A GUIDE TO WRITING AS AN ENGINEER

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Transmittal letter
Covers and label
Title page
Table of contents
List of figures
Executive summary
Introduction
Body of the report
Appendixes (including references)

The following sections guide you through each of these standard sections, pointing out the key features. As you read and use these guidelines, remember that these are guidelines, not iron-clad laws. The standard for engineering reports is not intended as a straitjacket, but as a focal point to enable writers in the profession to maintain a familiar "look and feel" to their documents. You'll notice in your career that different companies, professions, and organizations have their own standards for reports—you'll need to adapt your practice to these as well.

LETTER OF TRANSMITTAL

The transmittal letter is a cover letter. An example is shown in Figure 6-1. Usually, it is attached to the outside of the report with a paper clip. It is a communication from you—the report writer—to the recipient, the person who requested the report and (who knows?) may be paying you for your expert consultation. Basically, it says "Okay, here's the report that we agreed I'd complete by such-and-such a date. Briefly, it contains this and that, but does not cover this or that. Let me know if it is acceptable."

The transmittal letter explains the context—the events that brought the report about. It contains information *about* the report that does not belong *in* the report.

In Figure 6-1, notice the standard business-letter format. If you write a report internally, you'll use the memorandum format instead; in either case, the contents and organization will be the same. Notice the contents of the letter:

- The first paragraph cites the name of the report, putting it in italics (if italics is available), underscores, or all caps. It also mentions the date of the agreement to write the report.
- The middle paragraph focuses on the purpose of the report and gives a brief overview of its contents.

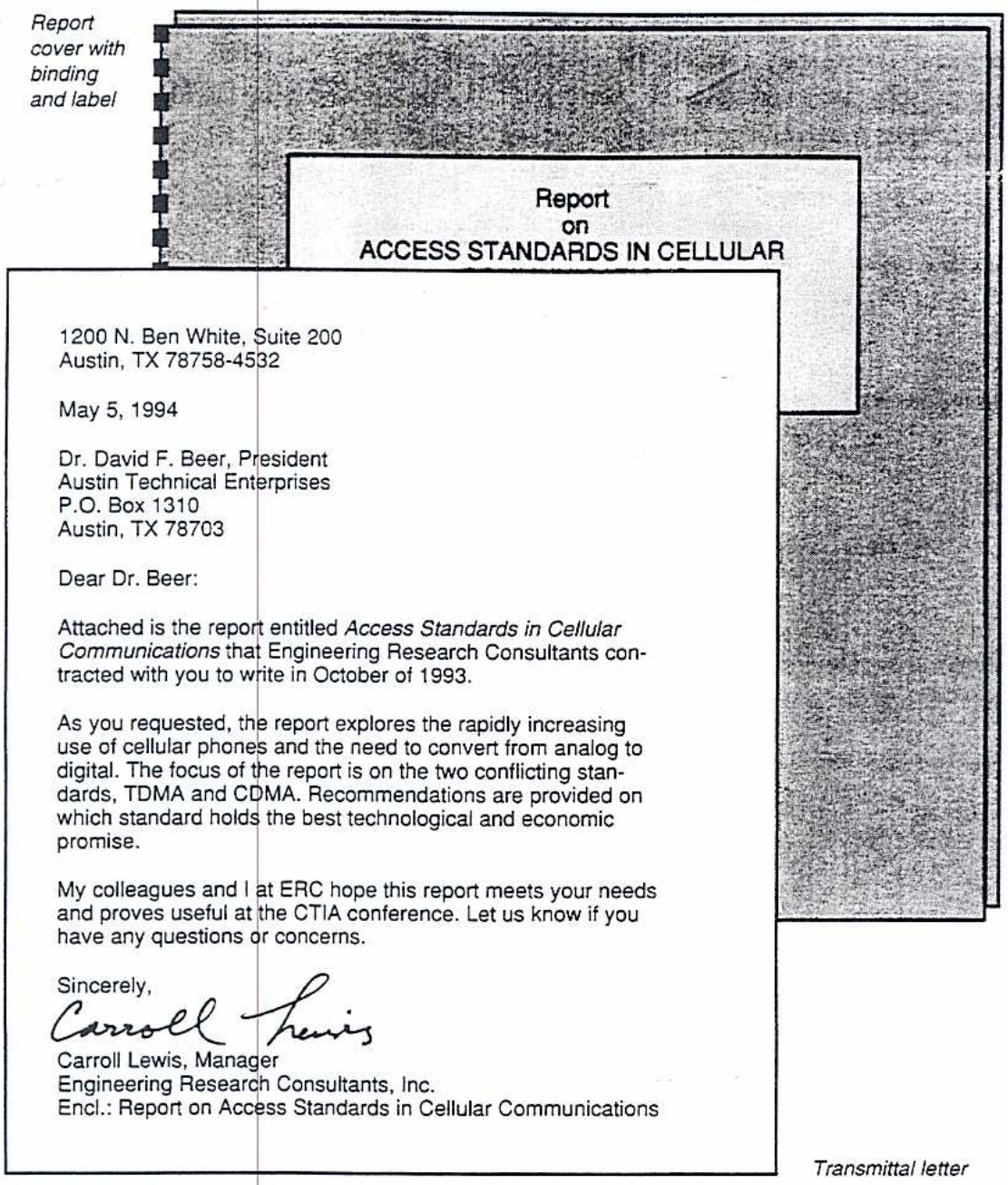

Figure 6-1 A cover letter and bound report with label on the front cover. Normally the transmittal letter is paperclipped to the front cover of the report.[8]

- The final paragraph encourages the reader to get in touch if there are questions, comments, or concerns. It closes with a gesture of good will, expressing hope that the reader finds the report satisfactory.

[8] Example material drawn from work done by Eric Manna and Jiandong Zhu, engineering students, University of Texas at Austin, 4 May, 1994.

Of course, the contents of this letter, as with any other element in an engineering report, may need to be modified for specific situations. For example, you might want to add another paragraph, listing questions you'd like readers to consider as they review the report.

COVER AND LABEL

If your report is over ten pages, you'll want to bind it in some way and create a label for the cover.

Covers

Good covers give reports a solid, professional look as well as protecting them. There are many types of covers you can use. When you go to the stationery store, keep these tips in mind:

- Totally unacceptable are the clear (or colored) plastic slip cases with the plastic sleeve on the left edge. These are like something out of freshman English; plus they are aggravating to use—readers must struggle to keep them open and hassle with the static electricity they generate.
- Marginally acceptable are the kinds of covers for which you punch holes in the pages of your report, load your pages in, and then bend down the brads. These work, but remember to leave an extra half-inch margin on the left edge to keep readers from having to pry your report apart to read it. Also, these kinds of covers typically do not lie flat; they force readers to grab for any available object or use various body parts to keep the pages weighted down.
- By far the most preferable covers are those that allow reports to lie open by themselves. It's a great relief for a report to lie open in your lap or on your desk. Check with your local copy shop or stationery store; these sorts of bindings are inexpensive. Most of them use a plastic spiral for the binding and thick, card-stock paper that comes in a range of colors for the covers.
- Generally less preferable are loose-leaf notebooks, or ring binders. These are too bulky for short reports. Of course, the ring binder makes changing pages easy; if that's how your report will be used, then it's a good choice. Otherwise, it's a nuisance; it's bulky; and the page holes tend to tear.
- At the "high end" are those overly fancy covers with their leatherette look and gold-colored trim. Avoid them. Keep it plain, simple, and functional.

