History of Structural-Steel Handbooks

By R. Fleming*

A number of handbooks of unusual interest lie before the writer.[1] The oldest, undated and unpaged, was published by the Phoenix Iron Co. in 1869 and is believed to be the first handbook issued by a manufacturer explaining in detail the use of iron for structural purposes. The book consists of 24 pages 3¼x5 in., 13 of which are taken up with the title, advertisements and lists of the Phoenix products, seven with tables and formulas; four are headed "Memorandum" and left blank. The engineering data are a table of the compressive strength of wrought and cast-iron columns, the Gordon column formula, a formula for the flexural strength of beams, and tables giving the safe loads of I-beams and deckbeams. The products listed are seven diameters of Phoenix columns, eight depths of I-beams, five of deck beams, three of channels, eleven sizes of equal-legged and six of unequal-legged angles, six sizes of T-bars, miscellaneous shapes and round, square and flat bars. The Phoenix Iron Co. issued the first edition of its handbook, "Useful Information for Architects, Engineers and Workers in Wrought Iron," a book of 124 pages 4x6½ in., in 1873 or 1874 (the book is undated).

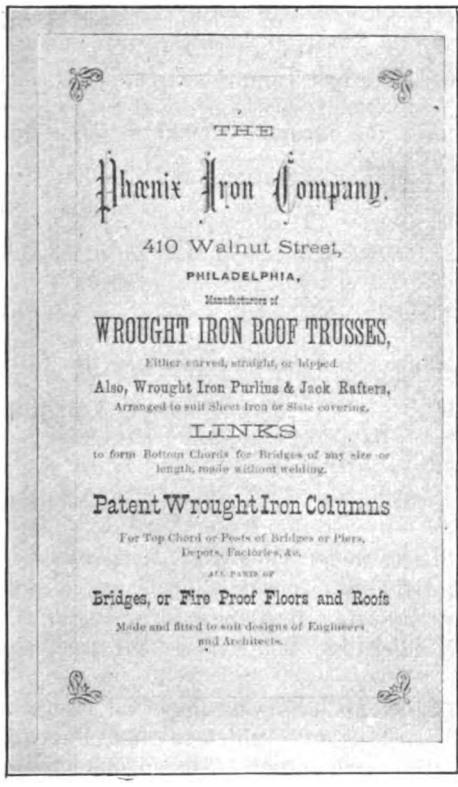

THE
Phœnix Iron Company.
410 Walnut Street,
PHILADELPHIA,
Manufacturers of
WROUGHT IRON ROOF TRUSSES,
Either curved, straight, or lipped.
Also, Wrought Iron Purlins & Jack Rafters,
Arranged to suit Sheet Iron or Slate covering.
LINKS
to form Bottom Chords for Bridges of any size or length, made without welding.
Patent Wrought Iron Columns
For Top Chord or Posts of Bridges or Piers, Depots, Factories, &c.
ALL KINDS OF
Bridges, or Fire Proof Floors and Roofs
Made and fitted to suit designs of Engineers and Architects.

FIG. 1. THE 1869 POCKET-BOOK WAS A PRICES-CURRENT

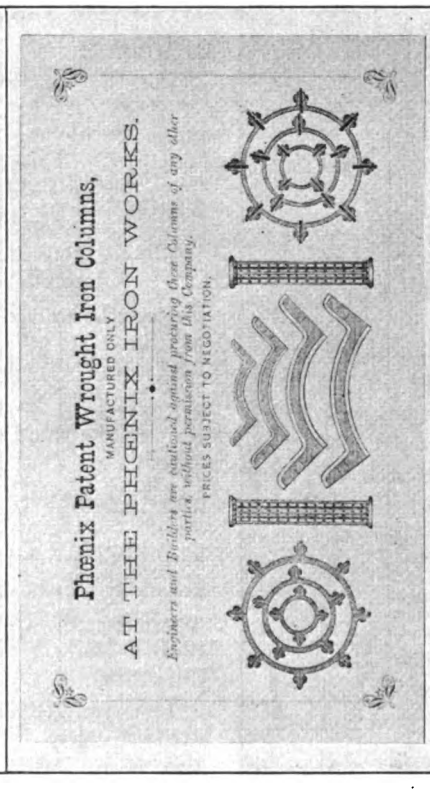

Phœnix Patent Wrought Iron Columns,
MANUFACTURED ONLY
AT THE PHŒNIX IRON WORKS.
Engineers and Builders are cautioned against procuring these Columns of any other parties, without permission from this Company.
PRICES SUBJECT TO NEGOTIATION.

