A TREATISE

ON

BRIDGE ARCHITECTURE.

&c. &c. &c.

A

TREATISE

ON

BRIDGE ARCHITECTURE;

IN WHICH

THE SUPERIOR ADVANTAGES

OF THE

FLYING PENDENT LEVER BRIDGE

ARE FULLY PROVED.

WITH AN HISTORICAL ACCOUNT AND DESCRIPTION OF DIFFERENT BRIDGES ERECTED IN VARIOUS PARTS OF THE WORLD, FROM AN EARLY PERIOD, DOWN TO THE PRESENT TIME.

BY THOMAS POPE,

ARCHITECT AND LANDSCAPE GARDENER.

Exulting Science now disdains
The ties of custom's proud controul,
And breaks the rude and barbarous chains
That fetter'd down the free-born soul.

NEW-YORK:

PRINTED FOR THE AUTHOR,

BY ALEXANDER NIVEN, No. 120 Duane-Street.

1811

CONTENTS.

PART I.

PART II.

PART III.

PART IV.

TO THE

FRIENDS OF SCIENCE,

AND THE

PROMOTERS OF THE POLITE AND USEFUL ARTS

THROUGHOUT THE UNITED STATES OF AMERICA,

THIS SMALL

TREATISE

ON

BRIDGE ARCHITECTURE,

Is, with the utmost respect,

Humbly inscribed,

By their obedient servant,

THOMAS POPE.

SUBSCRIBERS,

IN

NEW-YORK,

TO T. POPE'S TREATISE ON BRIDGE ARCHITECTURE.

HIS EXCELLENCY DANIEL D. TOMKINS,
Governor of the State of New-York.

THE HONORABLE DE WITT CLINTON,
Lieutenant Governor of the State, and
Mayor of New-York.

P. Mesier, Esq. Alderman
James Warner, Esq, do.
Caleb Pell, Esq. do.
G. Buckmaster, Esq. do.
Richard Riker, Esq.
Assistant Att'y-General
Jacob Morton, Esq.
City Inspector
John W. Wyman, Esq.
Counsellor
C. D. Colden, Esq, do.
T. A. Emmet, Esq. do.
John M'Kesson, Esq. do.
J. A. Graham, Esq. do.
J. Wells, Esq. do.
J. Woods, Esq. do.
Henry Meigs, Esq. do.
Jonathan Williams, Esq.
Colonel of Engineers.
William Harris, D. D.
President of Columbia College
John Kemp, L. L. D.
Professor of Mathematics, Columbia College
Peter Wilson, L. L. D.
Columbia College
John Bowden, D. D.
Columbia College
John M. Mason, D. D.
Columbia College
Rev. John Henry Hobart
Rev. John X. Clarke

SUBSCRIBERS.

W. Lupton, Esq. Counsellor
B. Ledyard, Esq. do.
B. Tucker, Esq. do.
Adrian Hegeman, Esq. do.
George Wilson, Esq. do.
D. T. Blake, Esq. do.
Samuel Burritt, Esq. do.
H. Maxwell, Esq. do.
Isaac L. Kipp, Esq. Register in Chancery
J. L. Riker, Esq. Attorney
Samuel Harris, Esq. do.
R. Hatfield, Esq. do.
S. Simpson, Esq. do.
Robert Jaques, Esq. do.
P. G. Hildreth, Esq. do.
Chs. Graham, Esq. do.
W. E. Dunscomb, Esq. do.
William T. Cock, Gent.
Mr. William Ovington
Charles Clinton, Esq.
James Renwick, Esq.
Mr. W. Howell, Accountant
William Paulding, Jun. Esq.
D. Dunham, Esq. Mercht.
T. Fairchild, Esq. Mercht.
I. Riley, Esq.
G. F. Hopkins, Bookseller
Benj. Romaine, Esq.
Theodorus Bailey, Esq.
A. T. Goodrich, Esq.
H. Edgar, Junr. Esq.

Samuel L. Mitchell, M. D. F. R. S.
C. M. Graham, M. M. D.
Stephen Allen, M. D.
Archibald Bruce, M. D.
Jotham Post, jun. M. D.
David Hosack, M. D.
D. P. Adams, Mathematician
Robert R. Livingston, Esq President of the New-York American Academy of Arts
John R. Murray, Esq. Vice President of do.
Robert Fulton, Esq. one of the Directors of do.
J. I. Holland, Esq. Arc't.
William Bridges, do do
J. M'Comb, Junr. do do
Joseph F. Mangin, do do
Joseph Newton, Builder
John E. West, Builder
George Ireland, Builder
Henry Hedley, Builder
James Ronalds, Builder
Isaac Sharpless, Builder
William Tilton, Builder
Edward Probyn, Builder
Garnsey & Finch, Builders
Joseph Board, Builder
N. Bogart, Junr. Builder

SUBSCRIBERS.

R. Dickey, Esq. Mercht.
John Delafield, Gent.
J. K. Paulding, Esq.
Augustus Wright, Esq.
Joshua Sands, Esq.
C. M. Gomez, Esq
Mr. E. M. Blunt, Printer
Mr. Napthali Judah
Mr. John S. Hunn
Mr. John Wade, Druggist
G. Gillespie, Esq. Mercht.
Hector Craig, Esq.
James Davidson, Gent.
Leonard Lispenard, Esq.
Robert Bowne, Esq.
Mr. Robert Henderson
Mr. Thomas Pye
Joseph Watkins, Esq.
Mr. Benjamin Judah
Mr. Thomas Tucker
Mr. Herman Vosburg
Mr. John Hillier, Mercht.
Mr. Joseph Vecchio
Noyes Darling, Esq. Mrcht.
Matthias Bruen, Esq.
Mr. Thomas Barnum
Mr. James Smith
Grove Wright, Esq.
John Stevens Esq.
Mr. Israel Horfield
Dr. John Bullus.
John Chauncey, Esq.
John Rogers, Esq.

Charles Trinder, Builder
T. B. Crane, Builder
Ford & Conray, Builders
Daniel Stagg, Builder
Joseph Walker, Builder
Elias Dixon, Builder
Moses Dodd, Builder
Daniel M'Cullum, Builder
Wm. M'Kean, Builder
Richardson Ryan, Builder
Job Furman, Builder
William Lord, Builder
Jacob Halsey, Builder
Moses March, Builder
Leonard Warner, Builder
Robert Shankland, Builder
Isaac Amerman, Builder
Alexander Allen, Builder
Thomas Taylor, Builder
Daniel S. Baker, Builder
Samuel Clark, Carpenter
John Waring, Carpenter
Joseph Horn, Carpenter
John Green, Carpenter
Evan Lloyd, Carpenter
James Walker, Carpenter
Adam Logan, Carpenter
E. Welshman, Carpenter
John Dixon, Carpenter
David Wilson, Carpenter
Wm. Rothery, Carpenter
John Williams, Carpenter
Wm. Stonay, Carpenter

SUBSCRIBERS.

Mr. George Ferguson
Mr. William Shotwell
Mr. White Matlack
Moses Ward, Esq.
G. & T. Meyer, Esqs. Merchants
F. A. Kleine, Esq.
Mr. Charles Pindar
Robert Benson, Esq.
Gilbert Robertson, Esq.
Archibald K. Kearny, Esq.
Abraham Wilson, Esq.
Gardner G. Howland, Esq.
John F. Diedericks, Esq.
M. Hogan, Esq.
Alexander Bleecker, Esq.
William H. Wiltse, Esq.
Mr. Charles G. Shipman
Robert Morris, Esq.
Isaac Heyer, Esq.
Mr. D. Leonard
Mr. Dk. Mazzinghi
Mr. Oliver Jaques, Mercht.
David Grim, Esq.
Ezekiel Hubbell, Esq.
Jones & Clinch, Esqs.
Joshua Linsley, Esq.
Isaac H. Jackson, Esq.
Mr. Joseph Wallace
Mr. Ebenezer J. White
James Stoughton, Esq.
Robert Chew, Esq.
Mr. William A. Rapp
N. Talcott, Esq.

Jas. Ridgway, Carpenter
Robert Millen, Carpenter
Abraham Dodd, Carpenter
I. O. Haviland, Carpenter
Mr. Charles Loss, Surveyor
Mr. U. W. Freemen, Surv.
Mr. Amos Corning, Surv.
Mr. C. E. Zoeller, Surveyor
Mr. P. Fenton, Timber Merchant
Mr. J. Randal, Surveyor
Mr. S. Wood, Bookseller
Mr. George Long, Printer
Mr. E. Sargeant, Bookseller
Messrs. Saml. Whiting & Co. Booksellers
Messrs. T. & J. Swords, do
Messrs. Collins & Co. do
Messrs. M. & W. Ward, do
Messrs. Inskeep & Bradford Booksellers
Messrs. Butler & White do
Mr. Christian Brown, do
Mr. D. Longworth, do
Messrs. Arden & Co. do
Mr. Thomas Powers, do
Mr. S. A. Burtus, do
Mr. J. Tiebout, do
Mr. N. Dearborn, do
Mr. J. R. Schenck, Bookbinder
Messrs. Prior & Dunning, Booksellers
Mr. Richard Johnson, do

SUBSCRIBERS.