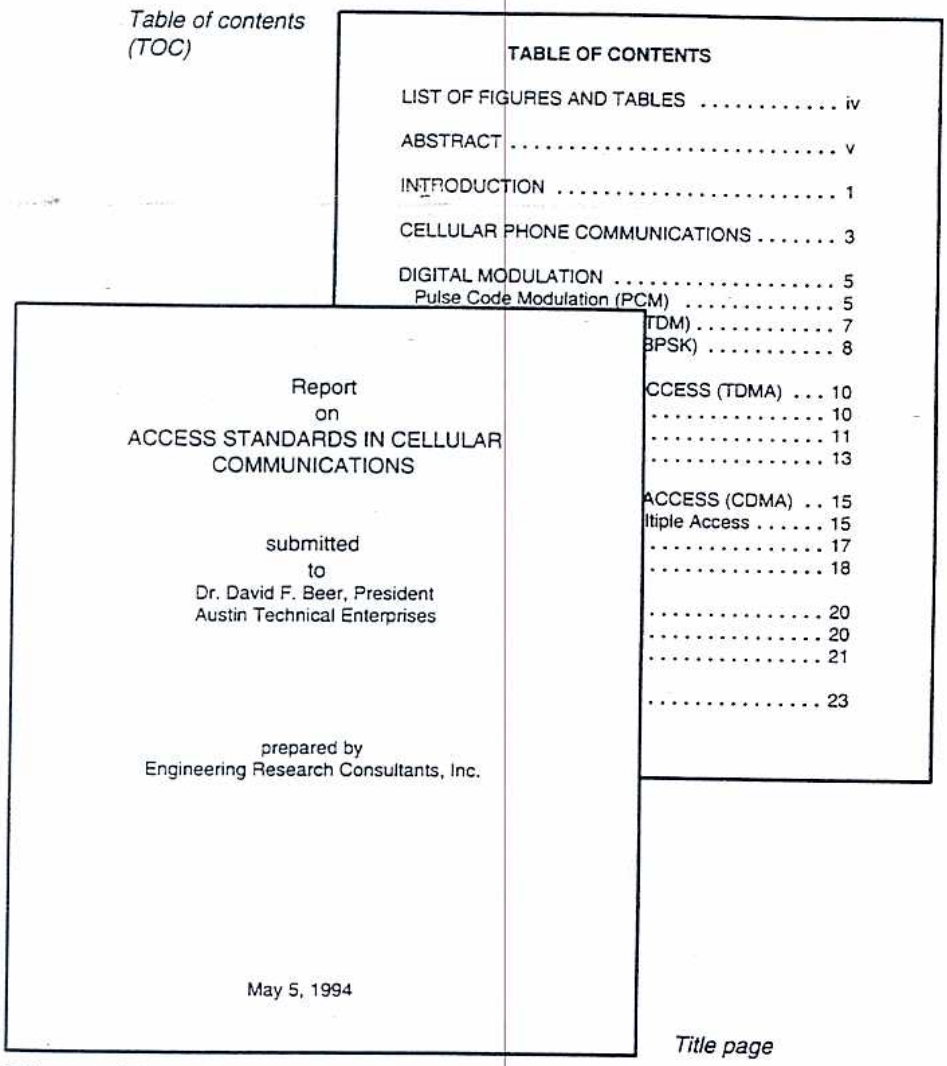

Figure 6-2 A title page and table of contents from an engineering report. (Some reports include a descriptive abstract at the bottom of the title page.)

length of the page.

ABSTRACT AND EXECUTIVE SUMMARY

Most engineering reports contain at least one abstract—sometimes two—in which case the abstracts play slightly different roles. Abstracts summarize the contents of a report, but the different types do so in different ways.

One common type of abstract is the *descriptive* abstract. It provides an over-

be read rather quickly.

If the executive summary, the introduction, and the transmittal letter strike you as repetitive, remember that readers don't necessarily start at the beginning of a report and read page by page to the end. They skip around: They may scan the table of contents to get a sense of the contents; they usually skim the executive summary for key facts and conclusions. They may read carefully only a section or two from the body of the report, and then skip the rest. For these reasons, reports are designed with some apparent duplication so that readers will be sure to see the important information no matter where they dip into the report.

TABLE OF CONTENTS

You're familiar with tables of contents (TOC) but may never have stopped to look at their design. A TOC shows readers the page number on which each of the major sections and subsections in the report starts. A TOC also shows readers what topics are covered in the report and how those topics are discussed (in other words, the subtopics).

In creating a TOC, you have a number of design decisions. One of the most important is how many of the headings and subheadings to include. The TOC is a collection point for the section titles and the headings and subheadings occurring within those sections. In longer reports, you may not want to include all of the lower-level headings because they would make the TOC long and unwieldy. The TOC should provide an at-a-glance way of finding needed information quickly.

Critical to a TOC is indentation, spacing, and capitalization. Notice in the example TOC in Figure 6-2 that the first-level sections are all aligned with each other; the second-level sections aligned with each other; and so on. Notice that page numbers are right-aligned with each other so that the last digit in a number is always in the same column. Notice also how capitalization is handled: Main chapters or sections are all caps; first-level headings are headline caps. If there were lower-level sections, they would use sentence-style caps.

Vertical spacing in a TOC is another design variable. Your goal is to spread the TOC nicely out on the page and to avoid just two or three lines of it spilling over to the next page. You can play with the spacing between lines to make this come out right, but keep it consistent. Make sure the spacing between headings of the same type is consistent.

One final note: Make sure the words in the TOC are the same as they are in the text. As you write and revise, you might change some of the headings—don't forget to go back and change the TOC accordingly.

LIST OF FIGURES AND TABLES

The list of figures has many of the same design considerations that the table of contents does. With the list of figures, the idea is to enable readers to find the illustrations, diagrams, tables, and charts in your report. The title shown in the list of figures is often shorter than it is in the actual text where the figure occurs. In the figure list, it's a good practice to shorten long figure titles to something complete and meaningful that readers can scan quickly.

Some complications arise when you have both tables and figures. Strictly speaking, *figures* are any illustration, drawing, photograph, graph, or chart. *Tables* are rows and columns of words and numbers and are not normally considered figures.

