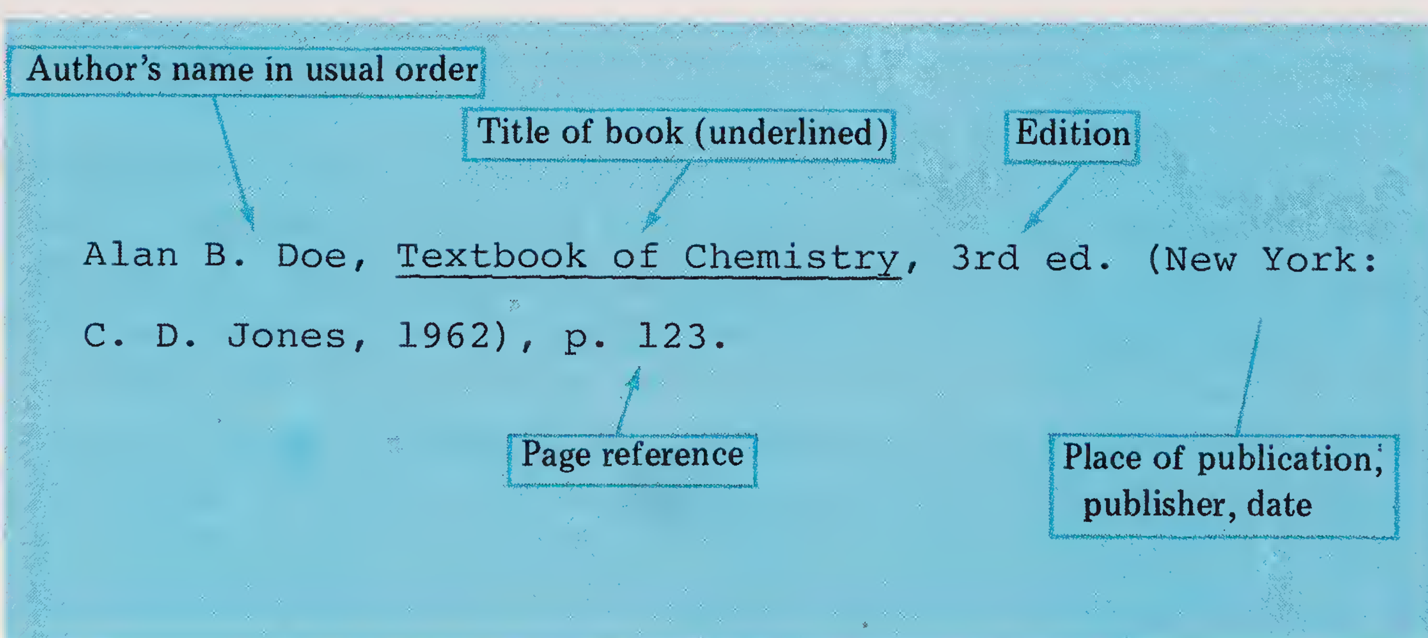
Showing (and sometimes even remembering) where things came from often troubles both student and professional writers. But a little attention can make the job routine—and easy. In technical discussions, which may be derived largely from published sources, a shorthand system is used to keep the mechanics of documentation from interfering with the readability of the text. Part of a writer's confusion in dealing with documentation can be traced to the large number of systems in use. Style does vary from college department to college department, from organization to organization, from journal to journal; the writer simply has to follow the directions the receiver of the report gives him. It may help the writer to overcome the surface difficulties of documentation if he keeps in mind the basic distinction among notes, references keyed to a list of sources given at the end of an article or report, and bibliographies.

NOTES

In a note system, an arabic numeral placed above the line of type refers the reader to a similarly numbered note at the bottom of the page (footnotes) or collected in a list at the end of the document (end notes). Scholars in the humanities and some social sciences as well as in chemistry and physics use such notes. The note may contain a citation for the source of the material presented in the text. The citation may be complete, or may be abbreviated if the article or report also contains a bibliography (see later discussion). Figure A-1 shows sample notes. The note may also clarify or otherwise comment on the text. It may explain a statement, define a term, discuss a dissenting opinion, or indicate a simplified method of referencing used in the text. Content notes are useful in subordinating material, but like all notes they cause an interruption in the reading and should be used sparingly. Some journals will not accept them. Content notes sometimes merely record the afterthoughts of a writer who carelessly tucks important matters into the notes that should have been included in the text (perhaps in parentheses if the material is of secondary importance).

Figure A-1. Sample notes.

BOOK



REPORT

Author's name in usual order

Title of report (underlined)

V. M. Pings, Interlibrary Loan: A Review of Library Literature 1876-1965, Wayne State University School of Medicine Library Report No. 23, Detroit 1966.

