J. TECHNICAL WRITING AND COMMUNICATION, Vol. 37(3) 281-303, 2007

THE STEEL BIBLE: A CASE STUDY OF 20TH CENTURY TECHNICAL COMMUNICATION

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ABSTRACT

The "steel bible" emerged in 1919 and went through 11 editions in 80 years. In its evolution we can see the shift from individual to group authorship, an increasing use of visual elements, and a physical change from a small, hand-held volume to a weighty desktop reference. In a textual analysis, we can see that it was essentially static, changing only by additions and deletions, as the industry evolved. The eventual closing of hundreds of plants and the migration of the industry to other countries can be seen in the change of publisher, the sudden absence of photography, and the international references. Originally, the steel bible came from the factory floor and the words of the plant managers, but by the 1990s, it was a highly-abstracted representation of knowledge. In the steel bible, we can see the history of the industry and the maturing of technical communication in the 20th century.

INTRODUCTION

One of the most fundamental industrial changes in American society that has led to an increased standard of living is the use of steel in construction, appliances, automobiles, and weapons. In fact, it is not unreasonable to say that the development of the steel industry is, in part, responsible for the dominance of America in politics. "Big Steel" first developed in America in the late 19th century, but by the end of the 20th century, many steel plants closed and the industry migrated to other countries. Presently, the steel industry is distributed around the globe. Throughout this evolution, the "steel bible" has functioned as a repository of information, a reification of positivism, a tool of capitalism, and an

doi:10.2190/TW.37.3.d
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example of group work, using consensus to create knowledge and make material changes possible. Its earliest versions still reflected the elaborate prose of the 19th century but it gradually became a true reference, a conglomeration of multiple authors, modes, and media, that was able to contain as much information as possible and reach many audiences. The last edition, which was published after the steel industry had migrated to other countries, had become a dispassionate abstraction of mathematical symbols, tables, and citations. Each of these editions reflects the conditions in the steel industry at the time.

The Making, Shaping and Treating of Steel (see Appendix for a listing of all editions) is often referred to as the steel bible because the first four editions looked like a bible and later editions were so important as a reference that many professionals always had a copy with them (see Figure 1). The first reference to the "Bible" is in the preface to the 10th (1985) edition.[1] The fact that this book on steel resembled a bible was probably not accidental: it was the source of a new form of (material) salvation. It was also published after the unsettling events of World War II and provided a reification of positivism—material proof that the world could be improved with knowledge and labor—that must have been heartening to the men who received it. Receiving the steel bible also must have been some form of initiation rite, a symbolic gesture that intimated entry into a guild. The first 10 volumes were distributed for free or sold at a fraction of their cost to academics, employees, salesmen, and students, both in the United States and abroad. Thus the distribution was very wide and the steel bible is still in use today.

This article will analyze the texts chronologically. Overall, the text was static: the shifts in textual content responded to shifts in changing methods of technology. The only change independent of the techno-economic context was the increasingly sophisticated use of page layout, graphs, tables, graphics, and photographs. This change illustrates a basic feature of technical communication: mature technical communication relies on visual, as well as verbal, communication. Visual communication can be more powerful than textual communication. It exists "at the intersection of image, word, number, [and] art" and thus allows the mind to take in information in multiple modes from multiple sources [1, p. 9]. With the complex knowledge transfer necessary to the steel industry, words alone were not sufficient for conveying such a massive amount of technical information.

Physically, the steel bible grew every year. Figure 2 shows a graph of the weights and number of pages. Each year it weighed more and each year the number of pages grew, except in 1957, when the book size changed from a

[1] The preface to the 10th (1985) edition says "*The Making, Shaping and Treating of Steel* was, and is, one of a kind and has been frequently referred to as "the bible of the steel industry." A letter to the author from D. John Armstrong, Manager of Public Affairs at United States Steel Corporation, dated March 14, 2006, states "There is no question that *The Making, Shaping and Treating of Steel* is the bible of our industry."

Figure 1. *The Making, Shaping and Treating of Steel,* 1925, 4th Edition. The first four editions looked like a Bible with a soft cover, rounded corners, thin paper, and gilt edges.

medium (6" by 9") format to a desktop (7-3/4" by 10-5/8") format with two columns of text.

The steel bible is remarkable in that the written text is consistent from volume to volume except when an overlooked technological subject is added, a superceded technology is dropped or a new technology is described. This, too, is a hallmark of mature technical communication. The only minor shift in authorial voice occurs when the volume evolved from two authors to group authorship and the eloquent introduction, quoted in part at the end of this article, is removed.

Just as literature emerges from a literary milieu, these texts emerged from the social discourse environment surrounding the American iron and steel industry. They were initially published by Carnegie Steel, then a subsidiary of U.S. Steel, then subsidized by U.S. Steel until the 10th (1985) edition, when the rights were transferred to the Association for Iron and Steel Technology (AIST), whose Foundation published the 11th (1998/1999) edition at a much higher price. However, even though they were published by a corporation, they were written by the people who worked in it. Much of the writing evolved from spoken words on the factory floor. And, although the publication of *The Making, Shaping and Treating of Steel* took place during a time of social turmoil, from the union riots of 1919 to the closing of many steel plants in the United States in the 1980s, the text remained essentially static. Thus, the steel bible reveals a different aspect of the steel industry than that which we see in the labor disputes: there was stability as well as change.

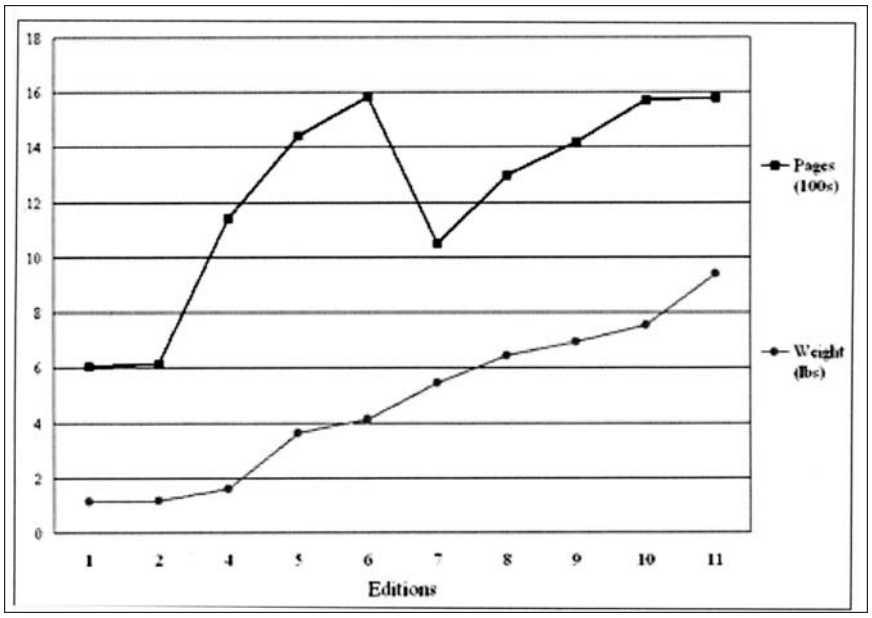


Figure 2. A comparison of the number of pages (100s) and weight (lbs) of each edition.

