





EX LIBRIS  
SOLOMON  
CADY  
HOLLISTER





THE CONWAY TUBULAR BRIDGE.

125

PRINCIPLES  
OF  
THE MECHANICS  
OF  
MACHINERY AND ENGINEERING.

BY JULIUS WEISBACH,  
PROFESSOR OF MECHANICS AND APPLIED-MATHEMATICS IN THE ROYAL MINING  
ACADEMY OF FREIBERG.

FIRST AMERICAN EDITION.

EDITED  
BY WALTER R. JOHNSON, A. M., CIV. & MIN. ENG.  
WASHINGTON, D. C.

FORMERLY PROFESSOR OF MECHANICS AND NATURAL PHILOSOPHY IN THE FRANKLIN INSTI-  
TUTE, AND OF CHEMISTRY AND NATURAL PHILOSOPHY IN THE MEDICAL  
DEPARTMENT OF PENNSYLVANIA COLLEGE. AUTHOR OF A  
REPORT TO THE UNITED STATES NAVY DEPART-  
MENT ON AMERICAN COALS & C. & C.

IN TWO VOLUMES.

ILLUSTRATED WITH EIGHT HUNDRED AND THIRTEEN  
ENGRAVINGS ON WOOD.

VOL. II.  
APPLIED MECHANICS.

PHILADELPHIA:  
LEA AND BLANCHARD.  
1849.

Hollister

TA

350

W42

1848

v.2

ENTERED according to the Act of Congress, in the year 1849, by

LEA AND BLANCHARD,

in the Clerk's Office of the District Court of the Eastern District of Pennsylvania.

PHILADELPHIA :

T. K. AND P. G. COLLINS, PRINTERS.

## PREFACE BY THE AMERICAN EDITOR.

---

IN submitting to the American reader the second volume of Weisbach's *Mechanics of Machinery and Engineering*, we cannot, perhaps, better express our own appreciation of the value of this part of his labors, than by citing a passage from the advertisement of the English translator, Prof. L. Gordon.

“The usefulness of this second volume will be manifest from the practical interest and importance of the subjects treated. The first part of the volume, though far from giving a complete theory of engineering and architectural construction, brings many important questions of practice before the student in a simple form, and in a light by which he will more readily recognize the bearings of the mathematical calculations on this subject, than has been usually the case in English works. The second part of the volume contains the only Theoretical Treatise on Water Power of the least practical value hitherto printed in the English language. The real *importance* of such a treatise will be variously estimated; but as it is the first publication in which a systematic attempt is made to familiarize English Machinists with the application of exact reasoning in developing the theory of the machines treated of, it is believed that it must be interesting to them, and if so, it cannot fail to be useful likewise.”

The most available treatise on the numerous forms of reaction wheels, and other turbines to which the American student has access, is believed to be embraced in this volume. The author, it may be observed, has not contented himself with giving a general theory on that subject, but by skillfully analyzing the several effects produced, and computing separately the prejudicial and the useful resistances

to the action of the water, has presented conclusions challenging the highest confidence, especially as they stand confirmed, in most cases, by the results of numerous direct experiments.

In reference to the water-pressure engine, also, it may be said that the present volume will afford to the American student the most direct and positive information as to the useful application of water in that species of motor.

In the original work of Prof. Weisbach, the second volume embraced the science applicable to the steam engine, but as that subject has now assumed so distinct an importance, and as its numerous topics and improvements could scarcely be presented with sufficient clearness, in a less space than an entire volume, it has been deemed expedient, in imitation of the English translator, to reserve that branch of the mechanics of engineering for a separate treatise.

In assigning to their appropriate chapters the additions of the translator, which had in the English edition been thrown into the form of an appendix, we have been guided by a desire of rendering the work more serviceable to the student, by placing before him the whole matter pertaining to each branch under its appropriate head.

We have added a few articles particularly relating to the strength of materials, which, we hope, may not be found uninteresting to the student. Indeed, when we take into view the lamentable, and often wilful and obstinate disregard of the truths which science has elicited relative to this department of our subject; when we see machines and engines intended to perform the most powerful operations, and edifices, or monuments, designed to endure for ages, constructed of materials, either utterly worthless, or, at best, of very inferior character and durability, or containing in their composition the elements of weakness and decay, we may estimate, with some justness, the importance of those researches and computations, which prove what may be expected from the employment of good or bad materials respectively, for any of the purposes of the architect and engineer.