FIG. 2. ILLUSTRATION FACING TABLE OF PHŒNIX COLUMNS

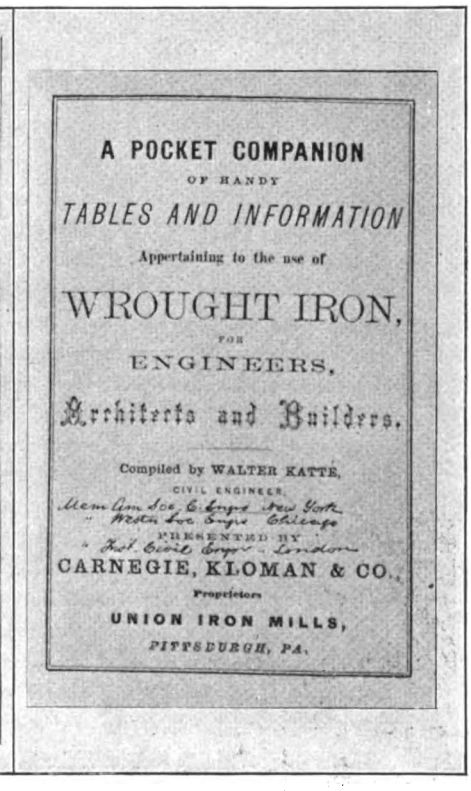

A POCKET COMPANION
OF HANDY
TABLES AND INFORMATION
Appertaining to the use of
WROUGHT IRON,
FOR
ENGINEERS,
Architects and Builders.
Compiled by WALTER KATTÉ,
CIVIL ENGINEER.
Mem. Am. Soc. C. Engrs. New York.
" Mech. Soc. Engrs. Chicago.
PRESENTED BY
" Inst. Civil Engrs. London.
CARNEGIE, KLOMAN & CO.,
Proprietors
UNION IRON MILLS,
PITTSBURGH, PA.

FIG. 3. TITLE-PAGE OF FIRST CARNEGIE—From Mr. Katté's own copy

Another early book, the second in chronological order, is entitled "Rolled Iron Beams Made by the New Jersey Steel and Iron Co."; it is dated 1871 and consists of 22 unnumbered printed pages 3¼x5¼ in. The beams listed comprise nine depths and eighteen weights, ranging from a 4-in. beam of 2.01-sq.in. area to a 15-in. beam of 20.02-sq.in. area. The safe load, deflection, correction for lateral deflection, strength as a strut and moment of inertia are given for each beam; also tables of weights of flat, round and square iron and of bolts and rivets. In 1876 the New Jersey Steel and Iron Co. published an enlarged handbook of 81 pages and three plates. Later editions bore the title "Useful Information for Engineers, Architects and Constructors, and Tables of Rolled Beams, Channels, Angles, etc., made by the New Jersey Steel and Iron Co." Pages and plates were added as warranted.

The third book in order of time is the first edition of the widely known "Carnegie." The title page reads "A Pocket Companion of Handy Tables and Information Appertaining to the Use of Wrought Iron, for Engineers, Architects and Builders. Compiled by Walter Katté, Civil Engineer. Presented by Carnegie, Kloman & Co., Proprietors Union Iron Mills, Pittsburgh, Pa." The cover bears the date 1873. The book contains 70 pages, 30 of which are taken up with Carnegie products. The weights, dimensions, properties, safe loads and deflections of beams and channels are fully given. Miscellaneous information and tables complete the rest of the book. Page 14 is headed "Sir Charles Fox's Rules for Proportion of Heads and Pins for Upset Links," and on the next page there is a "Table Showing the Saving in Iron, Effected by the Use of Bolts with Upset Ends."