THE EMERGENCE OF THE STEEL BIBLE

The purpose of the steel bible, from the start, was to provide training to salesmen and managers at Carnegie Steel. The preface in the 1st (1919) edition gives the background of the training methods:

> From the first, the method pursued in this work has been that of taking the students, under proper guidance, into the mills, where they obtain, first hand and individually, such information as they desire and are able to collect, and of supplementing the knowledge gained from these visits with talks and explanations delivered in a classroom where conditions are more favorable for this kind of instruction than they are in the mills (p. v).

Since it is almost impossible to hear in the mills, the processes and procedures were eventually written down and distributed in the form of hectographed notes (similar to mimeographs). Copies of the lectures were given to each student; as the demand increased, Carnegie Steel decided to publish *The Making, Shaping and Treating of Steel*.

The 1st (1919) edition was similar to the one seen in Figure 1 but thinner. It has no designation of edition, indicating that the authors may not have foreseen its continuance. From the beginning, the authors attempted to report empirical

experience as clearly as possible. In the first three (1919, 1920, 1925) volumes, the authors state:

> Our aim throughout has been to describe conditions and things as they are and to explain the causes for their being as they are, rather than to tell how they might be or how they ought to be. To accomplish [this] purpose, we have been compelled to rely mainly upon our personal observation and experiences . . . (pp. v, vii).

In the prefaces to the volumes, the authors—whether group or team—give the background of the current edition and state its goals. In these early prefaces, the authors thank the plant superintendents and the heads of departments for the information that they gave them. Thus, the steel bible evolved from spoken descriptions of processes in the plants, through various filters and iterations, into a textual form.

The authors of the first four (1919, 1920, 1925, 1940) volumes were James McIntyre Camp (1858–1927), the Director of the Bureau of Instruction at Carnegie Steel, and Charles Blaine Francis (dates unknown). The 2nd edition appeared in 1920 and a 2nd impression was produced shortly thereafter. Although references are later made to a 3rd edition, it is most likely the second printing of the 2nd (1920) edition. The 4th edition appeared in 1925 with a new section on "The Manufacture of Steel Wire, Sheet Metal and Tubular Products." These first three editions were mainly text, with few illustrations. They were small with soft leather covers and thin paper with rounded gilt edges.

The middle editions were pivotal in the evolution of the steel bible (as well as the evolution of the industry). The majority of the changes occurred between the 1940, 1951, 1957 volumes, during the pre- and post-World War II industrial activity. The steel bible changed from individual, named authors to anonymous group authorship. It also changed from portable to desktop format. Technological (and thus textual) changes happened gradually from 1940 on. These changes and the continual addition of graphics made each volume larger than the one before.

In the later editions (1964, 1971, 1985, 1998/99) the individual voice was gone, but the books were rendered with attention to the user and contained as much material as possible to make the content accessible and understandable—graphs, pictures, diagrams, tables, etc. The eventual migration of the steel industry is visible in the absence of photos in the 11th (1998/99) edition, its international references and its change in publisher. There is also a statement in the preface to the 10th (1985) edition that mentions the "challenges" that faced the steel industry:

> Industrial developments in the Third World, energy problems beginning with the oil embargo of 1973 and the resultant energy price increases, additional concern for the environment, and worldwide competition for steel markets have led to numerous technological changes (p. vii).

The preface goes on to say that these technological changes, necessitated by social forces, have been incorporated into the volume. It does not say that by 1985 most of the steel plants in the United States had closed, largely due to lower wages, government subsidies, and newer plants abroad.

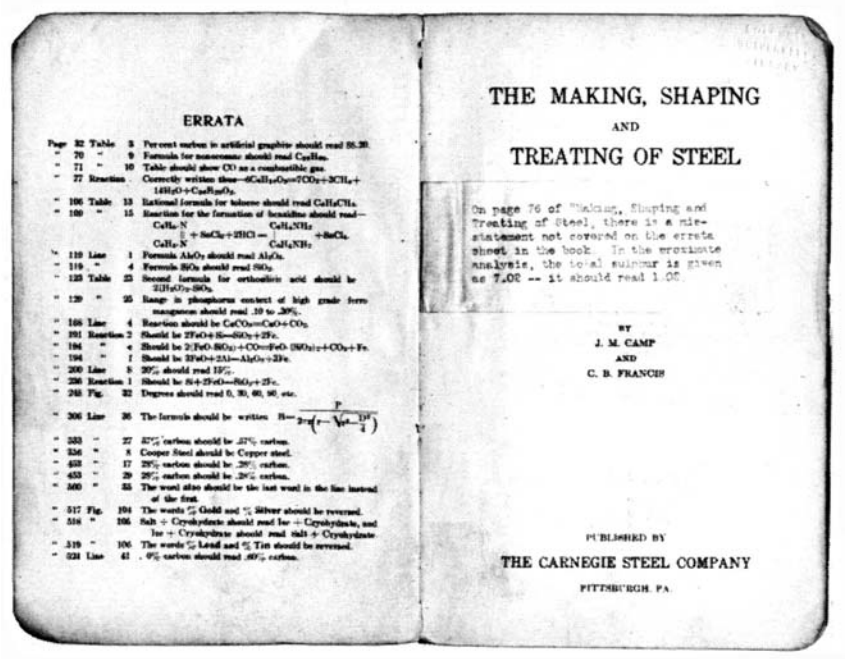
THE EARLY EDITIONS

The first editions are different from the others in several ways. First of all, an authorial voice is very much present. They were also didactic, written to teach non-technical employees (and others) about iron and steel. Since the steel bible evolved from lectures, the early editions have a "Plan of Study" introducing many sections that suggests the best possible approach to the material. There is also the voice of 19th century positivism the volumes, demonstrated in the sentence: "we have aimed to make this book at least a stepping stone to higher and better things" (pp. v, vii). Thus, the early editions resemble the bible in several ways: physically; in their goal of transcendence; and in that they are mainly text. The authors wrote in an immediate, personal dialogue with the reader with passion and eloquence, as can be seen in the introduction quoted, at length, at the end of this article. Perhaps this immediacy compensated, in part, for the lack of visual communication in the volumes. Although there are tables, photos and illustrations, they are an adjunct to the textual description of the processes, rather than a consistently used tool to aid in understanding. In the early stages of the steel bible, visual communication was still in its infancy.

In 1919, when the 1st edition was published, riots were occurring in Pittsburgh and elsewhere between the National Committee for Organizing Iron and Steel Workers and Federal troops, operating on behalf of the coal and steel corporations. The steel workers were trying to unionize to get better wages and end the 12-hour workday. By 1920, when the 2nd edition was published, the riots were over (20 strikers had been killed) and the effort to unionize had been crushed [2, p. 117]. However, the riots had brought more public attention to the difficult conditions in the mills. A Senate committee investigated and found that the workers had a just complaint; in 1923, prior to the 4th edition, President Harding wrote to Elbert Gary of U. S. Steel, requesting him to abolish the 12-hour work day and U.S. Steel complied [2, p. 119]. None of this turmoil is reflected in *The Making, Shaping and Treating of Steel*.