The fact that the public has often been basely imposed upon by reason of employing as architects and engineers those who would pander to the cupidity of contractors for materials and labor, and



erect public works wholly discreditable to the nation, is an additional reason why works, written for the purpose of imparting correct information on the physical properties and the relative values of materials, ought to be diligently studied by those who desire correct and reliable knowledge.

The list of illustrations which we have added will much facilitate reference to the several topics to which they relate, and the execution of the cuts, with the creditable manner in which they have been used by the printer, will be sufficiently apparent to the most casual observer.

WASHINGTON, *August*, 1849.



## AUTHOR'S PREFACE.

---

IN writing this, the second volume, I have adhered as closely as possible to my views of what the work should be, as explained in the preface to the first volume.

I am aware that these views are not adopted by all who are capable of judging in the matter, and that a more general and mathematical treatment of the subject would have been preferred by many. But I have now long experience in teaching to fall back upon, and am thereby convinced, that the comparatively elementary style adopted as it can be followed by those who have not made extensive mathematical acquirements, will more surely lead to the introduction of applications of Mechanical Science in the routine practice of engineers, than the more general methods of treating these subjects have done.

A basis on true principles and established facts, and simplicity in the method of analysis, are the main requisites in a work intended for the instruction and guidance of practical men. And it is chiefly the want of these, in technical literature, that has retarded the introduction of science amongst those engaged in the execution of works, and the erection of machinery. If in evolving rules of art, imperfect facts be assumed, or unwarranted hypotheses be adopted—if the essential be not distinguished from that which is merely collateral, and if important considerations be neglected, it cannot be expected that the rules deduced, however correct the process of deduction, will be available for any useful application. But this is no uncommon fault. Authors forget that the mathematics can only *guide* our ideas, and not *give* us any: and thus, in admiration of their analytical processes, they often overlook the worthlessness of the premises. Hence it arises that practitioners not unfrequently reproach *theory* as valueless, whilst it is, in reality, the facts of the case that have been erroneously stated or applied. Besides, it is not an easy matter to deduce rules of art by the principles of

science; for this requires not only an intimate acquaintance with the subject investigated, but generally requires special observations or experiments to be made, in order to *create the facts*, so to speak, that are to be reasoned upon and reduced to a theory which shall interpret them.

In this second volume of his work, the Author has done his utmost to develop theories that will be found applicable in practice—to furnish the guide above alluded to—well aware, however, that his endeavors have only imperfectly succeeded.

This volume is divided into two parts; the first, the application of Mechanics in Construction, and the other to the theory of Machines recipients of Water and Wind Power. The Author regrets now his not having entered more at large into a discussion of the theory of the construction of wooden and stone bridges, and more particularly not to have been able to avail himself of the information contained in Ardant's *Etudes sur l'établissement des charpentes à grande portée*, as this subject is, in these times of railway extension, of especial importance (in Germany).

The second part of the volume is as concisely written as was consistent with the object I had in view. I now regret having been so brief on the important subject of Dynamometers. The chapter on Turbines may appear to some to err in excess, from my having given the details of the theory and construction of the old impact and pressure turbines; but I consider that it is important to be aware of the faults or imperfections of one construction of a machine, in order fully to appreciate the improvements introduced in a more perfect one. Again, the application of Water-pressure Engines, being almost entirely confined to the Mining Engineer's province, the fullness with which I have treated this engine may appear to exceed its relative importance. The circumstance, however, that there is no work in any language, that I am aware of, treating of these engines, must be my apology for attempting to fill that gap in technical literature.

I hope soon to preface a volume, containing a Treatise on Mechanism, and on the principle *Operators*, or machines performing various mechanical operations.

JULIUS WEISBACH.

FREIBERG, December, 1847.