William Cahoone, Esq.
Nathaniel G. Minturn, Esq.
William D. Titus, Esq.
Henry Fanning, Esq.
Mr. Moses Jaques, Junr.
Mr. Nathaniel Freeman
Mr. Thomas Bashford
D. Henderson, Junr. Esq.
Mr. John P. M'Kinney
Mr. L. Brewer
John Hunter, Esq.
Frederick Depeyster, Esq.
James M'Vickar, Esq.
Thos. G. Wetmore, Esq.
Mr. William Stewart
Marinus Willet, Esq.
S. L'Hommedieu, Esq.
James Johnson, Esq.
Henry Gahn, Esq.
Nathaniel Richards, Esq.
Joseph Bates, Esq.
Mr. James Bell
Mr. B. S. Collins
Thomas Buckley, Esq.
Abraham Barker, Esq.
Jarvis Larkum, Esq.
Samuel Mott, Esq.
Mr. Samuel Lyons
John Hagerty, Esq.
Reuben Crump, Esq.
Mr. Samuel Osborn
Mr. W. Holmes
Mr. J. Scudder, Museum

Mr. B. Crane, Stationer
Mr. J. Corson, Stationer
Messrs. Shedden & Boyle, Booksellers
Mr. David Bliss, Stationer
Mr. J. C. Totten, Bookseller
Mr. William Barlas, do
Mr. W. Myers, Bookbinder
Mr. Henry C. Southwick, Printer
Mr. J. Norris, Statuary
Mr. James Douglass do
Mr. John Meyher, do
Mr. Wm. Mc Kenny, do
Messrs. Rae & Oliver, Stone Cutters
Mr. Luke Britton, Statuary
Mr. Jas. Crichton, Stone Cutter
Mr. John Crow, do
Mr. Moses Miller, do
Mr. William Anderson, do
Mr. Alex. Anderson, do
Mr. R. Pitcaithly, do
Mr. J. I. Labagh, do.
Mr. P. Hoffmire, Mason.
Mr. James Sutherland. do.
Mr. J. Lippincott, do.
Mr. J. Bloodgood, do.
Messrs. T. & G. Lovett, do.
Mr. John Stoakhouse, do.
Mr. Stephen P. Brittan, do.
Mr. Abraham Stagg, do.

SUBSCRIBERS.

Mr. William Webb
Washington Library
Franklin Company
Methodist Library
Mr. Lespinard Colie
Messrs. J. & J. Stuart
Lebbeus Loomis, Esq.
Samuel Jones, Junr. Esq.
Lynde Catlin, Esq.
Henry Remsen, Esq.
George M'Kay, Esq.
Mr. David Slidger
Charles Denston, Esq.
Thomas A. Cooper, Esq.
Mr. Thomas Haynes
Mr. George Dominick
James W. Bleecker, Esq.
Mr. William Alexander
Mr. Charles Postley
Thomas Barrow, Esq.
Mr. James Poillon
Mr. Peter Kirby
Mr. Peter Morte
Mr. Charles Rudd
Mr. William Wilson
Joseph Delaplaine, Esq.
Mr. Thomas Barnum
Mr. Michael M. Titus
Mr. James Smith
William M. Price, Esq.
John Slidell, Esq.
Amasa Jackson, Esq.
William Adamson, Esq.

Mr. John O. Blenis, Mason
Mr. John Harriman, do.
Mr. John Boardman, do.
Mr. Henry Roff, do.
Mr. John Wynant, do.
Mr. Joseph Little, do.
Mr. A. Ball. do.
Mr. Andrew Hatfield, do.
Mr. James Murray, do.
Mr. P. O'Dennis, do.
Mr. John M'Crakan, do
Mr. Moses Platt, do
Mr. George Cowan, do
Mr. W. L. Ayres, do
Mr. Thomas Evans, do
Mr. Uzziah Codington, do
Mr. W. Duncan, Junr. do

SHIPRIGHTS.

Mr. Foreman Cheesman,
Mr. Henry Eckford,
Mr. Adam Brown,
Mr. Noah Brown,
Mr. Charles Brown,
Mr. Christian Bergh,
Mr. William Ball,
Mr. Jacob Weaver,
Mr. F. Gants,
Mr. R. Brooks, Ship Joiner
Mr. William Weeks, do
Messrs. Willis & Revere do
Mr. Abm. Leggett, Smith
Mr. Thomas Stevenson, do
Mr. Edward Price, do

SUBSCRIBERS.

Messrs. Smiths, Taylor, & Co. Merchants
Messrs. Duncan, Pearsall & Campbell
John Jackson, Esq.
Mr. John J. Lord
Mr. William W. Berwick
George F. White, Esq.
Daniel M'Cormick, Esq
George Kemble, Esq.
Charles King, Esq.
Frederick Philips, Esq.
Joseph Blackwell, Esq.
George Talcott, Junr. Esq.
J. W. Schmidt, Esq.
Mr. W. N. Dyckman, Jun.
William Cairnes, Esq.
Benj. Palmer, Merchant
Dr. James S. Stringham
A. Sherman, Esq. Attorney
George Gibbs, Esq.
Nathaniel Lightburn, Esq.
N. M'Neill, Esq.
Thomas W. Moore, Esq.
John Jackson, Esq.
Jasper Lynch, Esq.
Mr. William Donington
Mr. Joseph Curtis
Mr. Frederick Shonnard
Mr. Ben. Vandervoort
Mr. Thomas Musgrove
Mr. John Chapman
Mr. R. Poillon, Boat-Builder
Mr. David M'Carter, do.
Mr. Thomas Smyth, do
Mr. John Patten, do
Mr. Isaiah Jennings, Artist
Mr. John Le Maire, Carver
Mr. John Fine, Lockmaker
Mr. J. Harmer, Painter
Mr. John Chambers, Boat Builder
Mr. G. W. Brown, do
Mr. W. S. Leney, Engraver
Mr. W. Rollinson, do
Mr. Charles Rollinson, do
Mr. John Geib, Senr. Organ Builder
Mr. John Geib, Junr. Piano Forte Maker
Mr. George Geib, Professor of Music
Mr. Uri K. Hill, do
Mr. John Hearsing & Son Piano Forte Makers
Mr. Wm. Giffon, Machine Maker
Mr. J. Kaviland, Sail Maker
Mr. George Youle, Plumber
Mr. J. Youle, Air Furnace
Mr. J. Rooke, Lumber Mt.
Mr. Thos. Rees, Plaisterer
Mr. E. Whipple, Ship Joiner
Mr. Andrew Gifford, Cabinet Maker
Mr. T. H. Beall, do
Mr. T. H. Moore, Wheelright

SUBSCRIBERS.

Mr. J. Dougherty, Cooper
Mr. Jacob Day, Carpenter
Mr. Joseph Osborn, do.
Mr. Daniel Howell, do.
Mr. Thomas Tuthill, do.
Mr. Wm. Crane, Cooper
Mr. N. Bartell, Carpenter
Richard Van Riper, do.
Robert Meeker, do.
Hugh O'Neil, do.
James Scots, do.
Daniel M'Euen
J. Horne, Jun. Carpenter
J. Bloodgood, Coach Maker
John Targay, Carpenter
William Cowan, do.
R. March, Coach Maker
Mr. J. Riley, Chair Maker
H. Lamprey
A. Wright, Cabinet Maker
S. Newson, Ship Master
David Keys, Cooper
Samuel Day, Carpenter
Mr. Hugh Wishart
Mr. John Ford
J. C. Grygier, Upholsterer
Jas. Woodbery, Carpenter
Robert Brown, Carpenter
Mr. William Dally
A. G. D. Tuthill, Portrait Painter
Messrs. March & Pangburn
Mr. Alexander M'Donald

Mr. Andrew Van Valer, Cabinet Maker
Mr. R. Haywood, Blind do
Mr. Robert M'Queen, Air Furnace
Mr. W. Simmons, Cooper
Mr. Wm. Hopkins, Gilder
Mr. Cornelius De Pen
Mr. John Woodward Coach Maker
Mr. John Edwards, Scale Beam Maker
Mr. George Edwards, do
Mr. J. Cooper, Gun Smith
Mr. J. Cooper, do
Mr. Wm. Al Burtis Coach Maker
Mr. G. Hooper, Carpenter
Josiah Dunn, do.
James Barnes, do.
Nathaniel Brown, do.
David Jaques, do.
Abraham Brown, do.
Martin Blanch, do.
Henry O. Blenis, do.
Daniel Banward, do.
Jonathan Pierson, do.
James Kerr, do.
Gozen S. M'Lean, do.
Henry Smith, do.
Timothy Cory, do.
Thomas Bartser, do.
Benjamin Tharp, do

ERRORS

Occasioned by the carelessness of the Printer.

xvii, line	12, *for*	an appropriate	*read*	unappropriate.
xviii, -	4, *for*	ashort - - -	*read*	a short.
xix, -	12, *for*	Dentals - -	*read*	Dentells.
xxv, -	9, *for*	appear - - -	*read*	appears.
xxx, -	10, *for*	make - - -	*read*	makes.
xxxi, -	5, *for*	knowledge that	*read*	knowledge whence that.
xxxi, -	7, *for*	is *in same note*	*read*	are.
45, -	22, *for*	See plate No. 6	*read*	See plate No, 10.
48, -	6, *for*	Constrtcted - -	*read*	Constructed.
61, -	6, *for*	advances - -	*read*	advance.
71, -	4, *for*	lare - - - - -	*read*	large.
99, -	15, *for*	ide - - - - -	*read*	side.
131, -	24, *for*	Pensylvania - -	*read*	Pennsylvania.
159, -	17, *for*	over steepest, -	*read*	over the steepest.
164, -	6, *for*	*the word* from - -	*read*	form.
164, -	24, *for*	*Fig.* 20 - - -	*read*	Fig. 2, *and* See Plate 6.
189, -	22, *for*	an other - - - -	*read*	another.
193, -	30, *for*	if it were - - -	*read*	that which is often.
221, -	24, *for*	locus - - - - -	*read*	locust.