Name of organization issuing report and report number as given (if any)

Place and date of publication

DISSERTATION (UNPUBLISHED)

Author's name in usual order

Title (in quotation marks)

Eric Wordsmith, "Testing for Readability in the Published Prose of Engineering Professors: A Study and Bibliographical Guide," Diss., State University of New York at Buffalo, 1975, pp. 28-42.

University where dissertation submitted

Indication of dissertation

Page references

JOURNAL ARTICLE (SINGLE AUTHOR)

Author's name in usual order

Title of article (in quotation marks)

John Cairns, "The Cancer Problem," Scientific American, 233 (November 1975), 65.

Volume number

Date

Page reference

Title of journal (underlined)

JOURNAL ARTICLE (JOINT AUTHORS)

Authors' names in usual order and as given on first page

Robert A. Rapp, Andre Ezis, and Gregory J. Yurek, "Displacement Reactions in the Solid State," Metallurgical Transactions, 4 (1973), 1283-1292.

Title of article (in quotation marks) | Volume number | Year | Page references (here the whole article is cited) | Title of journal

PAPER IN A PROCEEDINGS

Author's name in usual order | Title (in quotation marks)

Dolores Landreman, "Selling in Technical Communications--The Mark of the Professional Editor," Proceedings of the 22nd International Technical Communication Conference (Washington, D.C.: Society for Technical Communication, 1975), pp. 380-384.

Title of proceedings* (underlined) | Place of publication, publisher, date | Page references

*There is no established standard concerning whether the entire title or merely *Proceedings* should be underlined. The student should follow the practice recommended in the journal to which he is contributing. The above title might be printed thus: *Proceedings of the 22nd International Technical Communication Conference*.

REFERENCES

In a footnote system, the superscript numerals merely refer the reader to another location where information is presented. In a reference (or cross-reference) system, numerals (either superscripts or in parentheses or brackets on the line of type) stand for the writer's sources. Sources are listed at the end of the article or report and arranged alphabetically without numbering, or numbered consecutively. Numbered lists are in alphabetical order according to author or are in order of mention in the text. The list is headed "Literature Cited," "References," "Works Cited," "References Cited," or some similar title. If an unnumbered reference list is used, then within the text the researcher's name or the statement documented is followed by the year of publication in parentheses in the former case or both the researcher's name and the year in the latter. If the references section is numbered, then the researcher's name or the statement documented is followed by the reference number or numbers. Reference numbers (unlike note numbers) may be grouped to show that several authorities support one statement. The same source always bears the same number. Figure A-2 gives one journal's specific instructions for styling of a numbered reference system.

STYLING OF REFERENCES

1. References to the technical literature (described as readily available on subscription and included in most library collections) will be made by author and journal reference (with title of article omitted) as shown by the following example. Journal abbreviations will be those used in the current listing of *Chemical Abstracts Service Source Index Quarterly.*
   Example: Author: Journal, year, ser., vol., pp.
   J. P. Hirth and M. Cohen: *Met. Trans.*, 1970, vol. 1, pp. 3-8.
2. References to books will include the title and pages within the book.
   Example: Author: *Book*, edition, vol., page, publisher, place, date.
   M. Hansen: *Constitution of Binary Alloys,* 2nd ed., p. 1262, McGraw-Hill Book Co., New York, 1958.
3. A "private communication" or "unpublished research" may be referenced when required to give proper credit. The citation must include the affiliation and address of the person involved.
   Example: J. J. Doe: AAA Company, Washington, D.C., unpublished research, 1970.
4. References to internal reports and other publications of limited availability* are not desirable. However, they will be permitted when the use results in a saving of page space or is required for proper recognition. In these matters the author's judgment must be supported by the review committee and editor. The report should be available on request.
   Example: J. J. Doe: Report No. 738, AAA Company, Washington, D.C., January 1970.
5. "In press" references must include the name of the journal. Balance of reference should be supplied when available. This may also be done on the proofs.
6. References such as "submitted for publication" and "to be published" are not acceptable.
7. No other references will be published.

*Not available by subscription.

Figure A-2. Instructions for a references section. (From *Metallurgical Transactions.* Copyright American Society for Metals, 1977.)

Natural resources (including forestry and wildlife management), biology, and psychology journals use the unnumbered style for references, with the author's last name and year of publication cited in the text, and a list of sources, usually in alphabetical order, included at the end of each article. The first item in the references section is the author's name; the second is the year of publication. These are followed by the title and other publication data. If the author's name is relevant to the discussion, it is mentioned in the text, outside the parentheses that enclose the date. If the finding rather than the author is to be stressed, both name and date are placed in parentheses, usually at the end of the relevant sentence. A page citation may also be included within the parentheses.