For longer reports that contain half a dozen or more of both figures *and* tables, you can create separate lists of figures and tables. Put them together on the same page if they fit, as shown in Figure 6-3. You can combine the two lists under the heading, "List of Figures and Tables," as in the figure.

INTRODUCTION

An essential element of any report is its introduction—make sure you are clear on its real purpose and contents. In an engineering report, the introduction prepares the reader to read the main body of the report. It does not dive into the technical subject, although it may provide a bit of theoretical or historical background. Instead, introductions indicate or discuss the following (but not necessarily in this order):

- Specific topic of the report (indicated somewhere in the first paragraph)
- Intended audience of the report; the knowledge or background that readers need to understand the report
- Situation that brought about the need for the report
- Purpose of the report—what it is intended to accomplish (as well as what it specifically does not intend to accomplish)
- Contents of the report—usually a numbered list of the key topics covered
- Scope of the report—what the report does not cover
- Background (such as concepts, definitions, history, statistics)—just enough to get readers interested, just enough to enable them to understand the context.

A common problem in writing introductions occurs when the discussion of background gets out of hand and runs on for several pages. For a typical twenty-page report, for example, the introduction shouldn't be too long—no more than two pages. You may view introductions as the place for discussing background. Ordinarily, that's not the case—the introduction prepares readers to read the report; it "introduces" them to the report. If there is just too much background to cover, move it to a section of its own, either just after the introduction or into an appendix.

Take a moment to look at the introduction in Figure 6-4. Notice how it handles the items in the preceding list. For some elements, the wording is straight-

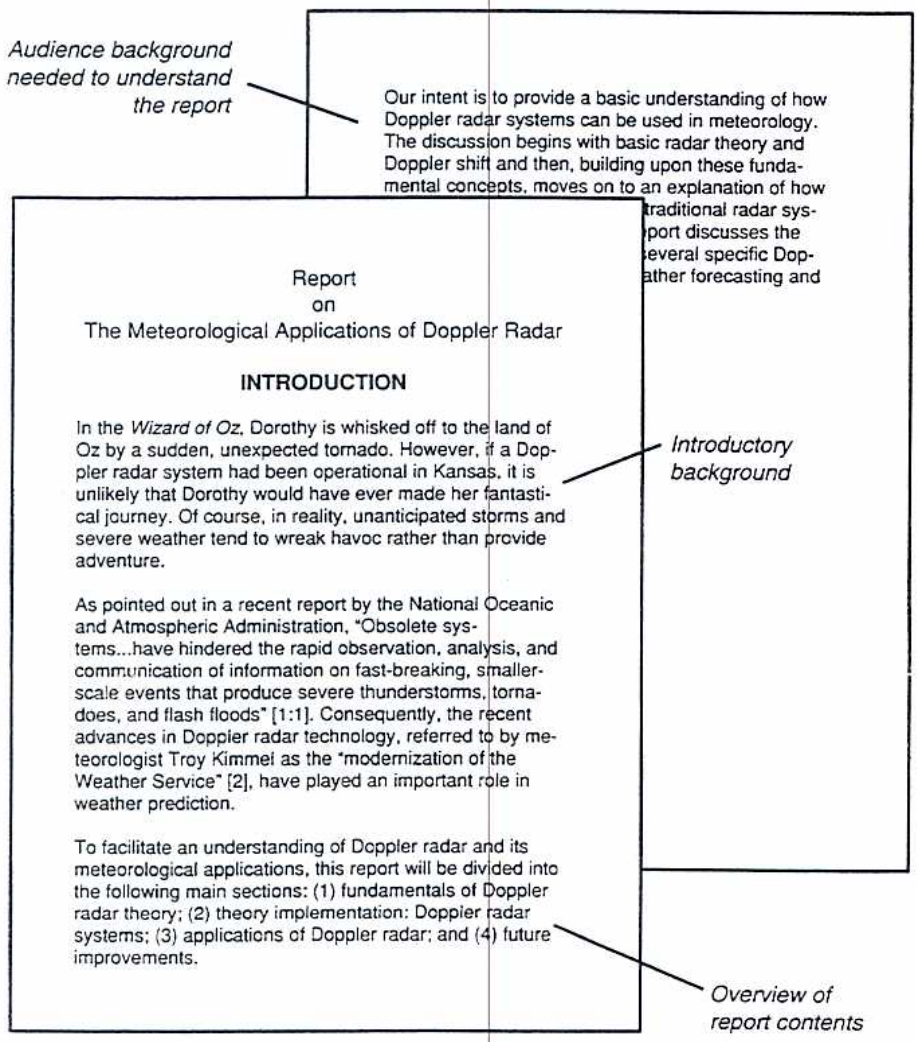

Figure 6-4 Introduction to an engineering report.[9]

[9] Example material drawn from work done by David Barron and Stephanie Braun, engineering students, University of Texas at Austin, 4 May, 1994.

forward ("This report will be divided into..."). Other elements are indicated subtly, as is the case with the background the audience needs to read the report: "a basic understanding" suggests that no specialized knowledge is needed to understand the report.

THE BODY OF THE REPORT

The body of the report is of course the main text of the report, the sections between the introduction and conclusion. Figure 6-5 shows a couple of sample pages.

HEADINGS

In all but the shortest reports (two pages or less), use headings to mark off the different topics and subtopics covered. This will enable readers to skim your report and dip down at those points where you present information that they want.

LISTS

In the body of your report, you'll also want to use the various kinds of lists where appropriate. Lists help readers by emphasizing key points, by making information easier to follow, and by breaking up solid walls of text. For example, if you have three key points that readers must not overlook, use a bulleted list. If you have a sequence of steps readers must perform, use a numbered list. If you have some key terms and definitions that need to stand out, use a two-column list.

SYMBOLS, NUMBERS, AND ABBREVIATIONS

Technical-report discussions often contain lots of symbols, numbers, and abbreviations. Remember that the rules for using numerals as opposed to words are different in the technical world. The old rule about writing out all numbers below 10 does not always apply in engineering reports.