PREFACE.

THE walks of SCIENCE having been, for more than thirty years, the author's chief delight, particularly those sublime ones which relate to practical as well as theoretical ARCHITECTURE, he has naturally been led, in the course of his contemplations, to trace the important footsteps of the ancients, in their invention and adoption of those fundamental rules, which have, in later times, governed the improvements of every age and civilized country.

For many ages prior to these attempts, we find that no standard existed whereby to resolve or proportionate the formation of any article of convenience, that man by his necessity might be led to contrive; and if, when executed, it answered the intended purpose, it was the effect of mere accident: experience, for the present, being their only preceptor.

For, as an eminent mathematician,* in his writings on this subject, observes, ' The art of mechanics being the first that men had occasion to make use of, it is reasonable to suppose that it took its beginning with man; and was studied in the earliest ages of the world. For no sooner did mankind begin to people the earth than they wanted houses to dwell in, cloaths to wear, and utensils to till the ground, to get them bread, with other necessaries of life; and being thus destitute of proper habitations and other conveniences of living, their wants must immediately put them on the study of mechanics. At their first setting out, they would be content with very little theory; endeavouring to get that more by experience than reasoning, and being unacquainted with numbers, or any sort of calculation; and having neither rule nor compass to work by, nor instruments to work with, but such as they must first of all invent; nor any methods of work-

* William Emerson, of Hurworth in England, who lived upwards of a century ago.

ing ; with all these disadvantages, we may judge what sort of work they were likely to make; all their contrivances must be mere guessing, and they could but ill execute what they had so badly contrived ; and must be continually mending their work by repeated trials, till they got it to such a form as to make a shift to serve for the use designed. And this is the first and lowest state of mechanics, which was enough to give a beginning to it ; and in this state it doubtless remained for a long time, without much improvement. But at length, as men found more leisure and opportunity, and gained more experience, manual arts began to take their rise, and by degrees to make some progress in the world. But we meet with no considerable inventions, in the mechanical way, for a long series of ages ; or, if there had been any, the accounts of them are now lost, through length of time ; for we have nothing upon record respecting them for two or three thousand years. After that period, however, we find an account of several machines that were in use. For we read in Genesis 49 c. 13 v. that ships were as old, even on the Mediterranean, as the days of Jacob, one thousand, six hundred and eighty-nine years before the birth of CHRIST. We likewise read 1 Sam. 13 c. 5 v. that the Philistines brought thirty thousand chariots into the field against Saul; so that chariots were in use one thousand and ninety-five years before CHRIST. About the same time Architecture was brought into Europe; and, one thousand and thirty years before CHRIST, Ammon built long and tall ships with sails on the Red Sea and the Mediterranean. About ninety years after, the ship Argo was built; which was the first Greek vessel that ventured to pass through the sea, by help of sails, without sight of land, being guided only by the stars. Dædalus also, who lived nine hundred and eighty years before CHRIST, made sails for ships, and invented several sorts of tools for carpenters and joiners to work with. He also made several moving statues, which could walk or run of themselves. And about eight hundred years before CHRIST, we find in second of Chronicles 26 c. 9 10 and 15 verses, that Uzziah made, in Jerusalem, engines invented by cunning men, to be on the towers and upon the bulwarks, to shoot arrows and great stones withal. Corn mills were early invented, for we read in Deuteronomy 24 c. 6 v. that it was not lawful for any man to take the upper or the nether mill-stone to pledge; yet water was not applied to mills before the year of CHRIST, six hundered, nor wind-mills used before the year twelve hundred. Like-wise, five hundred and eighty years before CHRIST, we read in Jeremiah, 18 c. 13 v. of the potter's wheel. Architas was the first that applied mathematics to mechanics, but left no mechanical writings behind him: it is said he made a wooden pigeon that could fly about. Aristotle, who lived about two hundred and ninety years before CHRIST, was one of the first who writ any methodical discourse on mechanics. But at this time the arts were contained in a very small compass, there being scarce any thing more known about it than the six mechanical powers; the Balance, Lever, Wheel, Pully, Screw, and Wedge. In this state it continuéd till the sixteenth century, and then clocks were first made. Archimedes, who by some writers is said to have lived about two hundred years before CHRIST, was a most subtle geometer and mechanic; he made engines that drew up the ships of Marcellus, at the siege of Syracuse; and others that would cast a stone of a prodigious weight to a great distance, as also darts and arrows; he was likewise well acquainted with the power of the Lever, as was manifest by the declaration he made on a certain occasion, in the following words: "Had I a Lever long enough, and a Fulcrum strong enough, I could wield the globe." In his days the liberal arts flourished, and learning met with proper encouragement; but afterwards they became neglected for a long time.'

We come now to the propitious æra, when lived that Roman oracle, Vitruvius, who flourished in the reign of Augustus Cæsar, and who was styled in those days, the Father of Architects. At this time the arts were more extensively encouraged, and their excellence more fully made known, than at any former period. To this celebrated artist in particular, and his successors, PALLADIO, SCAMOZZI, ALBERTI, VIGNOLA, DE L'ORME, CATANEO, PHILANDER, BULLANT, SERLIO, PERRAULT, VIOLA, BLONDEL, BERNINI, and many other their associates, we who live in the present day are incontrovertibly indebted for their origin and groundwork; for by their superior skill, not only the grand and suitable orders of Architecture were found out and established, but stately edifices were erected; such as Pantheons, Theatres, Temples, Domes, Arcades, Porticoes, and Bridges, covered with spacious galleries, which were supported by superb columns of brass, of the Ionic order, and various other erections of the most magnificent and costly kind, which prove that expense was not a consideration in those days. It also appeared at this time, that there existed a considerable emulation among the professors of the Arts, by which great improvements were made. But from that period, down to this time, it is to be lamented that a growing depraved taste in the execution of civil Architecture has been too manifest; and at no period was it ever more conspicuous than the present. For though it may not be strictly just to ascribe perfection wholly to the ancients above alluded to, yet it must be acknowledged, in common justice to truth, that the fundamental laws of Architecture, I mean STRENGTH, SYMMETRY, and true ELEGANCE, which they chastely handed down to us, have been, in many instances, bartered for weakness, disproportion and frivolousness, by unskilful pretenders to science, who have intruded themselves on the public. Hence we witness, in cities making no small pretensions to pre-eminence, huge costly piles intended for public use,* some of which are divided and subdivided in the internal parts, like unto a printer's type case, with scarce one room suitably arranged or proportioned either to the size of the building, or the requisites thereof; as though it were indispensibly necessary that all public edifices, for whatever purposes designed, should be erected on the plan of an asylum for lunatics, the private cells of which most generally are from eight to twelve feet square. But when we come to examine the external parts of these expensive fabrics, we find that the eye of sensibility and refined taste is still more deeply wounded;† for first we behold the external walls erected with materials of various colours, somewhat resembling a Harlequin's jacket; some elevations being brown and white, some brown, red, and white, and some blue, brown, and white. This variegated deformity at

* To these, the intelligent traveller, as a matter of course, directs his attention at his first entering a great city, whereby he expects to learn the character of the nation in which he is about to sojourn for a time.

