TRAUTWINE

THE CIVIL ENGINEER'S REFERENCE-BOOK

(formerly "Pocket-Book")

BY

JOHN C. TRAUTWINE

AND

JOHN C. TRAUTWINE. JR.

CIVIL ENGINEERS

EDITED BY

JOHN C. TRAUTWINE 3d, C.E.

CHAPMAN & HALL, Ltd.
LONDON

RENOUF PUBLISHING CO.
MONTREAL

Printed in U. S. A.

HADDON CRAFTSMEN
Printers and Binders
CAMDEN, N. J.

PREFACE

TO FIRST EDITION, 1872.

SHOULD experts in engineering complain that they do not find anything of interest in this volume, the writer would merely remind them that it was not his intention that they should. The book has been prepared for *young* members of the profession; and one of the leading objects has been to elucidate, in plain English, a few important elementary principles which the savants have enveloped in such a haze of mystery as to render pursuit hopeless to any but a confirmed mathematician.

Comparatively few engineers are good mathematicians; and in the writer's opinion, it is fortunate that such is the case; for nature rarely combines high mathematical talent, with that practical tact, and observation of outward things, so essential to a sucressful engineer.

There have been, it is true, brilliant exceptions; but they are very rare. But few even of those who have been tolerable mathematicians when young, can, as they advance in years, and become engaged in business, spare the time necessary for retaining such accomplishments.

Nearly all the scientific principles which constitute the foundation of civil engineering are susceptible of complete and satisfactory explanation to any person who *really* possesses only so much elementary knowledge of arithmetic and natural philosophy as is *supposed* to be taught to boys of twelve or fourteen in our public schools.*

* Let two little boys weigh each other on a platform scale. Then when they balance each other on their board see-saw, let them see (and measure for themselves) that the lighter one is farther from the fence-rail on which their board is placed, in the same proportion as the heavier boy outweighs the lighter one. They will then have learned the grand principle of the *lever*. Then let them measure and see that the light one see-saws farther than the heavy one, in the same proportion; and they will have acquired the principle of *virtual velocities*. Explain to them that *equality of moments* means nothing more than that when

The little that is beyond this, might safely be intrusted to the savants. Let them work out the results, and give them to the engineer *in intelligible language.* We could afford to take their words for it, because such things are their specialty; and because we know that they are the best qualified to investigate them. On the same principle we intrust our lives to our physician, or to the captain of the vessel at sea. Medicine and seamanship are their respective specialties.

If there is any point in which the writer may hope to meet the approbation of proficients, it is in the accuracy of the tables. The pains taken in this respect have been very great. Most of the tables have been entirely recalculated expressly for this book; and one of the results has been the detection of a great many errors in those in common use. He trusts that none will be found exceeding one, or sometimes two, in the last figure of any table in which great accuracy is required. There are many errors to that amount,

---

they seat themselves at their measured distances on their see-saw, *they balance each other.* Let them see that the weight of the heavy boy, when multiplied by his distance in feet from the fence-rail amounts to just as much as the weight of the light one when multiplied by his distance. Explain to them that each of the amounts is in *foot-pounds.* Tell them that the lightest one, because he see-saws so much faster than the other, will bump against the ground just as hard as the heavy one; and that this means that *their momentums are equal.* The boys may then go in to dinner, and probably puzzle their big lout of a brother who has just passed through college with high honors. They will not forget what they have learned, for they learned it *as play,* without any ear-pulling, spanking, or keeping in. Let their bats and balls, their marbles, their swings, &c, once become their philosophical apparatus, and children may be taught (*really* taught) many of the most important principles of engineering before they can read or write. It is the ignorance of these principles, so easily taught even to children, that constitutes what is popularly called "THE PRACTICAL ENGINEER;" which, in the great majority of cases, means simply an ignoramus, who blunders along without knowing any other reason for what he does, than that he has seen it done so before. And it is this same ignorance that causes employers to prefer this practical man to one who is conversant with principles. They, themselves, were spanked, kept in, &c, when boys, because they could not master leverage, equality of moments, and virtual velocities, enveloped in x's, p's, Greek letters, square-roots, cube-roots, &c, and they naturally set down any man as a fool who could. They turn up their noses at science, not dreaming that the word means simply, *knowing why.* And it must be confessed that they are not altogether without reason; for the savants appear to prepare their books with the express object of preventing purchasers, (they have but few *readers,*) from learning why.