SOURCES OF BORROWED INFORMATION

To write your report, you may have to borrow facts and ideas from other engineers as well as from people in other professions. When you do, you must

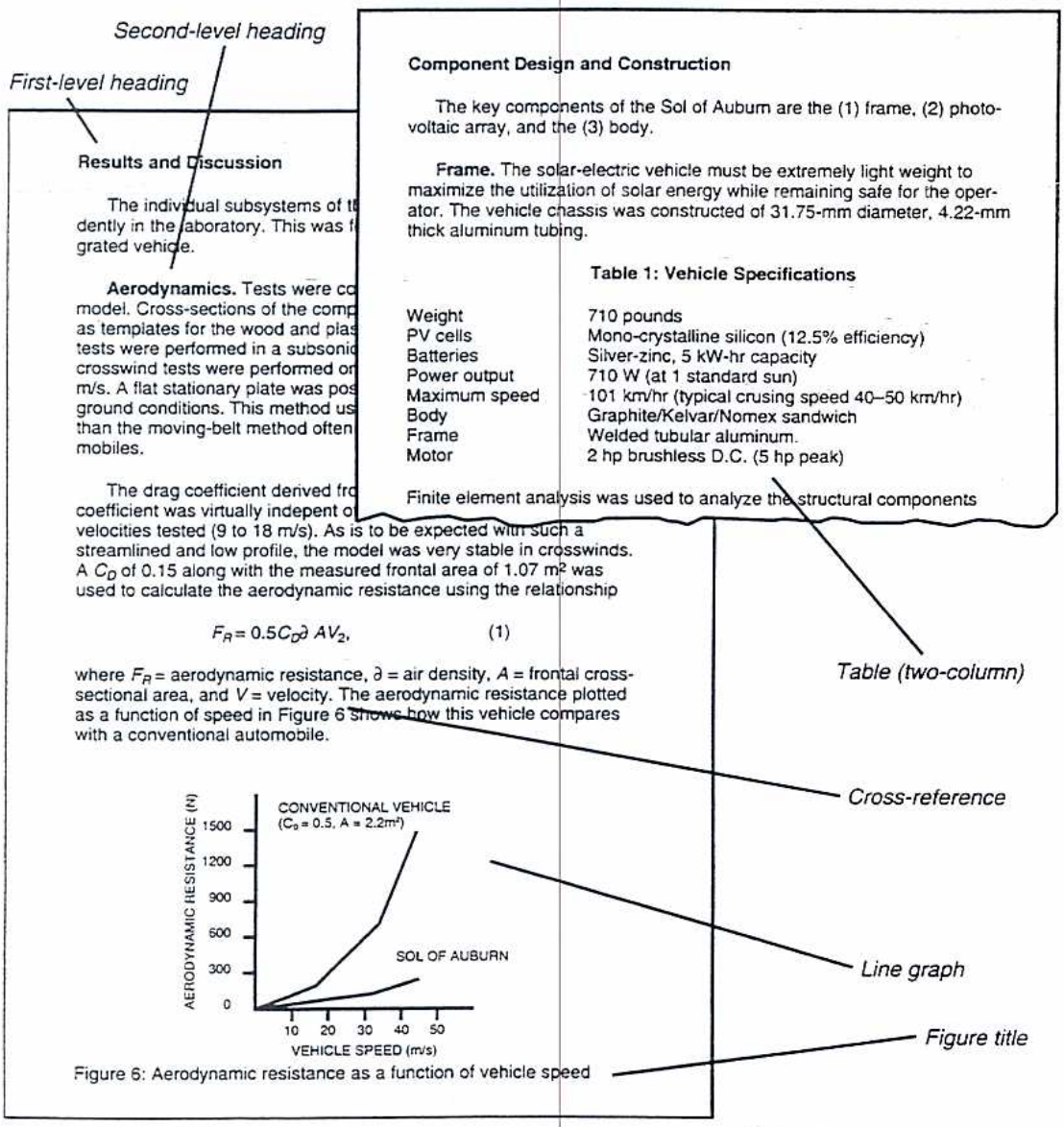

Figure 6-5 Pages from the body of an engineering report. Note the use of headings, tables, cross-references, and graphics.

indicate the sources of your borrowed information, which is known as *documenting* your sources.

GRAPHICS AND FIGURE TITLES

In your engineering report, you're likely to need drawings, diagrams, tables, and charts. These not only convey certain kinds of information more effectively but also give your report an added look of professionalism and authority. If you've

never put these kinds of graphics into a report, there are some relatively easy ways to do so—you don't need to be a professional graphic artist!

CROSS-REFERENCES

In your reports, you may need to point readers to other places in the report where closely related information is discussed, or to other books and reports that have useful information. These are called *cross-references*. For example, they can point readers from the discussion of a mechanism to an illustration of it. They can point readers to an appendix where background on a topic is given (background that just does not fit in the text). And they can point outside your report to other information—to articles, reports, and books that contain information related to yours. When you create cross-references, follow these guidelines:

- If you refer readers to another section of your report, put the heading or section title in quotation marks.
- If you refer to the title of a journal, book, or report, underline or italicize that title.
- If you refer to an article in a journal or encyclopedia, put quotation marks around the article title.

When you create cross-references, give readers some clue as to why they should see that information. Otherwise, they are likely to wonder. Indicate the topic of the cross-referenced information (don't assume the title indicates it fully) and suggest why readers might want to follow the cross-reference.

There are no rules as such on when to cite exact titles or when to supply page numbers in cross-references. The guiding principle is to make it easy on the reader. In a short report, say, one under twenty pages, citing page numbers may not be necessary (although word-processing software makes it easy to automate these details). If you supply the page number, then you can cite the subject matter of the section, not the exact title. It's common to shift text around, cut sections, add sections, change the wording of headings—all of which plays havoc with your cross-references.

CLARITY OF WRITING STYLE

As you rough-draft your report, don't get stymied over getting the words exactly right or avoiding grammar mistakes. In the rough-drafting stage, focus on the technical subject matter and don't get hung up on picky details that just slow you down.

However, once you've got a rough draft on paper or (more likely) in a computer file, reread it looking specifically for the common "writing style" problems that make engineering writing, or any writing, hard to read:

- *Unnecessary passive voice:* In the technical world, you may have to use the passive voice, but when it is misused, it leads to unclear, wordy writing.
- *Over-reliance on the* be *verb:* Heavy use of the *be* verb can make writing unclear and wordy as well.
- *Unnecessary expletives:* The expletives we mean here are the ones that use some form of "it is" or "there is." They too can inflate writing, making it less direct and understandable.
- *Redundant phrasing:* For examples of wordy phrases and their concise counterparts, see the section on redundancy in Chapter 3.
- *Noun stacks:* Another problem, particularly in the technical world, involves jamming three or more nouns together into a phrase, called a noun stack.
- *Weird combinations of subjects and verbs:* When you are struggling to express complex technical ideas, it's easy to combine subjects and verbs in strange ways, especially when lots of words come between them in the sentence. For example:

> The *causes* of the disappearance of the early electric automobiles *were devastating* to the future of energy conservation in the United States.

In this example, it should be the "disappearance" that was "devastating," not the "causes."

- *Sentence length:* In the discussion of complex technical matters, longer sentences may be necessary; but review them to see whether splitting them would make for easier comprehension.

All of these strategies for clearer, more economical writing are discussed in detail in Chapter 3, "Eliminating Sporadic Noise in Writing."

PARAGRAPH STRUCTURE

When you review your rough draft, look for ways to strengthen the organization and flow of your ideas. Do this kind of review at the level of whole paragraphs and whole groups of paragraphs:

- Strengthen transitions between major blocks of thought, such as between paragraphs or groups of paragraphs.