† For this obvious reason; the defects in the internal part of a structure of this kind, as well as all others, are alone to the loss of those who are to occupy the same; but the external defects of all public buildings, in great cities, is a national loss.

once leads the beholder to conclude that one of two things must be the cause of this barbarous appearance; either that the parties concerned in these buildings could not obtain enough of one sort of materials to build the whole, or that formerly the architect had been a sign-painter, who being obliged to use various colours for many years, could not submit to the hardship of confining himself to one alone. As soon as the eye can be relieved from these offensive colours, to examine the construction of the external part, it is again assaulted with the confused medley of an appropriate ornament with which the shaft of the building is loaded; so that, instead of those proportional parts of an elevation which correct taste would imperiously require on all occasions to be appropriated wholly to plane surfaces, for the purpose of furnishing a grand relief or ground for all suitable embellishments to rest upon, we have the painful mortification to witness the whole of an extended front, though built with *marble*, crowded with glaring absurdities from one end to the other. First we see so many bits of rustic,* like patches of letter-paper stuck upon the wall, with a space or gutter between each part. Then stand a number of diminutive useless columns,† which at a short distance appear like tobacco-pipe stems, clinging against the structure for protection, lest the tempest should beat them down. Next follow the kindred tribe of pilasters, which, by their reduced diameters, resemble so many shingle-laths cleaving to the front, fearing the like destruction. Between these, the scanty apertures for the admission of light now make their appearance, and by their inadequate area lead us to conclude,

* Alexander Pope, in his Moral Essays, describes such false taste, as is here manifested, in the following lines:

Load some vain church with old theatric state,
Turn arcs of triumph to a garden gate;
Reverse your ornaments, and hang them all
On some patch'd dog-hole ek'd with ends of wall;
Then clap four slices of pilaster on't,
That, fac'd with bits of rustic, makes a front.

† An eminent Italian Architect, on discovering some such like mock supports as these we now refer to, expressed his surprise in the following ludicrous lines, which he wrote with his pencil on one of the slender shafts of these ill-placed columns.

Dear little columns, what is't ye do there?
We know not, sir, unless to make you stare.

that such windows originally must have been intended for some Lilliputian temple or fairy-house.

Then comes the numerous host of petty breaks, advancing and receding from each other, like children playing at bo-peep, or hide-and-seek. At length we ascend in vision to the top of these fine decorated walls, and behold them capped with a cornice, large enough for a child's baby-house, and which, by the help of a magnifying glass,* we discover that it contains a number of ornamental members of various kinds; such as Cima-rectas, Cima-reversas, Fillets, Coronas, Modillions, Dentals, Cavettos, Facias, Friezes, &c. &c.; but which might as well have been one entire plane surface, for aught the public can distinguish at even a very small distance. In descending from this elevated spot last mentioned, for we have not time to ascend higher, lest the ghastly smoke-tunnels, *et cætera*, should detain us too long, the eye of

* The reader may here discover the propriety of this remark, by considering that distance lessens, in appearance, the magnitude of all bodies. Therefore, if Mouldings, Vases, Statues, or any kind of ornament whatever, be placed at a considerable height from the eye, we must expect they will appear trifling and insignificant if not proportioned accordingly.

sensibility has to undergo all that dislocation and torture which an unhappy victim would experience, who having, in a moment of despair, precipitated himself from off some tremendous height down headlong on the forked points of projecting craggy rocks, that the merciless hand of quarriers had left behind them : for, take which road you will, nothing but broken surfaces is to be found, whereby to mangle and obstruct the path of vision. And all the reasons we can have assigned to us for the introduction of such a crowd of absurdities as is here witnessed, is to be summed up in the old depraved principles and sorry language of corrupt taste; namely, that one cannot have too much of a good thing. And we find that, according to the old proverb, one error begets another. Hence we also find, that instead of the spacious Dome and lofty Spire being erected for the canopy or finishing of those temples intended for the worship of God, the great Architect of worlds, Steeples of the most ridiculous and preposterous forms are substituted in lieu thereof; some of which, in form, may be justly compared to an antique pepper-box, being perforated with numerous holes from the top half way downwards, for what purpose I know not, except it be to answer the use of a city pigeon-house. Others again are finished with a petty Cupola, open on every side to catch the rain and snow, in stormy seasons. These gross absurdities, and many more, that might be mentioned, not only tend to prove that the correct principles of the ancients are but little known in the present day, but also ill bespeak the wisdom, grandeur and correct taste of a great nation. Neither can such vile designs be furnished by men who have ever learned what mechanical Beauty meaneth.

But if we trace the origin of this depraved taste, so prevalent at the present day, we shall find that it may be attributed chiefly to two causes; first, instead of that reciprocal union and combination of talents, which ought ever to exist among theoretical and practical professors of science, we see little else than a contemptible assumption of pre-eminence and self-sufficiency in certain classes, particularly the gentlemen of the gown, who conceive that a black coat, and two or three unmeaning letters at the end of their names, form all that is necessary to rank them with an ARCHIMEDES or a

NEWTON, a VITRUVIUS or a PALLADIO, an INIGO JONES or a Sir CHRISTOPHER WREN; and, secondly, because those who are only practical professors have not sufficient theory to direct them in the execution of the work they undertake, and are too much disgusted with the proud pretensions of the *theorists* to ask their advice.

Could these evils be done away, and a combination formed of ingenious mechanics and learned mathematicians in every city, with steady aim

> ——— to make the falling arts their care,
> Erect new wonders, and the old repair,*

how advantageous would it be to individuals, and the nation at large! The discord that envy, pride and jealousy have heretofore sown between theorists and practical professors would quickly disappear, and a laudable emulation, like that which animated the ancients, would ultimately drive from the face of day those flimsy pretenders to Science, and enemies to the useful Arts, who now strut about like so many crows dressed in a few bor-

* ALEXANDER POPE.

rowed plumes, which only serve to make their deformity more conspicuous.

But if an union of talents were once accomplished, the mechanic, in the course of his practical experiments, would be assisted by the sound calculations of the mathematician, and his work would be sooner perfected. Also, the mathematician would undoubtedly find no small degree of profit from the practical demonstrations which the ingenious mechanic alone is able to produce.

OLINTHUS GREGORY, in the preface to his excellent work on the Theory of Statics, illustrates this subject in a manner which ought not to be here omitted. There are few artists but will admire his candour, and agree with his sound remarks.

He begins thus: "For some years I have seen, or thought I have seen, and often regretted, that a forbidding distance and awkward jealousy seem to subsist between the Theorists and the practical men engaged in the cultivation of mechanics in this country:* and it is a desire to shorten this distance, and to eradicate this jealousy, that has been a princi-

* ENGLAND.

pal stimulant in the execution of the following work.

"I have by long habit, combined perhaps with early acquired prejudices, been much delighted with the investigations of Theorists: but while I prize the deductions of sound theory as highly as any person, and rest as firmly upon them; yet am I desirous not to forget that, as all general principles imply the exercise of abstraction, it would be highly injudicious not to regard them in their practical applications as approximations; the defects of which must be supplied, as indeed the principles themselves are deduced from experience.

"Habits of abstraction and theorizing may be carried to excess; and crude experience without reflection will never be productive of essential good.

"But as an eminent philosopher,* for whose talents and virtues I entertain great respect, remarks, "Care should be taken to guard against both these extremes, and to unite habits of abstraction with habits of business, in such a manner

* Professor Dugald Stewart; Elements of the Philosophy of the Human Mind, p. 221, &c.

as to enable men to consider things either in general or in detail, as the occasion may require. Whichever of these habits may happen to gain an undue ascendant over the mind, it will necessarily produce a character limited in its powers, and fitted only for particular exertion. When theoretical knowledge and practical skill are happily combined in the same person, the intellectual power of man appear in its full perfection, and fits him equally to conduct with a masterly hand the details of ordinary business, and to contend successfully with the untried difficulties of new and hazardous situations. In conducting the former, mere experience may frequently be a sufficient guide: but experience and speculation must be combined together, to prepare us for the latter." 'Expert men,' says Lord Bacon, 'can execute and judge of particulars, one by one; but the general counsels, the plots, and the marshalling of affairs, come best from those that are learned. Admitting the truth of these observations, it will thence follow, that theoretical and practical men will most effectually promote their mutual interests, not by affecting to despise each other, but by blending their efforts; and further, that an essential service will be done to mechanical Science, by endeavouring to make all the scattered rays of light they have separately thrown upon this region of human knowledge, converge to one point.'

The above elegant and impartial hints, afforded us by the aforesaid friend to Science, Olinthus Gregory, merit the author's most sincere and ardent wishes, that they may be received by the Mathematicians and Mechanics of the United States, with all that attention and regard, a conviction of their truth must ever inspire.

We come now to remark, that from what has been advanced on the sorry taste of the unskilful builders of the present day, the reader is not for a moment to conclude that we are wholly destitute, in this part of the world, of those specimens, that bespeak a better knowledge and more refined taste in the science of architecture; and though we have to lament that the instances are not so numerous as we could wish, yet there are some, which by their excellence, are entitled to a respectful record, in as great a degree as the former merited contempt and reprobation.

The first, that justly claims our notice, is the New-York FREE-SCHOOL,* which for boldness of feature, and general chasteness of design, may vie with any of the productions of modern times. For this almost *unique* redemption from that depraved style, if *style* it may be called, which, has

> ——"only loaded earth
> "With labour'd heavy monuments of shame,"

we are indebted to the fine taste and classic acquirements of a gentleman,† who, amidst the turmoils and vexations of a counting-house, has found leisure to gather knowledge from the inexhaustible stores of the ancients, and enriched

* This building is erected for one of the most laudable purposes that can grace any country, or gratify the generous mind of man ; namely, the education of a numerous tribe of the rising generation of both sexes, which we hope in days to come the recipiants will record with grateful memory, the benevolent and affectionate regard manifested to them by the liberal hand of those, who from tender care, support this expensive institution.