# TABLE OF CONTENTS.

---

	PAGE
PREFACE BY THE AMERICAN EDITOR . . . . .	v
AUTHOR'S PREFACE . . . . .	ix

---

## SECTION I.

### THE APPLICATION OF MECHANICS IN BUILDINGS.

#### CHAPTER I.

The equilibrium and pressure of semi-fluids . . . . .	13
---	----

#### CHAPTER II.

Theory of arches . . . . .	27
----------------------------	----

#### CHAPTER III.

Theory of framings of wood and iron . . . . .	40
Strength of materials . . . . .	68

---

## DIVISION II.

### APPLICATION OF MECHANICS TO MACHINERY.

Introduction . . . . .	99
Rigidity of cordage . . . . .	102

## SECTION II.

## OF MOVING POWERS, AND THEIR EFFECTS.

## CHAPTER I.

Of the measure of moving powers, and their effects . . . . . 105

## CHAPTER II.

Of animal power, and its recipient machines . . . . . 121

## CHAPTER III.

On collecting and leading water that is to serve a power . . . . . 135

## CHAPTER IV.

Of vertical water wheels . . . . . 164

## CHAPTER V.

Of horizontal water wheels . . . . . 228

## CHAPTER VI.

Water-pressure engines . . . . . 298

## CHAPTER VII.

On windmills . . . . . 341

# LIST OF ILLUSTRATIONS.

NO.	PAGE
1. Angle of repose of disintegrated masses	13
2. Theory of the pressure of earth	14
3. Surcharged masses of earth	17
4. Retaining walls	18
5. Slipping of walls	19
6. Resistance of earth	20
7. Depth of foundations	21
8, 9. Heeling of retaining walls	22
10. Retaining walls with batter	26
11, 12. Dislocation of arches by slipping of voussoirs	28
13. Line of pressure and resistance	28
14, 15, 16. Dislocation of arches by rotation	29
17, 18, 19, 20. Equilibrium in reference to rotation	30
21. Stability of abutments	31
22, 23. Loaded arches	33
24. Test of the equilibrium of arches	34
25. Semicircular arches	36
26, 27, 28, 29, 30. Theory of framings of wood and iron	40, 41, 42
31, 32, 33. Thrust of roofs	42, 43
34. Compound roofs	44
35, 36. Supported rafters	45, 46
37. King posts	46
38, 39, and 40. Trusses	47, 48
41, 42, 43, 44, 45, and 46. Timber bridges	48, 49, 50
47. Roofs	50
48, 49, 50, 51, 52, 53, 54, 55, 56, 57, and 58. Posts	50, 52, 53
59, 60, 61. Braces or struts	54
62, 63, 64, 65, 66. Compound beams	55, 56
67. Lattice-framed beams	56
68, 69, 70. Curved beams	56, 57
71, 72, 73, 74, 75, 76, 77, 78, 79. Chain or suspension bridges	59 to 62
80, 81. Piers and abutments	66 and 67
82. Tenacity of iron, treated by thermotension	74
83. Conway tubular bridge	82
84, 85, 86, 87, 88, 89. Tubular bridges, detailed construction of	84, 85, 91, 92, 93
90, 91. Useful and prejudicial resistance	101, 103
92, 93, 94. Common balance	106
95, 96, 97, 98. Unequal armed balances	110 to 111
99, 100, 101. Weigh bridges	112 to 113