- Add topic sentences (particularly the overview kind) to paragraphs where appropriate.
- Check the logic and sequence of paragraphs or groups of paragraphs. To do so, label each paragraph or paragraph group with one or two identifying words—this way you can get the "global picture" more easily.
- Break paragraphs that go on too long, challenging the reader's attention span.
- Consolidate clusters of short paragraphs that focus on essentially the same topic. Too many paragraph breaks can have a fragmented and distracting effect.
- Interject short overview paragraphs at the beginning of sections and subsections.

Using these strategies guides readers through your report, showing them what lies ahead, where they have come from in the previous pages of the report, and how everything fits together.

GRAMMAR, USAGE, AND PUNCTUATION

As with writing style, you don't want to slow yourself down worrying about subjects and verbs, commas, apostrophes, and the like. Worry about these details later. However, once you've got a rough draft on paper or on disk, check for the various common mistakes such as those involving commas, apostrophes, spelling (particularly spelling of similar-sounding words), parallelism, agreement, and so on.

See Chapter 3, "Eliminating Written Noise," for details on grammar, punctuation, and usage rules.

PAGE NUMBERING

At first glance, the style for numbering pages in a report may seem arcane. But it is based on traditional publishing practice and can be reduced to a few simple rules:

- All pages in the report are numbered; but on some pages, the numbers are not displayed.
- All pages before the first page of the introduction use lowercase Roman numerals; all pages beginning with and following the introduction use Arabic numerals.

- Longer reports often use the page-numbering style known as folio-by-chapter or double-enumeration (for example, pages in Chapter 2 would be numbered 2-1, 2-2, 2-3, and so on). This style eases the process of adding and deleting pages and enables readers to know where they are in the report.
- On special pages, such as the title page and page one of the introduction, the page number is *not* displayed. (Imagine how a lowercase roman numeral "i" at the bottom of a title page would look.)
- Page numbers can be placed in one of several areas on the page, but wherever you place them, do so consistently. If you are printing or typing your report single sided, the best and easiest choice is to place page numbers at the bottom center of the page (and to hide them on special pages).
- If you place page numbers at the top of the page, you must hide them on chapter or section openers where a heading or title is at the top of the page. (Again, imagine how this would look.)

GRAPHICS

When you write your report, you're likely to need illustrations, diagrams, charts, graphs, drawings, schematics, and tables. Graphics like these help present your information more effectively and give a polished, professional look to your report. You don't need to be a graphics professional to bring good graphics into your engineering reports. At the very minimum, all you need is some scissors or an X-acto knife, some tape or glue, and access to a good photocopying machine.

However, there are many advantages to using the computer-based graphics tools that enable you to create or scan graphics. And of course with these tools, you need word-processing software that enables you to embed those graphics into your text files. These software approaches for incorporating graphics save you the trouble of physically cutting and pasting graphics into the pages of your report. These tools also enable you to send text and graphics files electronically to professional associates and to publishers. Thus, it's worth spending some time getting comfortable with handling graphics electronically. For an overview of features to look for in computer-based graphics tools, see Chapter 10.

AN OVERVIEW OF GRAPHICS

If you're new to using graphics in reports, consider the sorts of graphics you can use:

- *Drawings:* Drawings are simplified illustrations of objects, people, and places. You often see drawings used in instructions. They strip away extraneous detail and focus on the key subject matter.
- *Photographs:* Photographs, on the other hand, supply lots of detail—in some cases, too much. They are useful, for example, when you want to show a model of a new product.
- *Diagrams and schematics:* Diagrams are highly abstract illustrations of objects. They often focus on infrastructural matters such as circuitry and other detail. They are often accompanied by measurements and symbols.
- *Conceptual diagrams:* Graphics are also used to illustrate nonphysical things such as concepts. An organizational chart of a company is a typical example. A flowchart of a production process is another.

DESIGN AND FORMAT OF GRAPHICS

When you incorporate graphics into a report, pay attention to their standard components, their placement, and cross-references to them.

Components of Graphics. When you use graphics, keep these design considerations in mind:

- Add *labels*—Words that identify the parts of the thing being illustrated, and a pointer from each label to the part being illustrated.
- Add *figure titles*—Those identifying titles at the bottom of figures that indicate the subject matter of each figure and its sequence number in your report.
- Place graphics at the *point of first reference*—Position graphics just after the first point in your text where they are referenced, if not on the same page, then at the top of the next.
- *Intersperse* graphics with text—Insert graphics into pages with text rather than appending them at the end of the report. For readers, it's pleasing to have text broken up with graphics.
- Provide *cross-references* to your graphics—Don't just pitch graphics into your report without referring to them and explaining key points about them.

These components enable a graphic to stand by itself and make sense. The figure title should provide only a brief statement of the graphic's significance;

the textual discussion of the graphic can expand upon this more fully. Remember, the purpose of a graphic is to help your reader understand the information presented in your text, but the text must do the same for the graphic. That is, your reader needs to know, from your text, what to look for in the graphic.

Placement of Graphics. Each graphic should appear as soon as possible after you first mention it and as close as possible to your discussion of it. If there is no room between first mentioning it and the end of the page, put it on the next page but tell readers where it is with wording such as "As shown in Figure 6 on page...." Make sure there is adequate spacing between the graphic and the text and that the page is visually attractive and balanced.

The way to merge a graphic with your text depends on its shape and size. Graphics are usually full-page, half-page, or smaller than half-page. In each case, there are some general guidelines to follow:

- If you have a full-page graphic and if your document has left and right pages, place the graphic on the right-hand page if at all possible. Your discussion of it can then appear first on the left-hand page; both the graphic and your discussion of it will be visible.
- If you write a report with only one full-page graphic in it, follow the previous guidelines unless you refer to the graphic throughout the report. Then it's better to place it in an appendix at the end of the report. Be sure to cite its location each time you mention it—people forget.
- If your graphic is horizontal rather than vertical, make sure its top is placed along the inside of the page. For a bound report or book, this means placing the top side against the spine.
- If you have a half-page graphic that won't fit on the page where you begin discussing it, put it at the top of the following page.
- Many smaller graphics really should be a half-page in size. Don't be tempted to economize on space at the cost of readability. If you include wording within a smaller graphic, the print needs to be large enough to read. Make sure you don't challenge the eyesight of your readers—and thus create noise—when you provide them with a small graphic.
- If you create a graphic less than a half-page in size, you can have your text flow around it (Figure 6-6*b*). This is easy enough to do with modern word processing programs and gives your page a unique and professional appearance. Don't cramp things, however. Make sure you leave plenty of white space between your text and graphic.

Cross-References to Graphics. As indicated above, if you don't refer to the graphic, your reader may be left with a nice picture but no sense of its purpose

Word, AmiPro, and others provide this function, but of course the techniques are dramatically different with each software package.