1st (1919) Edition

This earliest edition has errata printed on the front inner pages and also a mimeographed errata glued in after binding (see Figure 3). Thus, corrected mistakes are the reader's first impression. There is also no designation of edition, possibly due to the authors not foreseeing its continuation. The edition I had was



ERRATA

THE MAKING, SHAPING
AND
TREATING OF STEEL

On page 76 of Making, Shaping and Treating of Steel, there is a misstatement not covered on the errata sheet in the book. In the proximate analysis, the total summar is given as 7.02 -- it should read 1.02.

BY
J. M. CAMP
AND
C. B. FRANCIS

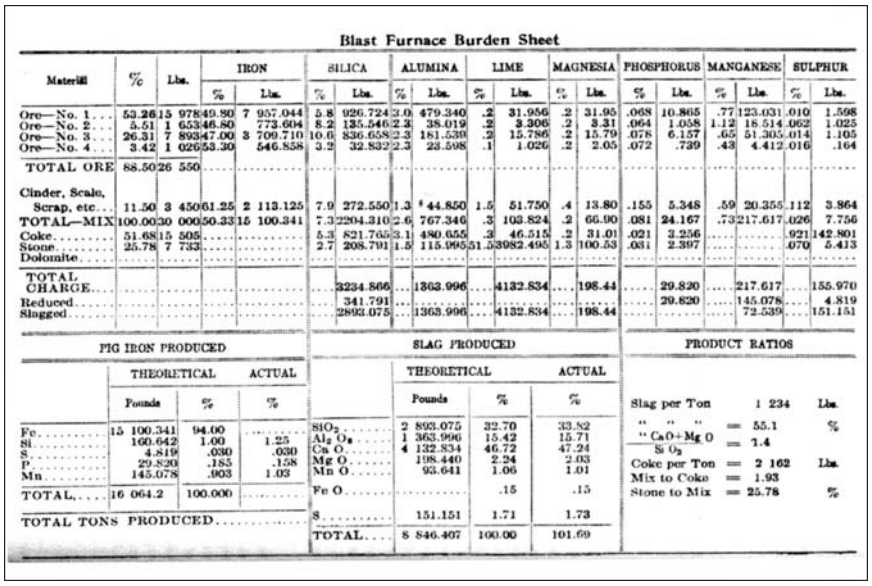
PUBLISHED BY
THE CARNEGIE STEEL COMPANY
PITTSBURGH, PA.

Figure 3. Title page of *The Making, Shaping and Treating of Steel,* 1919, 1st Edition.

well-used, broken in half, and missing a cover, with fingerprints and dirt in the margins. This instance was clearly a well-used book.

2nd (1920) Edition

This volume is essentially the same as the 1919 version except that the errata have been incorporated and a small amount of text (10 pages) has been added. The textual changes were made to give a fuller understanding of the processes of iron and steelmaking. For example, under the section about operating a blast furnace, they added two steps to the process and moved two other steps, giving them a section of their own called “The Blast Furnace Burden.” The blast furnace burden was an important, complex, and chemically misunderstood part of iron-making. Throughout history, ironmakers judged the amount of ore, flux, and fuel to add to the furnace by experience and experimentation. This was the blast furnace burden. The burden varied with the chemical composition of the ore, fuel, and flux, and thus it was very difficult to judge. Even the 4th (1925) edition noted that judging the correct amounts “involves a great deal of try-work with different combinations of the materials that may be available” (1925, p. 195).



Blast Furnace Burden Sheet

Material	%	Lbs.	IRON %	IRON Lbs.	SILICA %	SILICA Lbs.	ALUMINA %	ALUMINA Lbs.	LIME %	LIME Lbs.	MAGNESIA %	MAGNESIA Lbs.	PHOSPHORUS %	PHOSPHORUS Lbs.	MANGANESE %	MANGANESE Lbs.	SULPHUR %	SULPHUR Lbs.
Ore—No. 1	53.26	15 978	49.80	7 957.044	5.8	926.724	3.0	479.340	.2	31.956	.2	31.95	.068	10.865	.77	123.031	.010	1.598
Ore—No. 2	5.51	1 653	46.80	773.604	8.2	135.546	2.3	38.019	.2	3.306	.2	3.31	.064	1.058	1.12	18.514	.062	1.025
Ore—No. 3	26.31	7 893	47.00	3 709.710	10.6	836.658	2.3	181.539	.2	15.786	.2	15.79	.078	6.157	.65	51.305	.014	1.105
Ore—No. 4	3.42	1 026	53.30	546.858	3.2	32.832	2.3	23.598	.1	1.026	.2	2.05	.072	.739	.43	4.412	.016	.164
TOTAL ORE	88.50	26 550																
Cinder, Scale, Scrap, etc.	11.50	3 450	61.25	2 113.125	7.9	272.550	1.3	44.850	1.5	51.750	.4	13.80	.155	5.348	.59	20.355	.112	3.864
TOTAL—MIX	100.00	30 000	50.33	15 100.341	7.3	2204.310	2.6	767.346	.3	103.824	.2	66.90	.081	24.167	.73	217.617	.026	7.756
Coke	51.68	15 505			5.3	821.765	3.1	480.655	.3	46.515	.2	31.01	.021	3.256			.921	142.801
Stone	25.78	7 733			2.7	208.791	1.5	115.995	51.5	3982.495	1.3	100.53	.031	2.397			.070	5.413
Dolomite																		
TOTAL CHARGE						3234.866		1363.996		4132.834		198.44		29.820		217.617		155.970
Reduced						341.791								29.820		145.078		4.819
Slagged						2893.075		1363.996		4132.834		198.44				72.539		151.151

PIG IRON PRODUCED

	THEORETICAL Pounds	THEORETICAL %	ACTUAL %
Fe	15 100.341	94.00	
Si	160.642	1.00	1.25
S	4.819	.030	.030
P	29.820	.185	.158
Mn	145.078	.903	1.03
TOTAL	16 064.2	100.000	
TOTAL TONS PRODUCED			

SLAG PRODUCED

	THEORETICAL Pounds	THEORETICAL %	ACTUAL %
SiO_2	2 893.075	32.70	33.82
Al_2O_3	1 363.996	15.42	15.71
Ca O	4 132.834	46.72	47.24
Mg O	198.440	2.24	2.03
Mn O	93.641	1.06	1.01
Fe O		.15	.15
S	151.151	1.71	1.73
TOTAL	8 846.407	100.00	101.69

PRODUCT RATIOS

Slag per Ton	1 234	Lbs.
" " "	= 55.1	%
" $\frac{CaO+MgO}{SiO_2}$	= 1.4	
Coke per Ton	= 2 162	Lbs.
Mix to Coke	= 1.93	
Stone to Mix	= 25.78	%

Figure 4. The burden sheet, a form of technical communication that was added to the 2nd edition.

The 2nd (1920) volume added a sample “Burden Sheet” (see Figure 4), a textual aid for keeping track of the various combinations of fuel, flux, and ore. While the steel bible was maturing as technical communication, so was the use of technical communication as an aid to industry.