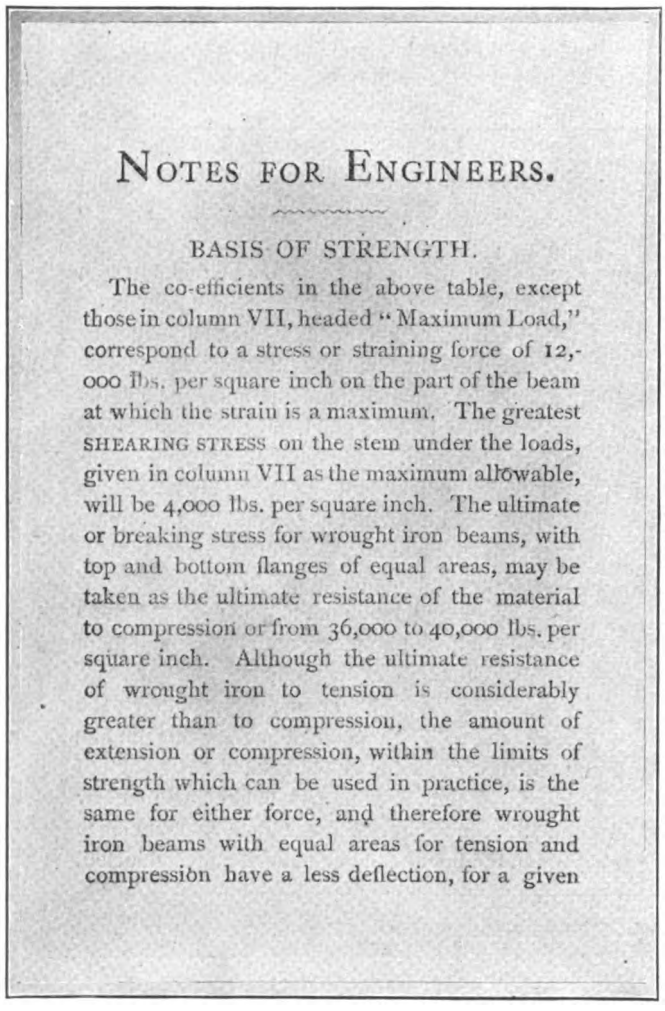
Another book of interest is the Carnegie Brothers & Co.'s "Pocket Companion," second edition, 1876. The first 30 pages are taken up with the table of contents and lithographs of rolled sections; Part First follows with 60 pages giving "Description and Elements of the Union Iron Mills, Rolled I-Beams, Deck Beams, Channel Bars, Angle Iron, T-Iron, etc., etc., with the Tables of Coefficients When Used as Floor Beams, Rafters, or Struts and

*American Bridge Co., 30 Church St., New York City.

[1]The writer is indebted to N. R. McLure, Chief Engineer of the Phoenix Iron Co., for the use of early Phoenix handbooks and to R. B. Woodworth, of the Carnegie Steel Co., for information regarding editions of the Carnegie "Pocket Companion."

Pillars"; Part Second fills 80 pages with "Miscellaneous Information for Engineers, Builders and Mechanics." A limited edition of the "Pocket Companion" was printed for distribution at the Centennial Exposition at Philadelphia. It was given mainly to important personages.

The evolution of a handbook is well illustrated in the long line of editions of this "Pocket Companion." No other handbook has been so widely circulated; of the fifteenth edition (1903) over 100,000 copies were distributed. The seventh edition (1892) contained data on both iron and steel, the profile cuts indicating by distinctive colors what sections were rolled in one or both materials. The eighth edition (1893) showed steel sections only and



NOTES FOR ENGINEERS.

BASIS OF STRENGTH.

The co-efficients in the above table, except those in column VII, headed "Maximum Load," correspond to a stress or straining force of 12,000 lbs. per square inch on the part of the beam at which the strain is a maximum. The greatest SHEARING STRESS on the stem under the loads, given in column VII as the maximum allowable, will be 4,000 lbs. per square inch. The ultimate or breaking stress for wrought iron beams, with top and bottom flanges of equal areas, may be taken as the ultimate resistance of the material to compression or from 36,000 to 40,000 lbs. per square inch. Although the ultimate resistance of wrought iron to tension is considerably greater than to compression, the amount of extension or compression, within the limits of strength which can be used in practice, is the same for either force, and therefore wrought iron beams with equal areas for tension and compression have a less deflection, for a given

FIG. 4. PAGE FROM THE TRENTON 1871 BOOK, A PIONEER STRUCTURAL POCKET-BOOK

marks approximately the end of the use of wrought-iron beams and channels.

Passing from these pioneer books to those of the present day—with a tribute to the excellence of the Pencoyd handbook, "Steel in Construction," no longer published—we find the field now covered by the handbooks of the Bethlehem Steel Co., 1911, 120 pages; Cambria Steel Co., 1916, 513 pages; Carnegie Steel Co., 1916, 434 pages; Jones & Laughlin Steel Co., 1916, 388 pages; Lackawanna Steel Co., 1915, 456 pages; and Phoenix Iron Co., 1915, 248 pages.