One approach to getting graphics into reports is to use a scanning device. Scanning equipment can be as cheap as $50.00 and as expensive as several thousand dollars. Watch out for the low-end scanners; they may produce blurry, low-quality images and may not be suitable for your needs. But if you can get good scanned images, it's a big advantage—you don't have to draw them yourself. Remember, however, you still must document borrowed graphic images the same as you must document borrowed text. And, if you are using the borrowed graphic in a commercial publication, you must also get formal permission from the originator of the graphic.

The other alternative is electronically drawing graphics yourself using software tools such as CorelDraw, AutoCAD, or any of the drawing tools that are available with most desktop-publishing systems.

"LOW-TECH" GRAPHICS PRODUCTION

If you don't have a scanner, have no access to or skill with software graphics tools, and consider yourself a horrible artist, there's still hope. Try the following technique:

1. Find the graphic that you want in a book, report, or journal, for example. Avoid graphics in low-quality print media such as newspapers; they won't photocopy well.
2. Photocopy it on a good-quality copier. Enlarge or reduce the image as needed.
3. Trim the copy, cutting out the figure title, wordy legends, but not necessarily the labels (usually they will work just fine as your own labels).
4. Add labels or other devices as necessary to make the graphics work in your report.
5. In the text of your report, plan where you'll place the graphic: try for the point at which it is first referred to or some point just after (to make the pagination work). Leave enough space above and below the graphic so that it won't appear "squeezed" in. Make sure it doesn't spill outside your regular right and left margins.
6. In your file or on your typed page, type the figure title. Because you've photocopied the graphic, you must cite the source, just as with any information you borrow.
7. When you've printed out or typed your report, carefully place your graphic in the space you've left open for it, and then tape or glue it in in such a way that the seams and the tape won't show in the photocopy.

8. Now, get a good-quality photocopy not only of this page but of *all* the pages in your report. *Never* submit a report with things taped or stapled or clipped in the pages. (And by the way, don't draw or color on your graphics; if that's what you want, use a color photocopier.)

It may not be so out of the question for you to create some of your graphics yourself. Consider tracing the images you want. If you draw freehand, use a soft pencil and light marking to get the drawing just right, then ink it in with a black marker. Erase your pencillings, then treat your drawing just like the photocopied graphics discussed above.

CHARTS

The term *charts* encompasses all those ingenious ways of showing relationships between data—for example, line graphs, bar charts, pie charts, and three-dimensional variations of these such as pictographs. All of these types of charts are visual representations of tables. They express a fundamental frustration with the dull old table—row upon row and column upon column of numbers and words.

In tables, it is normally difficult to perceive what is significant about the data without studying it. Charts and graphs make the significant stand out. For example, if your department has reduced defects in the manufacturing process each year over the past five years, a line graph shows this more vividly than a table. If those defects are primarily the result of faulty raw materials, then a pie chart might make this point much more vividly than a table.

Obviously, charts and graphs are great ways to dramatize key statistical points, or "trends" in the data. But how do you construct them and then incorporate them into your reports? Most of the major word-processing and desktop-publishing software packages now have chart-making features. You feed in the data and define how the chart should look, and the program constructs it and embeds it where you want it in your report. Spreadsheet and database programs also can produce charts and graphs, which some word-processing and desktop-publishing software packages can import. And of course there are the well-known chart-making programs such as Harvard Graphics designed specifically for this function. Again, many word-processing and desktop-publishing software packages can import these charts.

And finally there are the manual approaches: You can use simple graphics capabilities in your word-processing software to draw your chart or graph. One other way is to find the chart or graph you want in some other published source, copy or scan it, and bring it in manually or electronically into your text. Yes, this is legal, as long as you document it.

Whichever means you use to create charts and then incorporate them into your report, observe a few fundamental guidelines:

- Include a figure title just below the chart to identify its content and, if necessary, to identify its source (if you borrowed the data).
- Add labels on the axes to identify the units of measurement.
- Include a "legend" if you use different symbols, colors, shadings, or patterns to indicate different elements.
- Make sure your charts fit within your regular margins.

TABLES

Despite what we've just said about tables compared to charts, tables are useful and necessary elements. Tables present data efficiently; an added benefit is that tables, like charts, lists, graphics, and headings, break up big walls of text. Report writers often pass up good opportunities to present data in tabular form and instead leave it in regular paragraphs. Any time you see groups of numbers in your text, take a second look at them to see if they can be presented, or represented in the form of tables. Figure 6-7 illustrates how you can transform text into a table.

The sources of your data for tables can be varied. It's perfectly legal to copy a table from another source into your own report, as long as you document its origins. How you construct the table though is another matter. As with charts and graphs, there are numerous software tools such as Harvard Graphics that you can use to define the table you want, feed in your data, and then embed the results into your text. There is the "low-tech" method of photocopying tables from other sources and taping them in your text. And still another low-tech method involves hand-typing tables yourself.

Whichever technique you use to create tables, keep these design considerations in mind:

- Include a heading at the top of each column to identify the contents of the column.
- Include a row heading in the farthest left column to identify the contents of the row.
- Center columns of numbers under column headings; left-justify columns of text.
- Right-align or decimal-align columns of numbers.
- Don't forget to indicate units of measurement; and put these units in the headings rather than by each item in the columns.

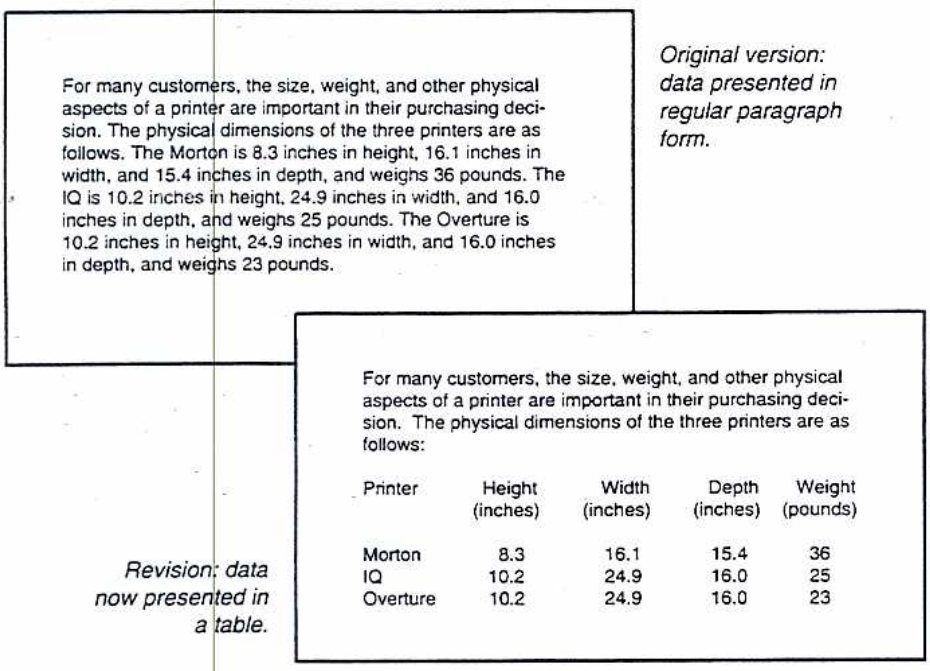

Figure 6-7 Transforming text into table. In the original example, the data clogs up the textual discussion; in the revision, it is taken out of paragraph form and put into a table, making it more readily scannable and breaking up the text.