4th (1925) Edition

Between the 2nd and 4th editions, there were two major changes: an entire section was added, “The Manufacture of Steel Wire, Sheet Metal and Tubular Products,” and the number of photos increased from 19 to 139. Eighty-eight (63%) of these photos are in the new section (which is 27% of the text). Thus, when they added the new section to describe additional processes they used photos from the factory floor. Many of the photos were taken inside the plants while it was in operation so the backgrounds are dark and smoke sometimes obscures the machinery. Many of the photos include workers. Thus, although the text does not undergo revisions (it has additions), we can see the beginning of a fuller use of visual material to help explain the physical reality of making iron and steel. Figure 5 is a comparison of the image-to-page ratio, which began to increase begin with the 4th edition.

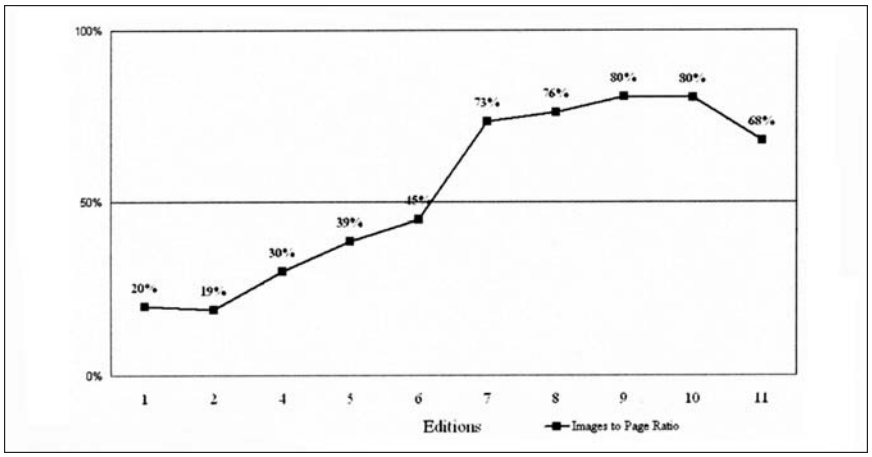


Figure 5. A comparison of ratios of the number of images to the number of pages.

THE MIDDLE EDITIONS

The middle (5th 1940, 6th 1951, and 7th 1957) editions of the steel bible undergo the most change. First, *The Making, Shaping and Treating of Steel* grew from a small, hand-held volume printed on thin paper to a massive desktop volume with thick glossy paper and sophisticated page layout. As seen in Figure 2, the weight and amount of text in each volume continued to grow (the apparent drop in number of pages between the 6th and 7th editions is due to a change in size from 6" by 9" to 7-3/4" by 10-5/8"). It no longer looked like a bible: it became a heavy desktop reference. These three volumes spanned the time before and after World War II, when the steel industry grew rapidly, incorporating many technological improvements. These were some of the most prosperous years for the steel industry, for both workers and owners. The authorship moved from being the work of an individual to an anonymous group. The technological advances were swift and were reflected in the increasing visual sophistication of the page layout, the quality of the paper, and the ever-increasing number of photographs and graphic images.

5th (1940) Edition

The 1940 edition was a bridge between the authorial and the anonymous voice. J. M. Camp died in 1927 and so C. B. Francis was responsible for the 1940 volume, which was published after a 15-year gap. The major difference between this and the previous texts is that each chapter ends with references to outside sources. There had been citations in the earlier volumes, but they were few and far between. Francis began his brief preface in a odd way: “This, the fifth edition of this book,

reveals little knowledge not available through other sources." It is possible that Francis was told to include sources even though the text did not change from previous versions, for whom the original sources were the lectures delivered on the factory floor. Each chapter ends with a section called "References" which are numbered but not mapped to locations within the text. They are a bibliography of the writing done on the subject matter of the chapter. There is also a section in this volume that is not repeated in the others—"Modern Steels and Special Processes—Ferrous Products Classified." This chapter was one of the many attempts to define "steel" [3]. In the next 6th (1951) edition, this discussion is gone, replaced with one line: "this term is generic rather than specific" (p. 371). The definition of steel was a site of international industrial contention for many years [4, pp. 16-17].

Although the 5th edition is still largely text-based (retaining the same text as the earlier editions), the number of photographs continued to grow. The two photographs in Figure 6 are from this edition. Today, we take photographs for granted: the ability to see photographically is so deeply embedded within our culture that we cannot see how much it has changed. William Ivins wrote,

> the exactly repeatable pictorial statement in its photographic forms has played an operational role of the greatest importance in the development of modern science and technology of every kind. It has become an essential to most of our industries and to all of our engineering [5, p. 179].

The tanks in the second picture contain acid at 140 to 180 degrees (pickling is removing iron oxides from the surface). The photograph is able to convey a sense of the immediate reality of the physical environment in a way that words never can. These photographs and the hundreds of others like them were used to document and communicate the industry and its processes.

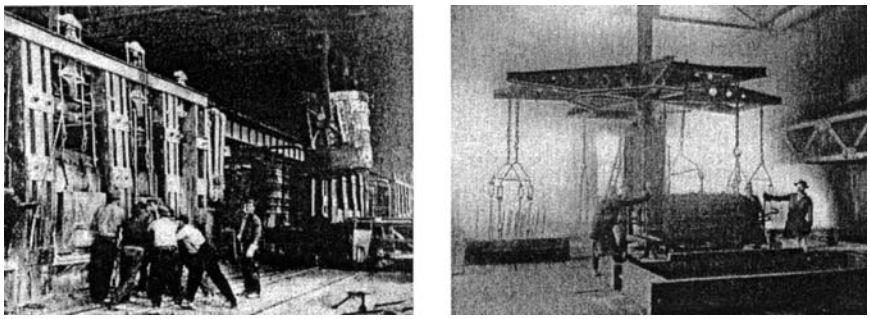


Figure 6. Typical photos, "View of charging side of furnace at tapping" and "Mesta pickling machine in operation showing vapors rising toward the ventilator" from 5th (1940) edition showing steel workers, the plants, and the machinery (pp. 417 and 1190).

6th (1951) Edition

This volume is a pivotal one in the evolution of the steel bible. Although in shape it resembles the earlier editions (it is still small enough to be carried), this is the first volume that was authored by a group. The passionate, metaphoric, and literary introduction "Iron, the Master Metal," seen in the conclusion to this article, is gone. Instead this edition begins with a clear and concise description of the basic physical properties of iron and steel and the most common processing methods. The volume is still attributed to Camp and Francis ("A Complete Revision Based on the Original Text by J. M. Camp and C. B. Francis") but they specifically say "The present sixth edition is no longer the exclusive work of any specific authors. It . . . represents the result of cooperative efforts of numerous authors, editors and reviewers, supervised by research personnel of the United States Steel Company" (p. vii). And, for the first time, the preface is unsigned; there is no authorial name connected to this volume.