The "Catalog of Bethlehem Structural Shapes" is, as called, a catalog rather than a handbook. The Bethlehem company handbook, "Structural Steel," issued in 1907, has not been continued. Only one edition was printed.

The information given in the Phoenix book is confined mainly to the properties of iron and steel. The introduction states, "No attempt has been made to compile a textbook covering the design of steel structures."

A brief comparison of these books may be of interest. They necessarily have much in common, and each manufacturing firm gives prominence to its own products. They contain a wealth of data and information invaluable to the structural engineer. The personal equation always enters into the selection of material for a compilation. Cambria devotes 23 pages to areas and circumferences of circles, giving two tables, one advancing by tenths and another by eighths, for diameters ranging from 0 to 100. Twelve pages are given to square and round bars. Carnegie, Jones & Laughlin and Phoenix give an unusually complete table of the functions of numbers from 1 to 1000. Phoenix devotes 30 pages to an exhaustive table of weights per lineal foot of steel plates from $\frac{3}{16}$x1 in. to 1½x120¾ in. for each $\frac{1}{16}$ in. of thickness and ¼ in. of width.

For the safe load in direct compression on steel columns Bethlehem uses the formula $16{,}000 - 55\frac{l}{r}$ for lengths over 55 radii of gyration and 13,000 for lengths under 55 radii; Carnegie and Phoenix use $19{,}000 - 100\frac{l}{r}$ for lengths from 60 to 120 radii, 13,000 for lengths under 60 radii and $13{,}000 - 50\frac{l}{r}$ for lengths over 120 radii; Cambria and Lackawanna use the Gordon formula, $P = \frac{12{,}500}{1 + \frac{(12L)^2}{36{,}000r^2}}$; Jones & Laughlin uses $16{,}000 - 70\frac{l}{r}$ for lengths between 30 and 150 radii and 14,000 for lengths under 30 radii. Carnegie, followed by Jones & Laughlin, considers loads on column brackets. Both err in using Rankine's formula for eccentric loading to determine the stresses for the case illustrated.

The strength assigned to beams unsupported laterally varies greatly. According to Bethlehem and Phoenix 80% of the tabular strength should be taken for a beam having a span 40 times the flange width without lateral supports. According to Cambria 73% should be taken, while Carnegie and Jones & Laughlin give 43%. Lackawanna makes no mention of beams unsupported laterally. This omission is unfortunate, for the inexperienced are liable to use the full tabular strength for all beams. Carnegie, followed by Jones & Laughlin, gives very convenient tables of the allowable uniform load on beams and channels in pounds per lineal foot.

The subject of grillage foundations is taken up by all except Lackawanna. It is noted that they agree in locating the maximum bending moment of a grillage beam at the center of the beam, correcting a grievous error found in some earlier editions. There is not the same agreement, however, in the determination of bearing plates for beams. Carnegie and Jones & Laughlin include calculations of rolled-steel slabs.

The location of the principal axis of unequal-legged angles is given in Cambria and Lackawanna. For the location of the principal axis of Z-bars it is necessary to refer to earlier editions of Cambria.

Cambria, Carnegie, Jones & Laughlin and Lackawanna give a formula for wind pressure on roofs, but it is the old Hutton or Unwin formula that has long been discredited.

Cambria fills 22 pages with an elaborate analysis of the building laws of 31 cities. This seems longer than necessary, for building codes are changed so often that these pages cannot be quoted as authority. Moreover, a clause in one part of a code is sometimes modified by a clause in another part which a tabulation fails to show. The two pages of "Contents of Storage Warehouses" in Carnegie are original and valuable. Wooden beams and columns receive attention in 21 pages of Cambria and in a dozen of Carnegie and Jones & Laughlin. Cambria and Carnegie give a few pages to reinforced concrete.

The question will here be raised, Why not have a standard notation for beam flexure? Why should Bethlehem and Cambria use such diverse systems? Or why should Jones & Laughlin and Lackawanna differ as they do? At present every textbook on mechanics or stresses is a law unto itself in its notation and is liable to remain so as long as there is no agreement among compilers of handbooks.