† John Rogers Murray, Esq. Vice-President of the New-York American Academy of Arts.

his country with the fruit of his researches; and it would be well if the example set by this gentleman would excite an emulation among others of our fellow-citizens, whose property and natural resources, might, united, implant on our soil that love and admiration of the fine arts, which would soon rescue us from the imputation of neglecting whatever can adorn and elevate human industry and genius; particularly in

> "That art, where most magnificent appears
> "The little builder, man———."*

That genius is indigenous in this western soil, no one with propriety can deny; but scarce doth it rear its head above the surface of the ground, when it is nipped by the cold frost of neglect. Like the modest violet, it often blooms unseen in the wild; and only requires the discerning eye and the kind hand of patronage to lift its glories to the day. The petty feuds of party; the jealousies and intrigues of the wealthy; and the baleful influence of unworthy ambition, are

* "THOMSON'S Liberty."

the principal enemies of a plant of so delicate a growth: it shrinks from vulgar gaze, and must be courted in the still sequestered vales of life. When society amongst us shall have gained that height of civilization, which lifts man above the pursuit of a little pre-eminence in office, and relieves him from that insatiable thirst after wealth, which overpowers in his breast every other consideration, then shall we witness the proud scenes which now flourish under eastern skies, and be taught

"How forests in majestic gardens smil'd,
How menial arts, by their gay sisters taught,
Wove the deep flower, the blooming foliage train'd
In joyous figures o'er the silky lawn,
The palace chear'd, illum'd the story'd wall,
And with the pencil vy'd the glowing loom."*

I should conceive it an insult to the artists who have produced some other buildings in this country worthy of attention, were I not to notice their labours.

* "THOMSON's Liberty."

The Bank of Pennsylvania, for example, is not inferior to any thing of the kind, which modern Europe has produced.

The Gothic part of Trinity Church in this city, is also worthy of remark; and there are some excellencies in the new Grecian structure called Grace Church.

The Spire of the Brick Meeting, is, without exception, the greatest ornament of New-York, in the distant view; and make some amends for the too conspicuous and squat phenomena of the Theatre, and other public edifices, which, at a much smaller expense than that which has been lavished on them, an appearance might have been produced, that would have contributed to the elegance and grandeur of this our commercial metropolis.

To those who possess not the true spirit of artists, we shall alone apologise for this digression from our main object of BRIDGES; and, in travelling over this important subject, would wish the reader to remember, that the author has in view, the simple illustration of effects produced by the square and plummet, rather than the elegance of oratory or fine diction.

That he will have to contend, as heretofore, with the opposition of envy, the illiberality of prejudice, the insolence of scepticism, and the criticism of ignorant insignificance, he cannot doubt; for as the celebrated FULTON observes, in his excellent treatise on the improvement of canal navigation,* "Men of the least genius are ever the first to depreciate, and the last to commend, and for an obvious reason, they have not sense to know the produce of genius, when they see it: but

"Men of true genius glow with liberal spirit,
And bind a garland round the bust of merit,
While blockheads, void of wisdom's grateful light,
Bury distinction in eternal night.†

But the author is not insensible of the many defects, which, from various causes, will no doubt accompany this work, and which those who are

* This work was published in England by that gentleman, in the year 1796, a work worthy the perusal of all those who indeed regard the prosperity of these United States; and from the prolific cabinet of knowledge that work has sprung, the public may without disappointment expect, many valuable additions on that subject, is fully matured, and now in store.

† MOOREHEAD.

accustomed to studies of this nature will not only expect, but also will generously allow for many faults. For

" Whoever thinks a faultless piece to see,
Thinks what ne'er was, nor is, nor e'er shall be.
In ev'ry work regard the writer's end,
Since none can compass more than they intend ;
And if the means be just, the conduct true,
Applause, in spite of trivial faults is due.*

* Alexander Pope.

HISTORY

OF

BRIDGES.

ALTHOUGH the History of Bridges might have been dispensed with, as not absolutely essential to the development of the author's great undertaking, it may be pleasing to those who delight in man's ingenuity to learn by what slow degrees the conveniences of life found their way into common use.

That Bridges were requisite in the earliest periods of time, we cannot doubt, from the knowledge we possess of the common operations of nature. Seas, Lakes, Rivers, Brooks, and Swamps, must have existed formerly as well as now; and man, in his common pursuits, must have invented means of surmounting these obstacles to his correspondence with his fellow man, and keeping up the chain of connexion so necessary to his existence, as well as to his gratification.

The rude trunk or branch of a tree, we may easily conceive, was the first means made use of to pass the smaller streams; but the broad Arc, the extended Chain, and massy Pile, were reserved for those ages, the labours of which have little more than served to prove that approaches to perfection were still very uncertain.

Long before the invention of any kind of geometrical Bridge, mankind had adopted modes of crossing extensive rivers; and, although some authors pretend to ascertain at what particular periods boats and ships were first invented, it is more than probable that they were coeval with the first nations of the world.

We read that the Egyptians crossed the Nile on floats of various kinds, drawn by swimming horses, trained for the purpose; and we do not find that even the Greeks, who exceeded all other nations in ingenuity and keenness of perception, had employed, before the time of the Roman Republic, any regular plan for Bridges.

The Bridge of Boats, constructed by XERXES over the Hellespont, was probably the first thing of the kind witnessed by the European nations. If Bridges had been previously used in Asia, or other parts of the globe, we have no account of them, unless the description of the one erected over the river Euphrates, in the ancient City of Babylon, may be relied on.

Ancient history is unfortunately so much confused, and the clues to information, on important points, so almost completely cut off by the destruction of the great Library at Alexandria, and other similar disasters, that the most minute research would not enable us fully to ascertain what were the acquirements of those ages which the unerring hand of time has long since swept from the face of the earth; nor is the investigation necessary to our present undertaking. We can only draw comparisons of utility and elegance from *data* within our reach; and we shall proceed to enumerate and treat on the different constructions denominated BRIDGES, of which we have any accurate account, from a remote period, down to the present time: and first we shall mention the ancient

BRIDGE AT BABYLON,

OVER THE RIVER EUPHRATES, CONSTRUCTED OF BRICK,

supposed to be built by NIMROD, the third from NOAH, who lived about one hundred years after the flood.

Babylon, the capital of Chaldea, we read, was one of the most splendid cities ever built. Its form was an exact square, sixty miles in circumference; fifteen on each side. The walls thereof were, in thickness, eighty-seven feet; in height, three hundred and fifty; on which were built, two hundred and fifty towers; these were constructed of large well-burnt bricks, laid in bitumen,* a glutinous slime, which, in that country, issues out of the earth, and in a short time, when exposed to the air, grows harder than the very bricks which are laid therein.

This city was wholly surrounded by a ditch filled with water, extremely deep and wide. The river Euphrates running through the same, from north

* Consisting chiefly of what the Chemists call Asphaltum.

to south, divided it into two equal parts, over which, we are told, a magnificent Bridge, with a single Arc, upwards of six hundred and sixty feet span, by thirty feet wide, was erected; which joined the two parts of the city together in the middle.

At the east end of this stately Bridge stood the old Palace, which took up four squares, and was four miles in circumference.