This volume uses visual communication much more than the previous editions. An early critique of the steel bible, mentioned in the 4th (1925) edition, was that "some parts of the book were not adequately illustrated for readers" (p. vi). There are schematic diagrams on pull-out pages that show the layout and parts of the plants supporting the different major processes (open hearth, Bessemer, etc.). It is probable that, with the team approach, they were able to hire an illustrator (or illustrators). Almost every page uses a graphic, photo, table, or list to break up the space visually. As seen in Figure 7, the hand-drawn graphics describing electrical processes have been replaced by graphics composed with specialized

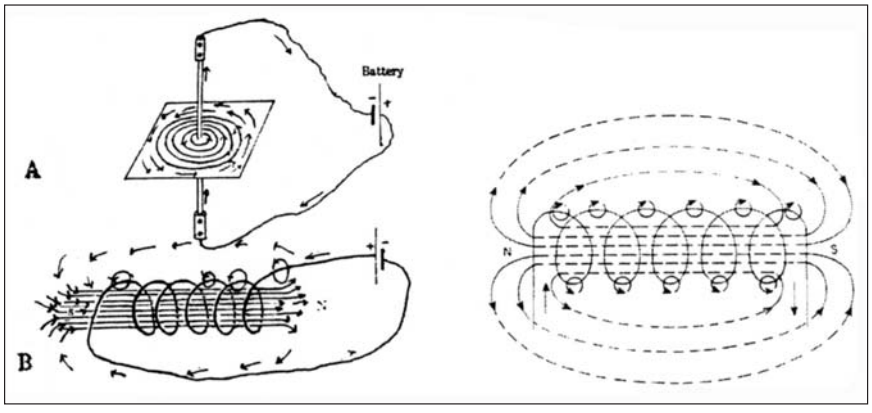


Figure 7. Drawings of the same subject from the 5th (1940, p. 464) and 6th (1951, p. 48) editions: "Lines of force in the current bearing helix" and "Magnetic field about a solenoid carrying a current."

tools. In this case, the new schematic diagram is not as clear as the hand-drawn one (the schematic design appears to be two-dimensional whereas the hand-drawn one conveys three dimensions).

The table of contents is reorganized for the first time. The separate sections that correspond roughly to making, shaping, and treating (with the addition of specific products in the 4th edition) are now gone. There are 38 consecutive chapters that follow a different logic—making, shaping, products, treating and testing. All the types of products (merchant iron, tubes, and wire) are moved together and the technical and chemical specifics of heat treatment and alloys are at the end, followed by testing. Although this seems to be a small change, it opened the way for the volume to proceed more logically and to reflect current changes in technology. They also made other changes that reflected the changing technology and assumptions of basic knowledge, including moving the discussion of electricity from the chapter "The Manufacture of Steel in Electric Furnaces" into the chapter "Some Fundamental Principles of Chemistry and Physics."

7th (1957) Edition

This volume marks the move to the large-format, desktop volume. The book is less intimate and more like a reference: it is too large and heavy to carry easily. However, the larger format is a leap forward for the visual layout (see Figure 8). The earlier editions never open fully or lay flat for reading. The space on their pages is too small to have extensive drawings. Thus, even though there are photos, it is difficult to see them in the crowded format. Here the photos are much clearer, the pages lay open by themselves, and the illustrations are larger. In this volume, we can see the maturing of the methods of visual communication. The page layout helps to guide the eye to remembered locations and the visuals provide instant communication regarding the topic of the chapter or section without having to read and decipher words. Walter Ong wrote "one visualizes some kind of structure in space made up of recognizable parts standing in fixed relations to one another and then associates what one wishes to memorize with the various parts of the structure" [6, p. 105]. By arranging the text on the page with graphics, the authors were instinctively providing a visual indexing system for the user.

In the preface to the 7th edition they kept the policy of anonymity but list that "A total of approximately 200 individuals took part in this activity, their contributions ranging from authorship of entire chapters to extensive rewriting of existing material, supplying illustrative material and critically reviewing and editing the manuscript" (p. viii). In past volumes, historical material about the iron and steel industry was distributed throughout the volume, short histories appearing near the processes they described. In this volume, there is a consolidation of historical material into one section called "Iron in Antiquity." There are also additions and deletions of processes that have come into use or fallen into disuse.

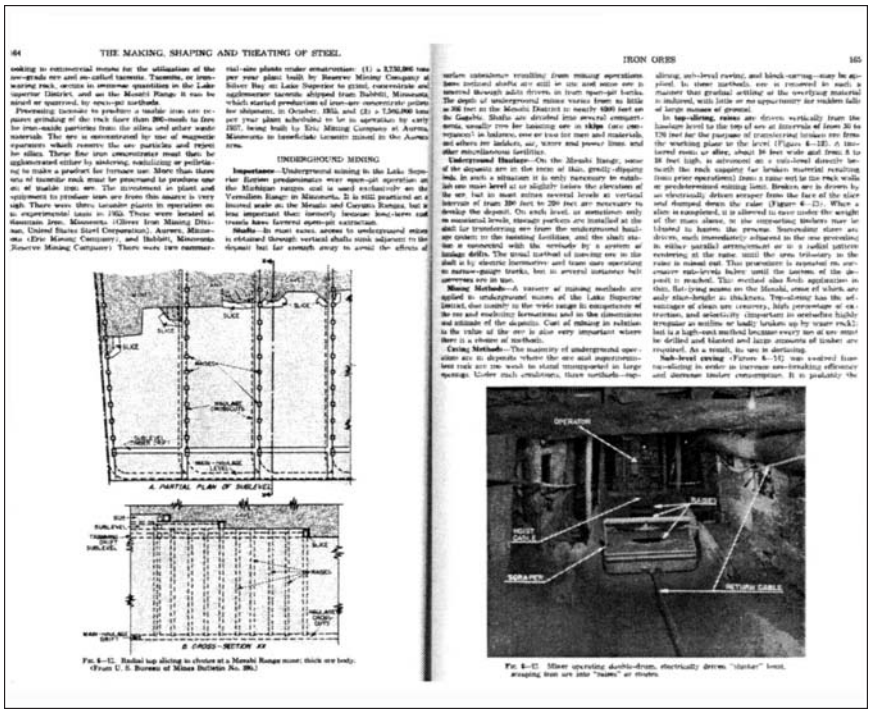


Figure 8. Page layout in the large format editions—this explanation of mining processes is illustrated with drawings and photographs and the text is organized by bolding and heading levels [7th edition, pp. 164-165].

THE LATE EDITIONS

8th (1964) Edition and 9th (1971) Edition

These two volumes are discussed together because they are very similar. By this date, the publication of *The Making, Shaping and Treating of Steel* had become a systematized and repeatable production. The preface to the 9th (1971) edition outlines the parts of the process: "collecting information and illustrations, writing new material, updating former chapters, checking manuscripts for completeness and accuracy, and providing other necessary services." Although it is still a group project, there is an editor, Harold E. McGannon, and the author's names are listed: in the 8th (1964) edition, 57 authors and 11 fact-checkers are listed as well as a graphic artist, Miss M. H. Snyder and a proofreader, Miss H. E. Kaiser; in the 9th (1971) edition, there is a total of 98 contributors (including all tasks). Production of the volume was an organized and delineated group effort.