> Bellnose et al. (1972) report that wood ducks were once abundant in Illinois.
>
> Wood ducks were once abundant in Illinois (Bellnose et al., 1972:37; Smith, 1974:255).

One advantage of this system is that it shows immediately in the text the authority behind a statement and the currency of the information. It also allows for easy inclusion of specific page numbers, an element of precision much desired by readers but often omitted in citations in scientific journals.

BIBLIOGRAPHIES

A bibliography is a list, in alphabetical order, of all the sources that the writer consulted in preparing his report, whether or not referenced in the report. Bibliographies are rarely necessary in journal articles, but students may find that both a reference section and a bibliography are required with their reports, to satisfy the instructor that a thorough literature search has been made. One standard form for setting up a bibliography is illustrated in Appendix B.

Students should also be aware of a special kind of bibliography called an annotated bibliography. It may be submitted in advance of or along with a final report. An annotation is a critical and evaluative statement about a document (see Chapter 3). It assesses the reliability of the book, article, or report and discusses its significance and importance for a potential user. It may discuss the author's credentials, the subject and purpose of the work, its format, and any errors, weaknesses, or strengths. Some annotations are written in full sentences, but this practice is not always followed.

Here is an example from a student report. The bibliographical citation is given first and then the annotation:

Beckerley, J. G. *Safety Aspects of Nuclear Reactors* (Princeton, N.J.: Van Nostrand Co., 1957). Beckerley, former Director of Classification of the Atomic Energy Commission, has written several books on nuclear energy, all of which are cited by leading researchers as excellent references. This book, a collection of papers presented at the first International Conference on Atomic Power at Geneva (1955), is a well-organized work that serves as a reference for anyone seeking guidance about the safety of reactors. It is geared to readers with a background in nuclear engineering, but each chapter begins with general information that could interest a lay reader. This book provided me with much of the information I used in my report. Although it was published in 1957, its information is still reliable and useful.

Here is an example from a professional newsletter that includes annotated bibliographies every month under the heading "Readings":

The Poverty of Power: Energy and the Economic Crisis. Barry Commoner. Knopf. $10.

The concerned citizen must be wary when reading books like this. Commoner's use of data to support his notion that we have 50 or 60 years for developing renewable energy supplies to supplant oil has already been attacked vigorously by M. King Hubbert, a respected analyst of the fossil fuel supply. Federal Energy Administration Circular 725 (1975), which was available to Commoner, estimates the domestic oil at less than half of the figure in this book, denying us adequate time for large-scale deployment of any system not ready-to-go today. The book contains a simply- and well-presented thermodynamics lesson, applied to show how poorly we match energy-producing machines to the tasks we set them and how costly is this flouting of the Second Law. Commoner argues that the U.S. economic system submerges any prospect for rational use of resources and he advocates a move toward socialism but does not analyze the performance of other systems.*

Varieties of Style

The arrangement of elements within a citation, as well as punctuation, abbreviations, and capitalization, varies widely among publications and organizations. Some journals (like *Science*) combine notes and references. Some accommodate footnotes to the text, separate from the references section, by using the asterisk (*), dagger (†), double dagger (‡), or superscript letters. All citations should be

*Reprinted from *The Key Reporter*, Volume XII, No. 4, Summer, 1976, p. 5. Used by permission of Ronald Geballe.

accurate, brief, and complete. The style should be consistent within one publication or within the reports put out by a particular organization. Several useful style guides are listed in Appendix B. The author should use the guide—or the special instructions—suggested by whoever is to receive his manuscript.

Whatever the style, the chief purpose of documentation remains the same: (1) to back up the writer's assertions, (2) to show where the information came from, and (3) to enable the reader to locate the original source. Documentation is not something tacked on at the end. It should be on the writer's mind as he gathers material, draws up an outline, and writes his report.

Selected Sources on Scientific and Technical Writing

I. General Guides to Scientific and Technical Research and Writing

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Barzun, Jacques. *Simple and Direct: A Rhetoric for Writers.* New York: Harper & Row, 1975.

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Zinsser, William. *On Writing Well: An Informal Guide to Writing Nonfiction.* New York: Harper & Row, 1976.

II. Representative Style Manuals

American Chemical Society. *Handbook for Authors.* Washington, D.C.: American Chemical Society, 1967.

American Institute of Physics. *Style Manual*, rev. ed. New York: American Institute of Physics, 1973.

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Entries in italics refer to the Handbook.

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