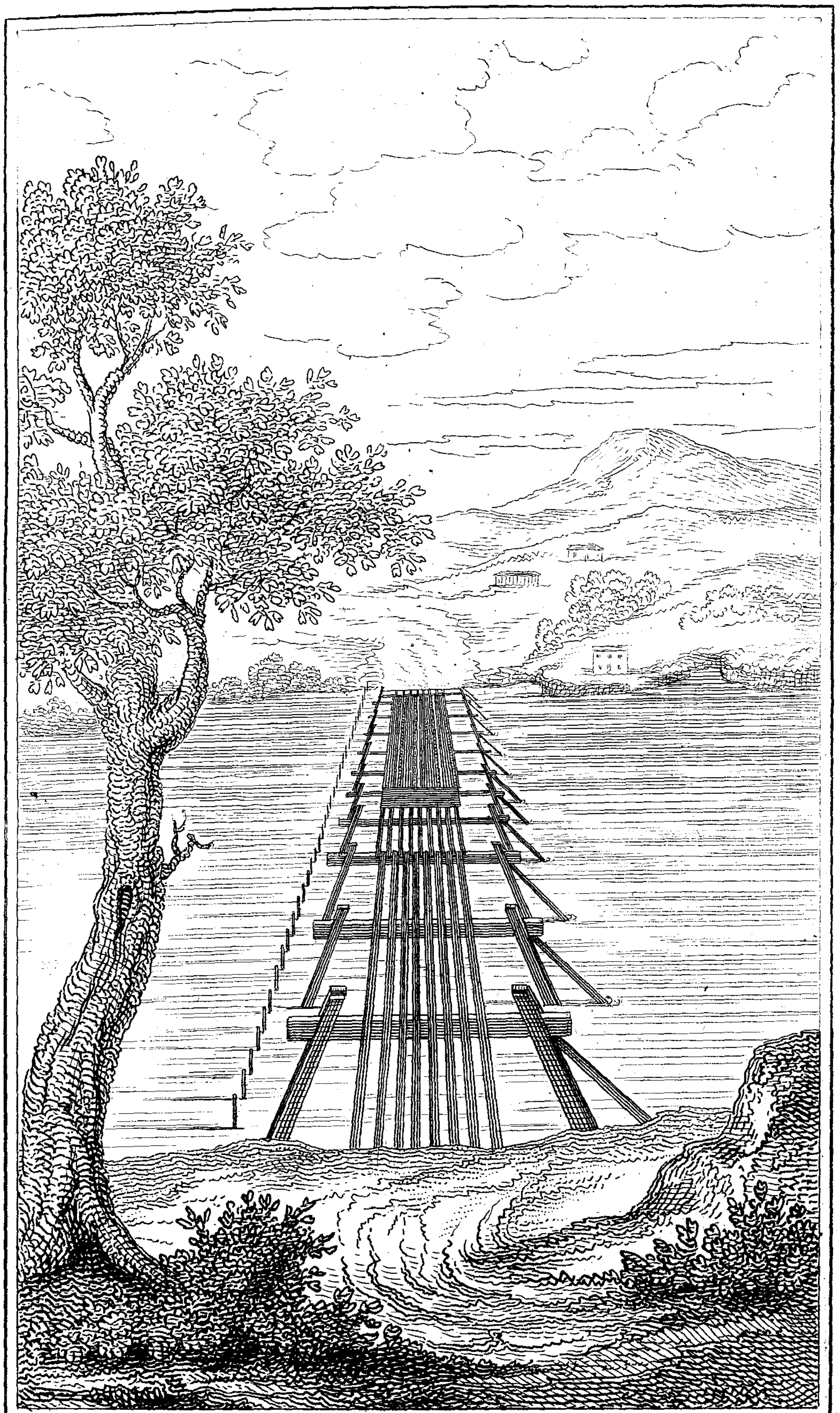
At the west end thereof stood the new Palace, which contained sixteen squares, being eight miles in circumference.

On each side of the river were erected strong quay walls, of the same thickness as those which surrounded the city; these formed the abutments of the Bridge, as well as a protection to the banks of the river; and, it is the opinion of certain commentators, that not only the boundary walls of the city, and those of the river Euphrates, as above described, were built wholly with brick, made of the clay dug out of the ditch round the city, as the historian describes, and of which we have seen many specimens that have been brought into Europe lately; but also, it is more than probable that the vast extended arc was likewise erected with the same kind of material. For it is said, that those employed in the erection of this City and Bridge had not discovered any stone at hand suitable to quarry, though they had been engaged, as MEGASTHENES informs us, in an immense excavation of fifty-two miles square, by seventy-five feet deep, thereby to form a lake, or reservoir, that should prevent the waters of the Euphrates from endangering the city, when the Armenian snows swelled it into an yearly overflow of its banks, as part of the current was then diverted into this lake, and afterwards, on proper occasions, were drawn forth to moisten the fields that lay below the level thereof. Neither was it to be expected, that they had attained as yet a sufficient knowledge by their experience in mechanics, to authorize them in the erection of a timber fabric of such extensive dimensions. And what tends still further to corroborate this opinion is, that they had already proved themselves competent to the erection of arches of no small dimensions; as we are informed that all the openings in that immense building erected by the offspring of NOAH, called the Tower of Babel, were turned with arches of this material. They had also evinced their skill, in the carrying of a brick tunnel under the channel of the river Euphrates, to afford a secret communication betwixt the two Palaces. These circumstances, with others that are recorded in sacred as well as profane history, tend to favour the impression that this Bridge, though erected at this early stage of the world, was wholly built of brick.

We pass on to observe that other remote ages of antiquity have furnished their various constructions for the crossing of rivers. It is written that about five hundred and ten years before the birth of Christ, Darius Hystaspes built a Bridge of Boats across the Danube, when engaged in his Scythian warfare. He also crossed the Thracian Bosphorus, with upwards of six hundred thousand men, by means of a Bridge of this sort, the strait being three thousand feet over. Xerxes, in the year four hundred and ninety, before Christ, had a Bridge of Boats of nearly a mile in length across the Hellespont. This first Bridge that Xerxes formed, being carried away by a tempest, he substituted two others; the one consisting of three hundred and sixty vessels of the largest kind used in ancient navies, and the other containing three hundred and forty; these were moored with large anchors. Six immense cables, fastened to large piles driven into the banks of the opposite shores, extended the whole length of the Bridges; across these were laid trunks of trees, and on them a flooring, which was covered with earth, for the passage of the army. The whole secured by a railing on each side, from end to end. These floating Bridges, and many others of a like nature, are objects of curiosity, and have their use on similar occasions; but we prefer to treat on those of more recent date and nobler form, and first we look at the illustrious

CÆSAR'S TIMBER BRIDGE,

erected upwards of eighteen hundred years ago, in his first expedition against the Suevi, across the Rhine; at which time it became necessary for him to throw a bridge over that river, for the safe passage of his troops; boats or shipping being deemed inadequate to the purpose, from various different causes. The difficulty of constructing a Bridge was also exceeding great, when the vast breadth and depth of the river, as also the rapidity of the current were considered; but Cæsar was not to be de-



T. Pope. del. C. Rollinson. Sc.

Cæsars timber Bridge across the Rhine.

terred by any obstacle that force and art could overcome, and he accordingly set to work by joining two posts of timber, each a foot and a half square, sharpened at the lower ends, and of a length proportioned to the depth of water, with braces or cross rails so contrived as to keep them two feet asunder. Letting these posts down into the water with machines suitable for the purpose, he caused them to be driven obliquely into the bed of the river, with wooden mallets, so as to lean the way of the current; and over againt these, at the distance of forty feet lower down the river, were driven other two posts, leaning against the stream, and connected in the same manner as the former with braces. These double posts were kept in their stations by cross beams, two feet square, to answer to the space between the posts, having their ends secured by the two braces or cross rails of each pair. One of the braces being above and the other under the beam, they were made fast to opposite sides of the posts; and such was the firmness of the work, and so complete the formation of the parts, that the more rapid and powerful the current, the closer and more compactly were the joints of the Bridge pressed together. After proceeding in this manner to the opposite shore, beams were spliced to each other and placed longitudinally; then straight planks were laid across them, and the whole covered with lath and hurdles; and that nothing might be wanting to secure the Bridge from harm, he directed piles to be driven obliquely into the water, to act as buttresses against the current, as also to prevent the force of timber, or any other floating commodity, which chance or the enemy might purposely throw into the stream, for destroying the work. On this Bridge CÆSAR passed with his numerous army, to show the Roman prowess to his German foes; and which, having accomplished his object, he soon afterwards destroyed.

In the East-Indies, are several ancient Bridges of singular construction. TURNER, in his interesting history of his embassy to Tibet, gives us an account of some that were then standing, of a very great age. p. 7.

A BRIDGE AT BENGAL,

CONSTRUCTED OF BAMBOO.

"We left Calamatty plain, and half an hour after passed Saftabarry, crossing a wide nullah, or creek, over which was thrown an elevated bamboo Bridge, constructed upon forked props. Bamboos resting in the fork, and covered with split bamboos woven into mats, composed the platform. It was strong enough for foot passengers, but unsafe, as I should suppose, for carriages or cattle."

A BRIDGE AT BOOTAN,

CONSTRUCTED OF TREES.

"Near the bottom of this hill, water constantly drips from the overhanging rock, and in a deep recess, at the foot of the mountain, a cascade, rushing from a thick wood, formed a large stream of water, over which was placed a Bridge constructed of trees, whose ends rested on either side of the rock, with split pieces of timber laid across them." p. 48. "In the course of this day's journey, we passed by a similar Bridge across a large stream, which came tumbling down, cataract over cataract, from the top of a lofty mountain." p. 49. "We next passed the Bridge Dadookoo, which is thrown across a torrent that rushes from the thicket over an immense ridge of rock: after this we passed also the Padoochieu Bridge." p. 53.

A BRIDGE AT BOOTAN,

CONSTRUCTED OF TWO ROPES.

"A very curious and simple Bridge, for the accommodation of single passengers, communicated between this and the opposite mountain. It consisted of two large ropes made of twisted creepers, stretched parallel to each other, and encircled with a hoop. The traveller, who wishes to cross over from hence, has only to place himself between the ropes, and sit down in the hoop, seizing one rope in each hand, by means of which he slides himself along, and crosses an abyss on which I could not look without shuddering. Custom, however, has rendered it familiar and easy to those who are in the practice of thus passing from one mountain to the other, as it saves them, by this expedient, a laborious journey of several days." p. 54.

A BRIDGE AT BOOTAN,

CONSTRUCTED OF SEVEN CHAINS.