The drawings and photos reached a consistently high quality. New photographs were able to capture clarity and detail that was not possible in the earlier volumes, partially due to the high-quality paper used in these volumes, partly due to advances in photography. In the photograph in Figure 9, for example, the photographer was able to capture a process *in medias res*, without having darkness and steam cloud the image. Some of the content changes point to changes in the industry and economy during this time period. For instance, discussion of iron mining was discontinued and now, for the first time, ores from outside the United States—Canada, Mexico, South America, West Africa—are described. At the time these changes were being made, social changes were affecting the steel industry that would eventually make it an international, rather than an American, concern. By this time, iron mining in the United States had largely ceased.

10th (1985) Edition

The preface to the 10th edition summarizes the history of *The Making, Shaping and Treating of Steel*, stating that "more than 230,000 copies were distributed to steel users, steel-plant employees, trainees in industry, students in technical schools and college, writers, librarians, and others here and abroad . . . " (p. vii). More significantly, although this edition was largely written by United States

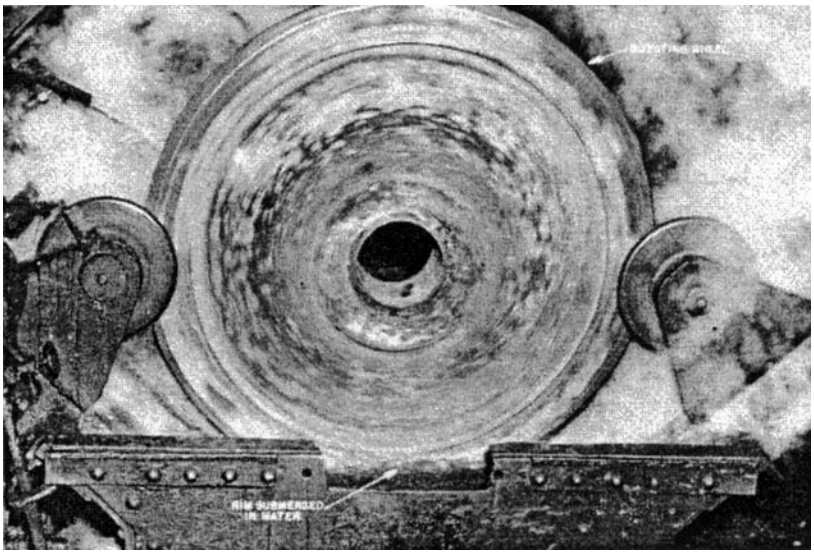


Figure 9. Improving photographic technique "Wheel undergoing quenching of the rim by being rotated in a special machine designed so that only the rim of the wheel contacts the quenching medium" [8th edition, p. 733].

Steel employees, it was published by the Association of Iron and Steel Engineers—in the aftermath of the closing of many plants and the downsizing of the corporation, U.S. Steel had transferred the rights to the AISE. 1973 was the year of U.S. Steel's greatest steel output (35 million tons) and 1986 was the year with the smallest output (9.6 million tons). The number of employees dropped, during that time, from 184,794 to 63,915. During the next several years, the number of employees continued to drop to 19,353 in 2000 [2, pp. 364-365]. Presently, U.S. Steel is part of USX, which makes high value-added steel with complex chemistries for specific markets in the United States [7]. The majority of the mass production of steel had moved to other countries. The social and economic upheaval occasioned by these changes received only a nod in the 10th (1985) edition in the sentence: "Today's steel industry faces many challenges" (p. vii). This is an understatement, given the neighborhoods that were abandoned, the lost jobs, and the changed lives. However, it is also reflective of stoicism in the industry in general, as well as of an understanding of historical circumstance—the iron and steel industries have always been subject to the vicissitudes of economic conditions, supply and demand. From the beginning of ironmaking in America, thousands of companies have formed, grew, and failed; stability was the exception, rather than the norm.

11th (1998, 1999) Edition

In the following years, the AISE consolidated with the Iron and Steel Society and changed its name to the Association for Iron and Steel Technology (AIST). It also transferred the rights to *The Making, Shaping and Treating of Steel* to the AIST Foundation, which is "dedicated to the advancement of the iron and steel industry of North America through training, publications, research, electronic resources and other related programs of benefit to the industry" [8]. The AIST Foundation planned to continue publishing *The Making, Shaping and Treating of Steel,* but they split the content into five volumes. They also provided a timetable that is mentioned in the prefaces to the first two volumes:

Ironmaking Volume (1998)
Steelmaking and Refining Volume (1998)
Casting Volume (1999)
Flat Products Volume (2000)
Long Products Volume (2000)

The *Steelmaking and Refining Volume* appeared in 1998, the *Ironmaking Volume* appeared in 1999, and the *Casting Volume*, on CD only, appeared in 2004. There are no present plans to complete the series [9]. Unlike the previous editions, the preface mentions the economic context. It refers to "massive changes in steel industry economics that had occurred during the 1980s and early 1990s . . . occasioned by restructuring, downsizing, and wholesale implementation of new and improved technology" (p. vii).

The 11th (1998/99) edition is very different from the others. It was written by expert authors invited "from individual steel companies, the steel industry supplier base, and several universities with close association with the steel industry" (p. vii). For the first time in its 80-year history, the volume began with a photograph of the editor and biographies of each author, 35 in the 1998 edition and 32 in the 1999 edition. The chapters are also signed by authors. The references are much more extensive than in the past. They are in IEEE style and international in scope, referring to conference and symposium proceedings, transactions, personal communications, and speeches, in addition to books and articles. The paper is lighter and not glossy.

Overall, the format of the book is more controlled and predictable, perhaps due to computerized formatting. The outline is numbered with levels. There are many equations, which have their own, separate numbering system in the right margin (as seen in Figure 10). There are fewer words on each page but the type is larger and easier to read. The tables, for the first time, are shaded to set them apart from the rest of the text. The number of photographs dropped significantly from all previous volumes (20 in the steelmaking (1998) and 42 in the ironmaking (1999) version). The 11th edition is a more stylized abstraction of knowledge, less tied to physical human processes. This may have been inevitable since the human processes which it describes physically moved away from the site of publication.

ANALYSIS

Audience Analysis

One of the features of the steel bible in general is that the authors took the audience into account. From the first editions, they were trying to correct issues that had been raised by the readership. As early as the 4th (1925) edition, the authors thanked their readers and critics:

> Their frank expressions have been a great aid in overcoming some of the shortcomings of the previous editions. For example, the two chief faults found with the former editions were that some parts of the book were not adequately illustrated for readers who do not have the advantage of access to the mills, and that the scope of the work did not justify the title (p. vi).

This attention to the readership continued through the 80 years of the volume. Several of the prefaces in the steel bibles named the intended audiences, such as that in the 4th (1925) edition which stated that the book was written for "employees of Carnegie Steel Company, employees of the other subsidiary companies of the United States Steel Corporation, customers of these companies, students of Ferrous Metallurgy in colleges and universities, and the general reader who desired a work for reference" (p. v). Audience analysis data collection may have happened through inter and intra-office communication, letters from readers,

2.5.3 Iron Oxide in Slags

Iron oxide dissolves in slags in two valency states: divalent iron cations Fe^{2+} and trivalent iron cations Fe^{3+}. The ratio Fe^{3+}/Fe^{2+} depends on temperature, oxygen potential and slag composition; this is discussed later in this section. In the formulation of the equilibrium constants of slag-metal reactions and the thermodynamic activities of oxides in slags, the total iron dissolved in the slag as oxides is usually converted to the stoichiometric formula FeO and denoted by Fe_tO, thus

$$\%Fe_tO = \%FeO \text{ (analyzed)} + 0.9 \times \%Fe_2O_3 \text{ (analyzed)} \quad (2.5.11)$$

or

$$\%Fe_tO = 1.286 \times \%Fe \text{ (total as oxides)} \quad (2.5.12)$$

For the ease of understanding, the subscript t will be omitted in all the subsequent equations and diagrams.