NO.	PAGE
102. George's weighing table	115
103, 104, 105, 106, 107. Index balances, or spring balances	116 to 118
108, 109, 110, 111. Friction brake	119 to 121
112 Dolly	123
113, 114. Diagrams of Bouguer's formula	124
115, 116, 117. Levers	127, 128
118, 119, 120, 121. Windlass	129, 130
122. Vertical capstans	131
123. Horse capstans	131
124, 125. Diagrams explanatory of horse gins	132
126, 127, 128. Tread wheels	133
129. Movable inclined plane	134
130, 132. Construction of weirs	137
131. Overfall weir	137
133. Manner of constructing wooden weirs	138
134. Sluice	138
135, 136. Height of swell	139
137, 138. Diagrams of back water	141
139, 140, 141, 142. Discontinuous weirs	142, 143
143. Amplitude of the back water	144
144, 145. Backwater swell	147, 148
146, 147. Dams	148, 149
148. Cross section of dykes	150
149. Stability of dykes	150
150. Offlet sluices for dykes	152
151, 152. Water leads	154
153, 154. Water tunnels	154
155, 156. Construction of water tubes	155
157. Flood gates	155
158. Syphon for waste water	155
159, 160. Sluices,	157, 158
161, 162, 163, 164, 165, 166, 167. Conduit pipes	159
168. Ventilator pipes	160
169. Waste cock	160
170. Forked pipes	162
171, 172. Overshot water wheels	167
173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183. Axles and gudgeons	170, 171, 172
184. Proportions of water wheels	172
185, 186, 187, 188. Form of buckets	174, 175
189, 190, 191. Line of pitch of buckets	176, 177
192, 193, 194, 195, 196, 197, 198, 199. Sluices	177, 178, 179, 180
200. Effect of impact	181
201, 202. Effect of water's height	183
203, 204. Number of buckets	186, 187
205, 206, 207. Effect of centrifugal force	188, 189
208, 209. Useful effect of wheels	192
210, 211, 212. High-breast wheels	196
213. Breast wheel with inside sluice	197
214, 215, 216. Overfall sluices	199
217, 218. Penstock sluices	201



LIST OF ILLUSTRATIONS.

XV

no.	PAGE
219, 220, 221, 222. Construction of the curb	202, 203, 205
223. Diagram of losses	206
224. Efficiency of breast wheels, diagram	210
225, 226. Undershot wheels	211
227. Wheel in straight course	213
228. Useful effect of undershot wheel	214
229. Boat mill	216
230. Poncelet's wheels	218
231, 232. Theory of Poncelet's wheels	219, 221
233. Curved water course	226
234, 235. Small wheels	227
236, 237, 238, 239. Impact wheels	229, 230, 231
240, 241. Impact and reaction wheels	232, 233
242, 243. Borda's turbines	234
244. Pit wheel	235
245. Burdin's turbines	236
246. Poncelet's turbine	238
247. Danaïdes or pear wheel	239
248. Diagram representing the reaction of water	240
249. Machine to measure the reaction of water	241
250, 251. Diagrams illustrating reaction	242
252, 253, 254. Reaction wheels	242
255. Whitelaw's turbine	245
256. Combe's reaction wheel	246
257. Cadiat's turbine	247
258. Redtenbacher's water-tight joint	247
259, 260, 261, 262, 263, 264. Fourneyron's turbine	248 to 553
265, 266. Cadiat's footstep for turbines	253, 254
267. Theory of reaction turbines, diagram	255
268. Sluices for turbines	264
269. Guide-curves of Callon's turbine	265
270. Sluice for impact and pressure turbines	266
271, 272. Diagrams to explain construction of guide-curve turbines	270, 272
273. Whitelaw's turbines	279
274. Comparison of turbines	281
275, 276. Fontaine's turbine	284
276, 277. Jonval's turbine	285, 286
278. Theory of Jonval's and Fontaine's turbine	286
279. Construction of the buckets	290
280, 281, 282, 283. Turbines with horizontal axes	295, 296
284, 285, 286, 287. Water-pressure engines	298, 299
288, 289, 290. Pressure pipes	300
291. Bend or knee piece	302
292, 293. The working piston	302
294. Compensation joint	303
295. Piston rod and stuffing-box	304
296, 297, 298, 299. Valves	304, 305
300, 301, 302. Slide-piston valves	306, 307
303. Valve gear	307
304, 305. Counter-balance gear	308, 309

NO.		PAGE
306, 307, 308.	Auxiliary water-engine valve gear	311 to 313
309, 310.	The valve cylinders	314
311.	Saxon water-pressure engine	316
312.	Huelgoat water-pressure engine	318
313, 314, 315.	Darlington's water-pressure engine	319 to 321
316, 317.	Adjustment of the valves	332, 335
318, 319, 320.	Chain wheels	339, 340
321.	Postmill	344
322, 323.	Smockmills	345, 346
324, 325.	Regulation of the power	347, 348
326, 327, 328.	Anemometers	351, 352
329.	Diagram representing the force of wind	353
330, 331.	Best angle of impulse	354, 356

Please note:

These pages were scanned  
as they appear in the original  
(no pages were skipped  
in the scanning process)