"We descended the mountain, and crossed the chain Bridge called Chuka-cha-zum, stretched over the Tehintchieu river, a short distance above the castle of Chuka, which is reckoned eighteen miles from Murichom. For the best explanation of its construction, I refer to the annexed plan and section, constructed from a measurement of the different parts.* Only one horse is admitted to go over it at a time; it swings as you tread upon it, reacting at the same time with a force that impels you, every step you take, to quicken your pace. It may be necessary to say, in explanation of the plan, that on the five chains that support the platform, are placed several layers of strong coarse mats of bamboo, loosely put down, so as to play with the swing of the Bridge; and that a fence on each side, of the same materials, contributes to the security of the passenger." p. 55.

A BRIDGE AT DURHAM,†

CONSTRUCTED OF CHAINS.

" A similar Bridge to the last mentioned, over the river Tees, is described by HUTCHINSON, in his History and Antiquities of Durham. " About two miles above Middleton, where the river falls in

* See plate No. 6. † ENGLAND.

repeated cascades, a Bridge, suspended on iron chains, is stretched from rock to rock, over a chasm nearly sixty feet deep, for the passage of travellers, but particularly for miners: the Bridge is seventy feet in length, and little more than two feet broad, with a hand rail on one side, and planked in such a manner that the traveller experiences all the tremulous motion of the chain, and sees himself suspended over a roaring gulf, on an agitated restless gangway, to which few travellers dare trust themselves." p. 56. "In a nation where no records are kept to perpetuate the memory of the achievements of genius, and in which the minds of the people are remarkably prone to superstition, perhaps more than a century may not be necessary, to deify the author of a great work. Thus it is, that the Bridge of Chuka is reckoned to be of more than mortal production. No less a being than the dewta Tehuptehup could possibly have contrived so curious a piece of mechanism. Neither the origin nor the history of this renowned Tehuptehup can be traced with any degree of certainty; but the works they assign to him, the road up the mountain, and the Bridge at Chuka, do credit to a genius, who deservedly ranks high upon the rolls of Fame, and justly claims from the inhabitants decided tokens of respect and gratitude."

A BRIDGE AT BOOTAN,

CALLED SELOCHAZUM, CONSTRUCTED OF TWO CHAINS.

"We had proceeded about five or six miles, when, at a small distance from the road, my eye was caught by a Bridge for foot passengers, of an extraordinary construction. It was composed of two chains stretched parallel to each other across the river, distant four feet from each other, and on either side resting upon a pile of stones raised upon each bank about eight feet high: they were carried down with an easy slope, and buried in the rock, where being fastened round a large stone, they were confined by a quantity of broken rock heaped on them. A plank about eight inches broad hung longitudinally, suspended across the river with roots and creepers, wound over the chains with a slackness sufficient to allow the center to sink to the depth of four feet below the chains. This Bridge, called Selochazum, measured, from one side of the water to the other, seventy feet. The creepers are changed annually; the planks are all loose, so that if the creepers give way in any part, they can be removed, and that particular part repaired without disturbing the whole." p. 59.

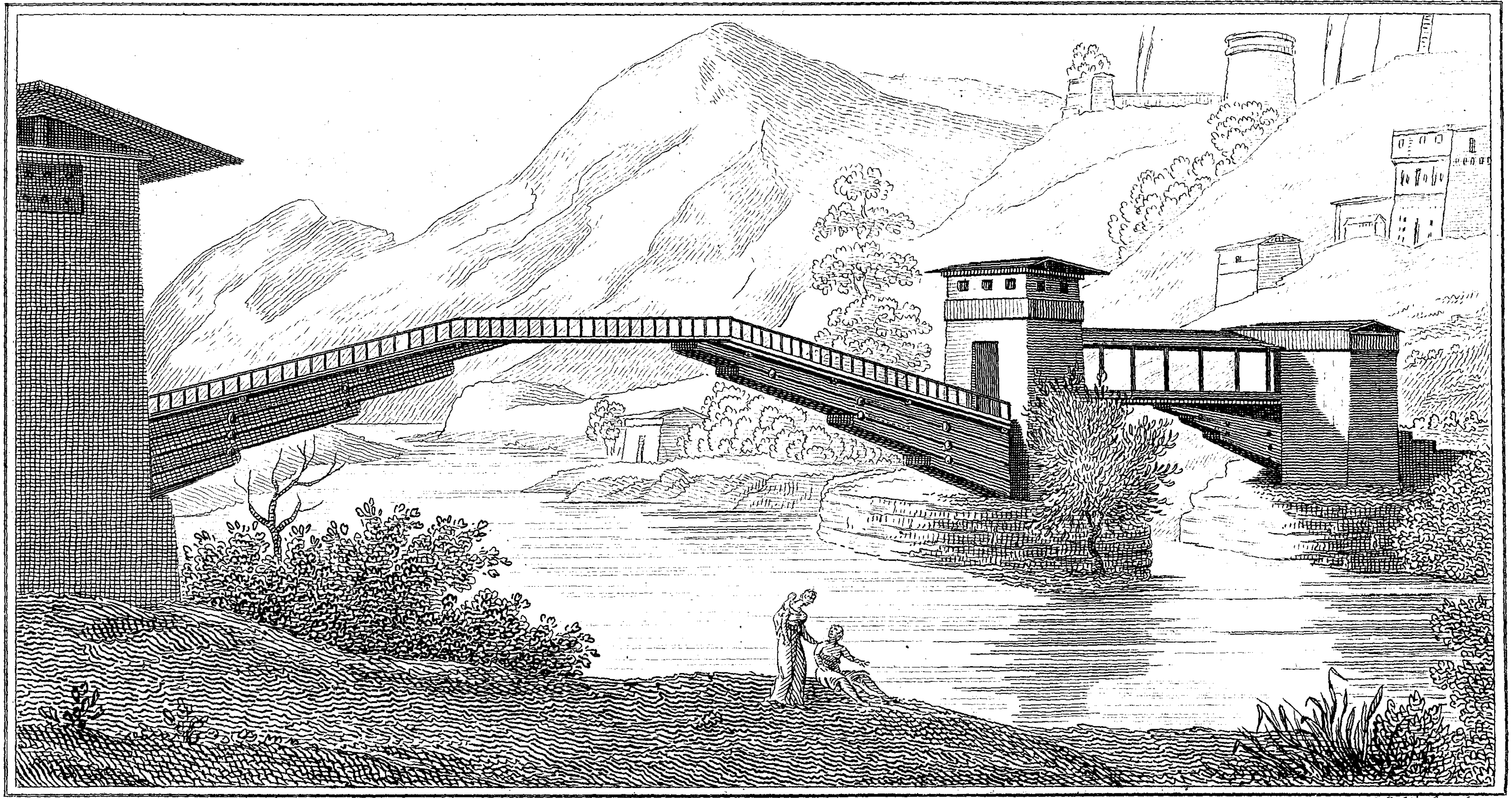
A BRIDGE AT BOOTAN,

OVER THE TEHINTCHIEU-PATCHIEU, CONSTRTCTED OF LONG BEAMS OF FIR.

"At a distance from hence we passed Durbee Castle, built upon the crown of a very steep rock, which stands on the road to Paro, and within its district. The foot of the rock is washed by the Tehintchieu-Patchieu, over which is thrown a wooden Bridge, constructed of long beams of fir, reaching from side to side, with deal planks placed crossways on them, and bound down with bands of bamboo. Although these Bridges are strong, yet they are of a most simple structure; and there is this peculiar advantage in them over heavy masses of masonry, that in times of commotion, they can be very quickly removed on the slightest emergency." p. 60.

"At the foot of the Chupka mountain, we crossed a Bridge, styled Russoo-Noomboo, and ascended by a very steep and rugged road to the Castle."

Plate. 9.



T. Pope. del. C. Rollinson. sc.

The Bridge at Wandipore

"There are wooden Bridges across the river at Choomboo, Sese, and other places that we passed." p. 61.

"We crossed a substantial and elevated wooden Bridge over the Tehintchieu, six miles from Wangoka, where the bed was a rocky descent, and the stream, of course, extremely rapid." p. 62. Finally, a Bridge over the Matchieu-Patchieu, conducted us to the hill, on which the Fortress of Wandipore stands. I must return to this remarkable structure to give a particular description of it. The Castle of Wandipore, with its gilded canopy, is of equal antiquity with the Bridge; and both are said to have been erected by Lam Sobroo, about one hundred and forty years ago, when he first entered and possessed himself of Bootan."

A BRIDGE AT WANDIPORE,

CONSTRUCTED WITH LOGS OF FIR.