especially where the recalculation was very tedious, and where, consequently, interpolation was resorted to. They are too small to be of practical importance. He knows, however, the almost impossibility of avoiding larger errors *entirely;* and will be glad to be informed of any that may be detected, except the final ones alluded to, that they may be corrected in case another edition should be called for. Tables which are absolutely reliable, possess an intrinsic value that is not to be measured by money alone. With this consideration the volume has been made a trifle larger than would otherwise have been necessary, in order to admit the stereotyped sines and tangents from his book on railroad curves. These have been so thoroughly compared with standards prepared independently of each other, that the writer believes them to be absolutely correct.

In order to reduce the volume to pocket-size, smaller type has been used than would otherwise have been desirable.

Many abbreviations of common words in frequent use have been introduced, such as abut, cen, diag, hor, vert, pres, &c, instead of abutment, center, diagonal, horizontal, vertical, pressure, &c. They can in no case lead to doubt; while they appreciably reduce the thickness of the volume.

Where prices have been added, they are placed in footnotes. They are intended merely to give an approximate or comparative idea of value; for constant fluctuations prevent anything farther.

The addresses of a few manufacturing establishments have also been inserted in notes, in the belief that they might at times be found convenient. They have been given without the knowledge of the proprietors.

The writer is frequently asked to name good elementary books on civil engineering; but regrets to say that there are very few such in our language. "Civil Engineering," by Prof. Mahan of West Point; "Roads and Railroads," by the late Prof. Gillespie; and the "Handbook of Railroad Construction," by Mr. George L. Vose, Civ. Eng. of Boston, are the best. The writer has reason to know that a new edition of the last, now in press, will be far

superior to all predecessors; and better adapted to the wants of the young engineer than any book that has appeared.

Many of Weale's series are excellent. Some few of them are behind the times; but it is to be hoped that this may be rectified in future editions. Among pocket-books, Haswell, Hamilton's Useful Information, Henck, Molesworth, Nystrom, Weale, &c, abound in valuable matter.

The writer does not include Rankine, Moseley, and Weisbach, because, although their books are the productions of master-minds, and exhibit a profundity of knowledge beyond the reach of ordinary men, yet their language also is so profound that very few engineers can read them. The writer himself, having long since forgotten the little higher mathematics he once knew, cannot. To him they are but little more than striking instances of how completely the most simple facts may be buried out of sight under heaps of mathematical rubbish.

Where the word "ton" is used in this volume, it always means 2240 lbs.

There is no table of errata, because no errors are known to exist except two or three of a single letter in spelling; and which will probably escape notice.

JOHN C. TRAUTWINE.

PHILADELPHIA, *November* 13th, 1871.

FROM PREFACE

OF TWENTIETH EDITION, 1918.

As in our preceding editions, all new work and all revisions have been the subject of our personal attention, and "scissors-and-paste" methods have been scrupulously avoided.

As in all cases heretofore, every rule and every formula and every description of methods, etc., can be readily understood by anyone, engineer or layman, understanding the use of common and decimal fractions, of roots and powers, of logarithms, and of elementary plane trigonometry. On the other hand, one who is not possest of this very meagre stock of mathematical knowledge will hardly approach engineering problems, even as an amateur . . .

. . . Extraordinary precautions have been taken for the protection of our readers against the occurrence of typographical and other errors. In this, as in previous editions, special attention has been given to the matter of typography, which, like other steps in manufacture, has been under our own direct personal control. This includes the preparation of illustrations . . .

The manuscript was thoroly checkt before it was sent to the printer. The first proof was minutely read by ourselves, as well as by the printer. In this work we used a new apparatus, of our own invention, to facilitate the verification of punctuation, of bold and italic characters, etc. Another device of our own was used in comparing successive proofs, to detect any accidental shifting of type matter. . . .