2.5.4 Selected Ternary and Quaternary Oxide Systems

Most steelmaking slags consist primarily of CaO, MgO, SiO_2 and FeO. In low-phosphorus steelmaking practices, the total concentration of these oxides in liquid slags is in the range 88 to 92%. Therefore, the simplest type of steelmaking slag to be considered is the quaternary system $CaO–MgO–SiO_2–FeO$.

First let us consider the ternary system $CaO·SiO_2–FeO$; the liquidus isotherms of this system is shown in Fig. 2.53. The isothermal section of the composition diagram in Fig. 2.54 shows the phase equilibria at 1600°C.

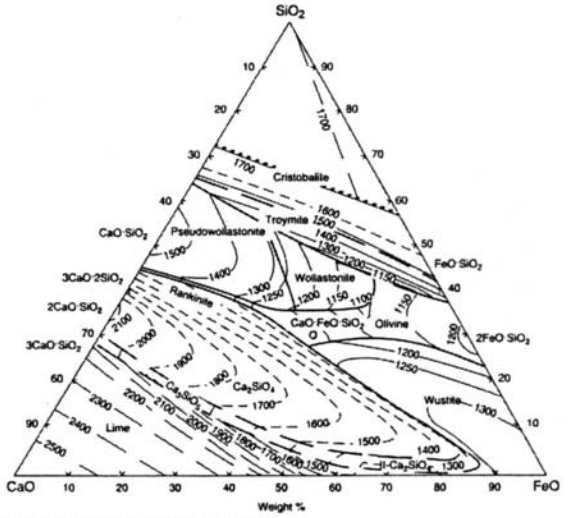


Fig. 2.53 Liquidus isotherms of $CaO–SiO_2–FeO$ system.

81

Figure 10. An example of a page with numbered headings, an equation and an illustration from the 11th (1998) edition published by the AIST Foundation.

occasional conversations and other informal communications. However, U.S. Steel never kept records about its distribution or its use [10, pp. 1, 8].

In 1984, the Communications Design Center (CDC) at Carnegie-Mellon University (1979–1990) published a usability study for *The Making, Shaping and Treating of Steel*. In their systematic data collection, the study authors "never encountered a person who had not at least heard of MSTS" and, for most people, it

was "the reference of first resort" [10, pp. 15, 33]. For the first 10 editions, U.S. Steel subsidized the publication of the book, and it was so popular that some owners took it home and read it at bedside [10, p. 21]. The authors discovered that most book owners obtained the book in college or were given a copy when they first started their job and once they owned it, they owned it for life [11, pp. 15, 16]. One of the reasons it was so popular was that it provided information about how the various aspects of the steel industry fit together [10, p. 18].

What is most interesting, however, is that in the study authors discovered that readers found their information by leafing through the pages [10, p. 38]. Most often readers were looking for specific information on a specific topic and they located the correct page by using the visual clues embedded in the page. Also, half the time they found the material in a visual object (tables, diagrams, charts, drawings, photographs) and half the time they found it in the text [10, p. 4]. More will be said about this in the "Visual Analysis" section of this article, but it is interesting to note that in an industry as complex and including as many different processes and technologies as the steel industry, visual communication was paramount. This report made some suggestions that were followed in the 11th (1998/1999) edition, such as the addition of more footnotes and references to use as resources for further reading, but overall it could not forestall the inevitable. The study authors were right when they wrote "It is quite possible that many of these [steel] mills will no longer be in operation by the time the next edition of the book is published" [10, p. 25].

Textual Analyses

The text in the steel bible largely changed only when the technology changed. Much of the text is repeated verbatim from volume to volume and any additions were made at the end of a paragraph or section. The main form of textual change was the addition or deletion of entire sections, largely occurring between the 5th (1940) and 7th (1957) editions (the 11th edition is so different that it barely resembles the earlier editions). The overall structure, as evidenced in the table of contents, was also completely revised in the 6th (1951) edition, the first group edition, and was modified only slightly thereafter. Textual changes reflected the changing technology—for instance, the section on "Fuels" grew as the importance of coke byproducts grew, as did the sections on electric furnaces, heat treatment, and alloys.

The textual style changed slowly as well. The voice of the original authors was literate and didactic (see the quote in the conclusion). Gradually it changed from a respectful author addressing a broad audience to an objective description of the empirical world directed to a more sophisticated reader. This change in voice began with the first group edition (1951) and was most pronounced in the last (1998/1999) edition. An example of sentence style from the 1st (1919) edition is "Rolling mills are somewhat like houses. Thus, while they are alike as to

gross features, they differ greatly as to the details of construction" (p. 358). An example from the 11th (1998/1999) edition is "In many metallurgical operations the rate is not controlled by a single reaction step such as mass transfer or chemical kinetics but rather two steps in series such as mass transfer followed by chemical kinetics" (p. 47). In the first quote, a didactic voice is still present but in the second, the authors assume a knowledge of scientific style on the part of the reader.

Visual Analysis

The steel bible showed an increasing use of visual communication throughout its development as seen in Figures 11 and 12. With each edition the images grew in number and sophistication. The sudden decline of photos and images in the 11th edition was probably due to the decline in the steel industry itself: U.S. Steel was no longer subsidizing the publication and providing expertise and images from the steel plants.

The group authors of the steel bible seemed to have instinctively known that including many visuals in the layout created the most efficient form of communication. As mentioned by the authors of the CDC analysis, the reader "leafs through trying to use graphic displays as a key to the content on the particular pages" [10, p. 5]. This is an example of the power of visual mnemonic

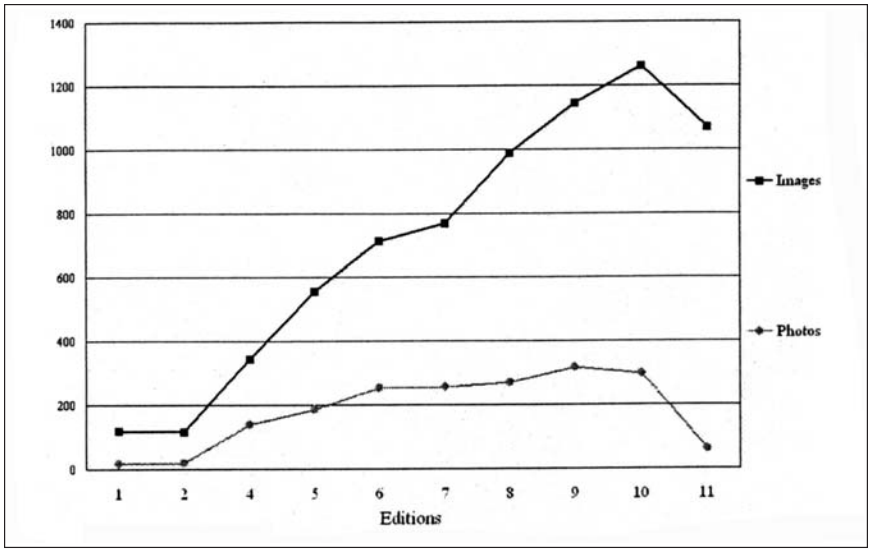


Figure 11. A comparison of the number of figures (illustrations) and photos in each edition.