CONCLUSIONS

For most reports, you'll need to include a final section, usually called a "conclusion." When you plan and write final sections of engineering reports, think about the functions they can perform in relation to the rest of the report:

- They *conclude*—that is, they draw logical conclusions from the discussion that has preceded; they make inferences upon what has preceded.
- They *summarize*—that is, they review the key points, key facts, and so on from what has been discussed. Summaries present nothing new—they leave the reader with a perspective on what has been discussed, the perspective that the writer wants them to have.
- And finally they *generalize* by moving away from the specific topic to a discussion of such things as implications, applications, and future developments—but only in general terms.

Your final section can do any combination of these, depending on your sense of what your report needs. See the example conclusion in Figure 6-8; it

An appendix to the report

APPENDIX A: FUTURE DEVELOPMENTS

The intent of this report is to review current implementations of Doppler radar. However, important activities are going on currently to improve this technology.

Although Doppler radar has proven to be an important step in the future of radar meteorology, current Doppler radar systems are not perfect. The main disadvantage of a single Doppler radar system is that only the *radial* component of wind velocities can be detected. This means that only the vector component of the wind that is blowing directly toward or *away* from the

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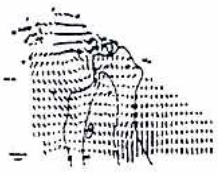

Figure 4: Two-dimensional wind field map produced by an experimental dual-Doppler system [22:JJ306].

CONCLUSION

Although basic Doppler radar systems have been in use since World War II, only recent developments in computer technology have enabled the large quantity of data collected by operational systems to be processed using state-of-the-art computer algorithms. The versatility of both hardware and software components of system computers make Doppler radar systems feasible for practical use. Each of the Doppler radar systems discussed in this report is still in the developmental stages; however, each has shown marked advantages over conventional radar systems when applied to weather forecasting and aviation meteorology. In addition, new dual-Doppler systems are currently being developed to increase weather forecasting accuracy by detecting otherwise hidden atmospheric conditions.

The implementation of the Weather Service Radar, Doppler, Terminal Doppler Weather Radar, and wind-profiling systems were important steps in the modernization of the National Weather Service. Each of these systems provides meteorologists with accurate information on current weather conditions, allowing them to draw conclusions about long-term weather forecasts. More importantly, meteorologists are able to predict and detect dangerous situations, such as flooding, tornadoes, microbursts, and wind shear, which pose a threat to the general public, as well as to the aviation industry.

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Conclusion to the report

Figure 6-8 Conclusion section and appendix of an engineering report. Note that each is a separate section and begins on a new page.

summarizes key points in the report and takes a brief look at the future of the technology discussed in the body of the report.

The length of the conclusion can be anything from a 100-word paragraph to a five- or six-page section. For the typical ten- to twenty-page double-spaced report, the final section would be one to two pages, but such ratios should never be applied without considering what's going on in the report. Watch out for conclusions that get out of hand and become too long. Readers expect a sense of closure, a feeling that the report is ending. When the final section becomes too long, consider doing one of the following: Move some of the discussion back into the body of the report; shorten and generalize the discussion and keep it in the conclusion; or find some other way to end the report.

APPENDIXES

Appendixes are those extra sections following the conclusion. What sorts of things do you put in appendixes?—anything that does not comfortably fit in the main part of the report but cannot be left out of the report altogether. The appendix is commonly used for large tables of data, big chunks of sample code, fold-out maps, or large illustrations that just do not fit in the body of the report. Anything that you feel is too large for the main part of the report or that you think would be distracting and interrupt the flow of the report is a good candidate for an appendix. Figure 6-8 shows an example of an appendix.

DOCUMENTATION

Documentation is the system by which you indicate the sources of the information you borrow in order to write an engineering report. Back in the "old days," they called it "footnoting"—thank goodness there are easier documentation systems to use (and word-processing software, which also makes footnoting much easier). As you probably know, writers document their information borrowings in order to

- enable readers to track down the information so that they can read it for themselves.
- protect the originator, the author of the information, so that she or he will get the credit and acknowledgment for having developed it.
- protect you from accusations of plagiarism—of stealing other people's hard-fought information discoveries.
- demonstrate to readers that you have done your homework, that you are "up" on the latest developments in this particular field.

Documenting your information sources has a lot to do with establishing, maintaining, and protecting your credibility in the profession. Borrowed information must be documented regardless of the shape or form in which it is presented; whether you directly quote it, paraphrase it, or summarize it, it's still *borrowed* information.

Nearly every field and profession has its own documentation system. A *documentation system* is the style and format that a particular field or profession uses. Even though systems for documenting sources of borrowed information

vary, they can be reduced to a few basic categories. The system used by professional engineers in their publications and recommended by the IEEE fits into the category of *number systems*. As Figure 6-9 illustrates, at the end of the report there is the *references page*, a numbered list of sources; in the body of the report there are *textual references*, codes that work with the references page to indicate the source of the borrowed information. Readers understand that if they want to check out your sources on a topic, they can look up the code number in the back of the document to see where the information came from.

REFERENCES PAGE

At the back of the report is the list of information sources, arranged and numbered according to their occurrence in the report. For example, if the first borrowed information that occurs in your report comes from a book by Robertson, Robertson would be [1]. If the next borrowed information came from an article by Adams, Adams would be [2]. But once you've established an information source in the references page, no further entries for it are needed. For example, imagine that several pages later in your report, you borrow from Robertson again. Would that be source [3]? No—it would be [1].

How entries in the references section are constructed may look complex. The best approach is to use the examples in Figure 6-9. They've been carefully selected to include the most common variations. Model your entries after these. In the examples, notice particularly:

- Names of books, journals, and magazines are in italics (use underscores if you don't have italics).
- Titles of articles in journals or magazines are put in double quotation marks.
- For books, list the city of publication, followed by a colon, the name of the publisher (but without all those "Co.," "Inc.," and "Ltd." words), followed by a comma, the year of publication, and a period.
- For each article, provide the date, volume number, and issue number that the article appeared in and the beginning and ending page numbers of the article. (See the style used in Figure 6-9.)