JOHN C. TRAUTWINE JR.
JOHN C. TRAUTWINE 3D.

Philadelphia, *August, 1918.*

PREFACE

TWENTY-FIRST EDITION, 1937

While the fundamental editorial policies well known for the past sixty-five years have been adhered to in the preparation of new material for this edition, yet changed conditions have prompted certain minor alterations of method.

In 1872, any new device was made usually by only one manufacturer, and the name of device and of manufacturer were often practically inseperable. Many an engineering project was new in character and method, and to describe it without identifying it seemd needlessly incomplete.

By 1937, however, nearly every device made for the engineer has become so nearly standardized that only one familiar with the many products of different manufacturers can discern the differences between them. Also, many engineering projects are almost repetitions of many others done about the same time, so that often it has been idle to state where the work was done.

Therefore, except where a product seems unusually promising, or where an engineering operation has outstanding novel characteristics, we have made it our practis to omit special cases, and to present, as it were, a "composit picture" of what has been done.

At first sight, a statement that a certain machine can be had with a capacity of from five to fifty tons, may seem entirely too indefinit. However, such a statement avoids the erroneus idea that is sure to obtain when the old practis is followd of describing some one machine of perhaps thirty tons capacity, and another of forty. Similarly, to cite, as of old, that the cost of earthwork on some one project was seven cents per cubic yard, and nine cents on another, is again misleading when the average may be nearer fifteen, and the range from four to forty.

Nor do we go into detail nearly as much as formerly in the solving of special or illustrative problems. Most engineering problems nowadays have many factors to be considerd. Indeed, any one type of problem may have special cases involving different factors. It is expected that the user of the book is able to figure out his own special cases from formulas and from the rather comprehensiv statements that we try to present.

In new matter prepared, we have used a type with exceptionally wide face, which we believ will be found much easier to read than the more usual type faces used heretofore.

The new material on Hoisting, Conveying and Excavating Machinery, together with that on Dredging which first appeared in the 3rd issue of the 20th edition, constitutes a rather complete exposition of the larger "tools" making up the "plant" of the contractor or constructing engineer.

As usual in our work, data have been collected, condenst and sometimes tabulated, and then studiusly arranged, especially as regards classification, headings, and the bold-facing of catch-words, to make it as easy as possible (especially in conjunction with the Index and Table of Contents) for the engineer to find what he needs, and to make as certain as possible that all will be clear.

The "decimal" method of paragraf or "section" numbering (first applied to the Price List) should help greatly in understanding the relation of any one paragraf to others in its vicinity. For example, it becomes easy to realize that 6.4291, Costs, relates to 6.429, Operation, of 6.42, Trucks, which are treated as a subdivision of 6.4, Automobiles, under the general head 6.0, Vehicles. Also, it will be understood that all paragraf numbers beginning with the figures 6.42, *e g*, relate to Trucks. Inasmuch as any one subject can seldom be naturally divided into exactly ten sub-heads, the omission of any final figures from 0 to 9 does not mean that any subjects have been omitted. Thus, the omission of sections 6.422 to 6.427 inclusiv resulted from the need for only three sub-divisions of 6.42.

We present a new Isogonic Chart and a map and table of Standard Times. The material on Location of the Meridian has been revised and all figures recomputed for another ten or twenty years.

The article on Hoisting, Conveying and Excavating Machinery has had the benefit of many practical suggestions, and has been verified by Major Wm. H. Balch, who has had long experience with such machines with the Aberthaw Construction Co., Winston & Co., and in the World War.

JOHN C. TRAUTWINE 3D.

Ithaca, N. Y., *July 1937*

Pages xii to xix inclusive are here omitted and reserved, in order to provide space for future additions to Prefaces or to the Table of Contents.

CONTENTS.

Specific Gravity.

Weights and Measures.

Surveying.

NATURAL PHENOMENA.

Sound.

Heat.