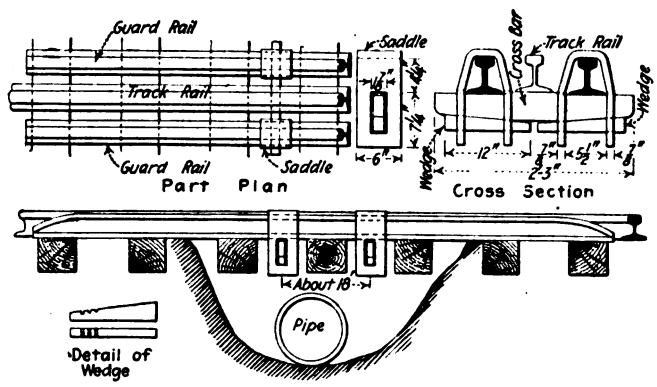
In concluding, attention is called to two leading English handbooks. The "Pocket Companion" of Dorman, Long & Co., Ltd., 1915, xl + 240 pages, is similar to American handbooks and calls for no special remarks. Of course, English terminology is used throughout.

The handbook No. 16, July, 1915, "Structural Steel," of R. W. Skelton & Co., 320 pages 6½x8½ in., is unique in its contents, arrangement, thumb-indexing and typography. It is stated in the introduction, "Except for the mathematical tables or where express acknowledgment is made to the contrary, the contents of this book are entirely original both in substance and form." The scope of the book is confined mostly to structural steel. Alone among the handbooks mentioned it quotes the well-established Duchemin formula for wind pressure on roofs. The "Nomogram" is introduced, and a number of these diagrams are found throughout the book. The notes regarding delivery of steel of the various sections are especially valuable. A few pages are given to "American" standard beams, channels and specifications. The last 20 pages are taken up with photographs of structures fabricated by Skelton & Co.

Supporting Tracks Across Trenches

Digging trenches through railway fills for culverts, pipe lines, etc., usually necessitates placing timbers and blocking under the ties, with increased excavation to put in this timbering. A method devised to reduce the amount and cost of such excavation consists in the use of short guard rails on either side of the track rails, carrying saddles with crossbars that support the track rails, as shown in the drawing.

The guard rails are about 10 ft. long, with ends beveled so as not to catch hanging chains or hose. Pieces of scrap rail can be utilized. These rails are laid on the ties, so as to span the location of the trench. Over each rail is placed a saddle having slots in the vertical legs below the level of the rails. A crossbar of 1¾-in. iron, with bottom sides tapered, is slipped through the legs of the two saddles, and wedges driven beneath it in the slotted holes force it to a bearing against the base of the track rail. For a trench 4 ft. wide one support is considered sufficient, while for a 5-ft. trench two supports should be used and the sides of the cut braced to prevent caving.



DEVICE FOR SUPPORTING RAILWAY TRACK ACROSS TRENCHES

This device is in service on a number of railways. It is the invention of R. S. Bohannan and is made by the Bohannan Easer Joint Co., of Ensley, Ala.

Barge with Plow Lays Cables 12 Ft. Below Bottom of Channel

By Paul J. Ost*

The City of San Francisco operates four drawbridges over narrow waterways where the regular traffic averages more than two boats per hour. At one of these bridges it was necessary to lay a new submarine signal cable having an outside diameter of 1¾ in., and at another bridge two control and signal cables, each having an outside diameter of 4 in. The channel, spanned by both of these bridges, has not been dredged for some time, and the present mud line is more than 10 ft. above the level to which the channel will be dredged. In order to lay the cable below the dredge line, it was necessary to sink it through about 12 ft. of fairly soft mud. The traffic, the character of the mud and expense made the dredging of a trench out of the question. The Butte Engineering and Electric Co., San Francisco, which had the contract for the work, devised the equipment described and illustrated.

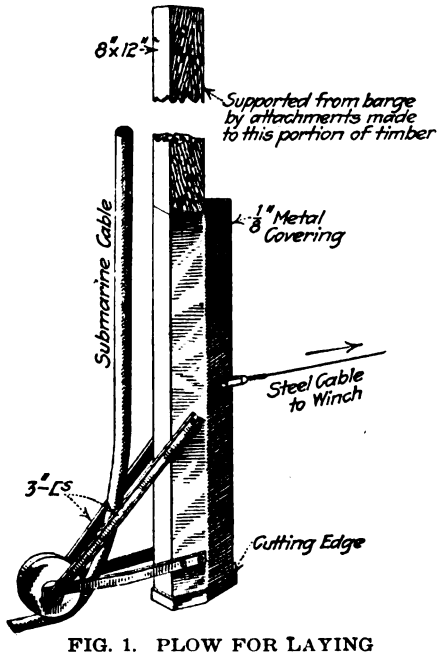


FIG. 1. PLOW FOR LAYING SUBMARINE CABLE

*Electrical Engineer, Bureau of Engineering, City of San Francisco.