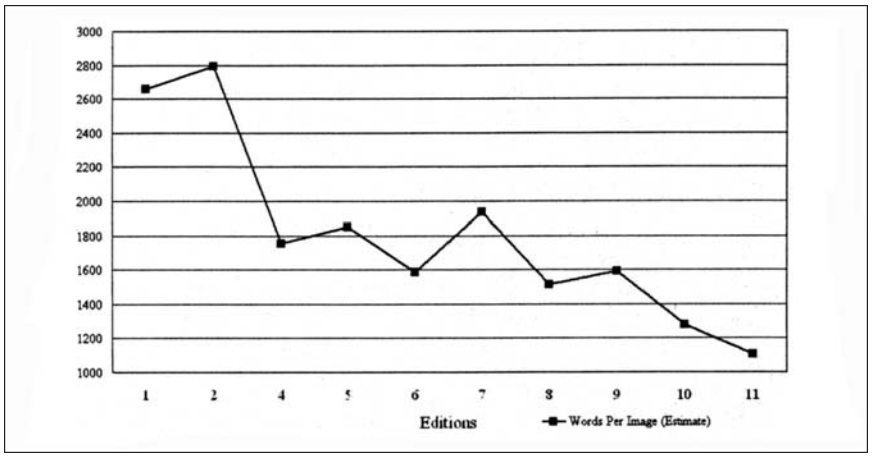


Figure 12. An approximate comparison of the number of words to the number of images.

clues, an idea described by Ong, Tebeaux, and Schriver [11]. In order to locate remembered material on the page, users look for an image or layout that they remember appearing near that information. Text itself, a dense block with few physical clues, is not as immediately accessible. Specific sections of text can be more easily located by scanning visual content. This visual formatting of text began in the Renaissance with the Ramist method of organizing page content: paragraphs, tables, and centered headings were used to "show diagrammatically how 'specials' are subordinated to 'generals'" [6, p. 184]. Thus, graphics, tables, drawings, and photos are important both in conveying information and also in that they provide contextual clues as to the location of textual information.

Visual communication was an essential part of the growth and popularity of *The Making, Shaping and Treating of Steel*. In fact, it is essential to our present technological abilities: both the printed word and the printed image have made our way of life possible. We live in a culture so inundated with visual information that we forget that, if it were not for the ability to draw, share and compare pictures, we could not have created the extremely complex and widely dispersed technology that we depend on for nearly every aspect of our lives. As William Ivins wrote:

> The exact repetition of pictorial statements has had incalculable effects upon knowledge and thought, upon science and technology, of every kind. It is hardly too much to say that since the invention of writing there has been no more important invention than that of the exactly repeatable pictorial statement [5, p. 3].

Visual communication was essential to the development and sharing of ideas about technology and how things work. The reliance of complex industry on visual communication is illustrated in the growth of images in the steel bible.

CONCLUSION

The early editions of the steel bible resembled a bible in feel and appearance: the cover and pages were soft and flexible, the edges gilt, the pages thin. One can only imagine the feeling of the steel plant employees when receiving this book—like a bible, it contained hope for the future (albeit of a material and technological kind). The emergence of the steel bible may have been a cynical attempt, on the part of management, to reduce widespread labor unrest and humanize the workplace; other texts, such as newsletters were created for this purpose as well [12, pp. 16-17]. It may also have been a replacement for religion since, until the 12-hour work day was abolished in 1923, most workers could not attend church. Many workers did what was called the "long turn," where they worked from 7 A.M. to 6 P.M. for two weeks, then worked from 7 A.M. Sunday to 7 A.M. Monday, whereupon they switched to the night shift of 6 P.M. to 7 A.M. The following Sunday they were off, but they were usually so tired they slept [13, p. 11]. However, the steel bible remained silent on these issues, just as it remained largely silent on the decline of the industry itself.

Texts such as *The Making, Shaping and Treating of Steel* have been part of the working stream of life and yet they are seldom subject to critical examination. The first four steel bibles began with these words, quoted at length here to illustrate the metaphorical value of iron in our lives:

> *Iron, the Master Metal:* In beginning this rather brief study of the metallurgy of the most important metal of a metallic age, it is difficult to refrain from pointing out a few of the qualities that have made iron the master metal, although its importance really needs no comment here. A little reflection shows it to be as vital to modern civilization as air and water are to life; and it has become so common that, like air and water, its true importance is lost sight of by most people, who look upon its abundance as a matter of course and value it accordingly. No other one metal has contributed so much to the welfare and comfort of man. There is scarcely an article used in our daily lives that has not been produced from iron or by means of it. Consider bread as an example. Plows made of iron turn the soil, harrows of iron level it, and drills of iron sow the seed; machines of iron harvest the wheat and thrash it; rolls of iron crush the grain to separate the flour; engines of iron bring the flour to our homes, where it is made into dough in iron pans and baked in an iron stove; finally the bread is sliced from the loaf with an iron knife, and served to us at a table made with iron tools (p. 1).

Northrop Frye wrote an analysis of the Bible in which he talks about the three historical phases of language, the hieroglyphic (mythical), the hieratic

(aristocratic), and demotic (vulgar). The last phase, the one in which we live now, is the demotic, or common age. That phase has made our technological world possible because its language is descriptive, allowing "the growth of science on a basis of inductive observation" [14, pp. 5, 14]. *The Making, Shaping and Treating of Steel* is an example of demotic writing, of instinctual human ingenuity and of group work. Like iron, common writing such as *The Making, Shaping and Treating of Steel* often goes unnoticed. That is unfortunate, since demotic writing often reveals the way the world works.

APPENDIX
The Making, Shaping and Treating of Steel Editions

Camp, J. M. and C. B. Francis, *The Making, Shaping and Treating of Steel*, Pittsburgh: Carnegie Steel Company Bureau of Instruction, 1919.

Camp, J. M. and C. B. Francis, *The Making, Shaping and Treating of Steel*, 2nd edition, Pittsburgh: Carnegie Steel Company Bureau of Instruction, 1920.

Camp, J. M. and C. B. Francis, *The Making, Shaping and Treating of Steel*, 2nd edition, 2nd printing, Pittsburgh: Carnegie Steel Company Bureau of Instruction, 1920.

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ACKNOWLEDGMENTS

This article was inspired by Robert English who handed me the 1925 edition of *The Making, Shaping and Treating of Steel* and said "Are you interested in this?" I am also indebted to the NJIT Interlibrary Loan Office, who can find almost anything.

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Another Article On Communication By This Author

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