For unusual sources not illustrated here, consult *IEEE Information for Authors*.

TEXTUAL REFERENCES

Indicating the source of borrowed information in the running text of an engineering report is simple—you construct "textual references," those bracketed

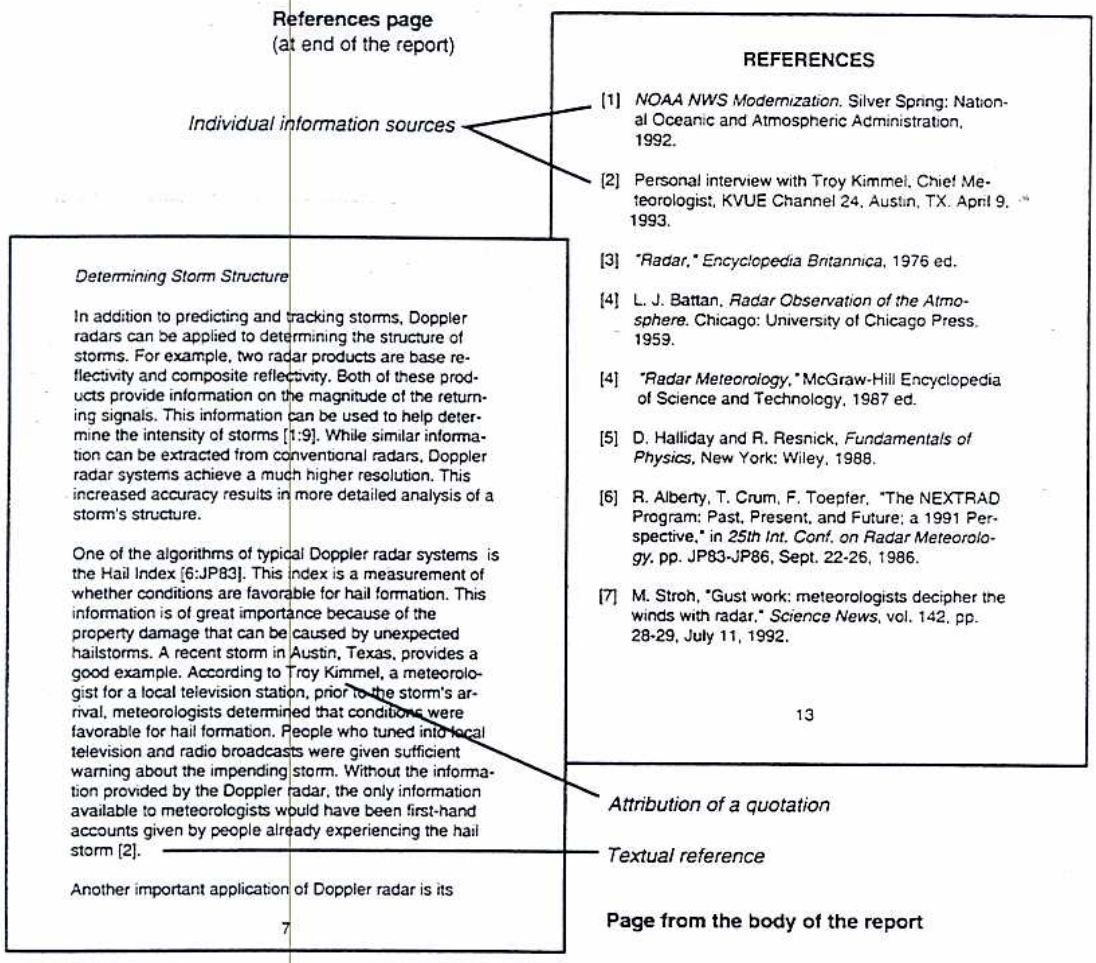

Figure 6-9 IEEE documentation system: The code numbers in the text of the report are keyed to the references page. Notice how the borrowed information is marked at the beginning by the attribution and at the end by the textual reference (the brackets).

things in the running text of a report (see the example page in the left portion of Figure 6-9).

- To indicate just the source, put the source number in brackets, for example, [3]. This tells the reader to check the references page for source 3.
- To indicate the source and the page, add a colon and the page number, for example, [3:116]. This tells the reader the borrowed information came from source 3, page 116.
- To indicate that the borrowed information came from a range of pages, add a hyphen and the end page number, for example, [3:116–122].
- To indicate that the borrowed information came from separate pages, not a range, use commas, for example, [3:116, 120, 122].
- To indicate that you've borrowed and merged borrowed information from two or more sources, use semicolons, for example, [3;7].

You may be wondering where to put the textual reference in relation to the borrowed information. There are no clear rules on this matter. Your goal is to indicate to readers where the borrowing begins and where it ends. But you don't want to create a distraction by ending every sentence with a textual reference. Some writers put the textual reference at the beginning of the passage in which borrowed information is used; some at the end. The best solution is to insert an "attribution" at the beginning of the passage and then put the textual reference in brackets at the end. An attribution is that phrase that indicates the source of the information: for example, "According to the 1990 U.S. Census Bureau . . ." or "In his study on SNMP sockets-based protocols, Edmund Smith notes that . . . ." (Figure 6-9 illustrates how an attribution phrase and a textual reference in brackets can mark off a passage of borrowed information.)

There is one last issue involving documentation: Just what do you document? The rule of thumb is that you need not document common knowledge. But what is "common knowledge"? What may be common knowledge to some may not be common knowledge to others. And is anything in the engineering world "common knowledge"? Consider several examples. Think of a theory you learned in engineering school: You can find it in practically every standard textbook on the subject, and it is not documented when it is discussed in those textbooks. That's common knowledge. But think of a controversial theory put forth by an engineer who is well known in his field. That's *not* common knowledge, and if you borrowed it, you would have to document your source for it. The same would be the case for another engineer who had made breakthrough discoveries. The difference then comes down to your familiarity with your field, whether you can distinguish common knowledge from the knowledge that is identified with specific individuals.

EXERCISES

Interview at least three professional engineers concerning the formal reports that they write, or ask to borrow examples of the reports they write. Ask the following questions or examine the example reports in the following ways:

1. How does the format of the engineering reports they create compare with the format shown in this chapter or with that specified by the American National Standards Institute's *Scientific and Technical Reports: Organization, Preparation, and Production*?
2. What are the common audiences for the reports? Are they fellow engineers or non-specialists?
3. Typically what purposes do the reports have? What functions do they perform for the engineering firm?

4. How are the graphics that are present in the reports created—by graphics specialists or by the engineers themselves?
5. How much are the reports a product of team writing—a group of engineers working on the same report together?
6. How much library research is typically required to produce the reports? How much information for the reports comes from print and nonprint sources?
7. What process does the engineering firm use in the production of reports? Do they use technical writers, graphics specialists, document designers, and editors; or is the production of reports mostly the responsibility of the engineers themselves?

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