"The Bridge at Wandipore is of singular lightness and beauty in its appearance. It is composed entirely of fir, and has not the smallest piece of iron, or any other metal, to connect its parts; it has three gateways; one on each side the river, and another erected in the stream, upon a pier, which is pointed like a wedge towards the current, but is on the opposite side a little convex; below it, the eddy, produced by the reunion of the divided water, has thrown up a large bed of sand, on which grows a large willow, that flourishes extremely. The gateway, on the Tassisudon side, is a lofty square stone building, with projecting balconies near the top, bordered by a breast-work, and pierced with a portcullis. The span of the first Bridge, which occupies two thirds of the breadth of the river, measures one hundred and twelve feet: it consists of three parts, two sides and a centre, nearly equal to each other; the sides having a considerable slope, raise the elevation of the centre platform, which is horizontal, some feet above the floor of the gateways. A quadruple row of timbers, their ends being set in the masonry of the bank and pier, supports the sides; the centre part is laid from one side to the other. The beams and planks are both of hewn fir; and they are pinned together by large wooden pegs. This is all the fastening I could observe; it is secured by a neat light rail. The Bridge, from the pier to the hill, is horizontal, and the beams rest on the pier, and on a triple row of timbers let into the bank: it has a penthouse over it, which is covered with shingles. The sound state of this Bridge is a striking instance of the durability of the turpentine fir; for, without the application of any composition in use for the preservation of wood, it has stood exposed to the changes of the seasons for near a century and a half, without exhibiting any symptoms of decay, or suffering any injury from the weather." p. 133.*

"We crossed the Patchieu over a covered wooden Bridge, and turning to the right, passed through a door way in a wall, that serves to part the court-yard from the Rajah's garden." 138.

A BRIDGE AT TIBET,

CONSTRUCTED OF TIMBER AND STONE.

"At the foot of Painom, over the broadest part of the river, was constructed a long Bridge, upon nine piers of very rude structure. The piers were composed of rough stones, without cement, but, to hold them together, large trees, with their roots and branches, had been inserted; and some of them were vegetating. Slight beams of timber were laid from pier to pier; and upon them large flat

* See plate 9.

stones were loosely placed, that tilted and rattled when trod upon: and this, I fear, is a specimen of their best Bridges in Tibet. Many of them were extremely dangerous to pass over."

Before we leave the East-Indies, we shall mention some of the Chinese Bridges, which are considered as wonderful pieces of art, scarcely to be parallelled by any thing of the kind in Europe. The most surprising of these structures is

A BRIDGE IN CHINA,

CONSTRUCTED OF WHITE STONE, WITH A SINGLE ARC,

which has obtained the name of the flying Bridge, from its being built over an extensive river, from one mountain to another, and consisting only of one single arc, five hundred cubits, or seven hundered and fifty feet high from the water, and four hundred cubits, or six hundred feet span. This immense arc is semicircular, the stones that form the archivolt are from seven to twelve feet in length, the voussoirs are intradossed and extradossed from a centre like unto the arches in Europe, and the whole of the masonry of this Bridge executed in a style that would do credit to the artificers of any country.

A BRIDGE IN CHINA,

CONSTRUCTED OF BARGES.

Another remarkable Bridge in the province of Chansi, at the conflux of two large rivers, which is built upon one hundred and thirty barges, chained together, but so contrived as to open and admit vessels to pass through, after paying the usual toll. This sort of Bridge is common in China.

TWO BRIDGES IN CHINA,

CONSTRUCTED OF STONE, WITH NUMEROUS ARCHES.

In the province of Fo-kien, is a Bridge of one hundred and eighty chains in length, or eleven thousand eight hundred and eighty feet, by twenty-five feet wide. It is built with three hundred and one horizontal arches, and supported by three hundred rows, or ranks of pillars, besides the two abutment piers; has a parapet on each side, and is adorned with the figures of lions, at certain distances; and a variety of other sculptures. At Fuchew, the capital of Fo-kien, is erected a Bridge of a similar kind, four thousand nine hundred and fifty feet in length, and consists of one hundred lofty arches.

The parapets of this Bridge are also ornamented with figures of lions and other animals. The whole of the material of these Bridges is fine hard white stone, and they are supposed to have been erected for many ages past.

A BRIDGE IN PERSIA,

CONSTRUCTED OF BRICK AND FREESTONE.

This bridge is built at Zulpha, one of the suburbs of Ispahan, and is represented by TAVERIER and THEVENOT, as one of the finest structures in Persia. It is nearly one thousand feet in length, and fifty in breadth. It is built with a great number of arcs turned with freestone, the water-tabling, cornices, and ornaments, are of the same sort of material, but the spandrel walls between them are of brick. The road over this Bridge is almost level, the middle of it being not much higher than the ends. On each side is a gallery ten feet broad, which reaches from one end of the Bridge to the other, and is raised several steps above the level of the Bridge; this gallery is also supplied with frequent openings for the sake of light, fresh air, and a prospect of the river. Those persons that desire a more open passage, may walk upon the platform over the said galleries, but generally the passenger is so much exposed to the heat of the sun in summer, and the effects of tempest in the winter, that he generally chuses the covered walk, which also serves for a horse-way, when the river overflows and fills the middle way of the Bridge, more particularly intended for that purpose. But what is most remarkable is another passage, when the water is low in summer, which is particularly agreeable, on account of the coolness it affords. This way is nearly even with the bottom of the river; but there are stones so placed that persons may walk over without wetting their shoes; and openings are made through the piers from one end of the Bridge to the other; the whole furnishing a most splendid appearance.

MODEL OF A PROPOSED

BRIDGE IN RUSSIA,

CONSTRUCTED OF TIMBER.

Mr. COXE, in the history of his travels through Muscovy, in Russia, in the year 1789, informs us of a certain Russian peasant, possessed of but little knowledge in the theory of mechanics, who, after having produced many truly curious inventions, projected the sublime plan of throwing a wooden Bridge, of a single arc, across the spacious river Neva, although the stream, in the narrowest part, is nine hundred and eighty feet broad. His plan is to form the Bridge by four frames of timber, two on each side, composed of various beams or trusses, which are to support the whole machine; the road, instead of being carried over the top of the arc, is to be suspended in the middle, and the structure is to be roofed at the top, and covered at the sides. According to the computation of the projector, this Bridge would require twelve thousand nine hundred and eight large trees, and five thousand five hundred beams to strengthen them, forty-nine thousand six hundred and fifty iron nails; and the expense of its erection would amount to three hundred thousand roubles, or sixty thousand pounds sterling. He is perfectly convinced of the practicability of this scheme, and the admired writer, from whom we have extracted the substance of this account, seems of the same opinion. But whether the execution of so stupendous a work be deemed possible or not, the model is certainly worthy of attention, and reflects the highest honour on the inventive faculties of an unimproved genius. The model is ninety-eight feet long, and is constructed with such uniform solidity, that it has supported fifty-six ton seventeen hundred three quarters and twelve pounds weight, including its own gravity, and the weight with which it was loaded, which is far more, in proportion to its size, than the projected Bridge would have to sustain from its own weight and the additional pressure of carriages.*

A BRIDGE IN ITALY,

CONSTRUCTED OF MARBLE.

This famous Bridge, called the Rialto, is at Venice, and is universally allowed to be one of the finest in Europe. It was built in the year one thousand five hundred and ninety-one, from a design of the celebrated MICHAEL ANGELO, and is said to have cost two hundred and fifty thousand ducats.

It consists of a single Arc, all of marble, has rails on each side, and two rows of jewellers shops in the middle. The dimensions of this Bridge are

* Wonders of Nature and Art, vol. iii, p. 120.

as follows: the segment of the arc is exactly one-third part of a whole circle; its span on the level of the water, from one abutment to the other, is ninety-five feet, and its height twenty-four.*

A BRIDGE IN SWITZERLAND,

CONSTRUCTED OF TIMBER.

The late Bridge over the Rhine, at Schaffhausen, was of singular architecture, and worthy of particular attention. Several stone Bridges had been carried away by the rapidity of the torrent, when a carpenter of Appenzel offered to throw a wooden Bridge of a single arc across the river, which is nearly four hundred feet wide. The magistrates, however, required that it should consist of two arcs, and that the middle pier of the old Bridge should be employed for that purpose; but although the architect was obliged to obey, he contrived to leave it doubtful whether the Bridge was supported by the middle pier, and whether it would not have been equally safe if formed after his own plan. A man of the lightest weight felt it vibrate under him, though waggons heavily laden might pass over it without

* Vol. ii, p. 94

danger. Its mechanism, though simple, was most extraordinary, and afforded a striking proof of the abilities of the man who projected and executed it, without the least knowledge of mathematics, and, in fact, without the least pretensions to literature. This curious Bridge was finished in less than three years, at the expense of eight thousand pounds; but it was burnt by the French troops, when they evacuated Schaffhausen, after being defeated by the Austrians, in the spring of seventeen hundred and ninety-nine.*

A BRIDGE IN SWITZERLAND,

CONSTRUCTED OF STONE.

At Bex, in the Canton of Bern, is a stone Bridge over the Rhone. It consists only of one Arc of a considerable height, with a handsome tower on the top, and is nearly five hundred feet span.

A BRIDGE IN SWITZERLAND,

CONSTRUCTED ALSO OF STONE.

In the canton of Uri is a stone Bridge, erected over the Russ, of a surprising height, consisting solely of one arc, resting upon two high rocks. The neighbouring peasants have given it the name

* Vol. ii, p. 204.

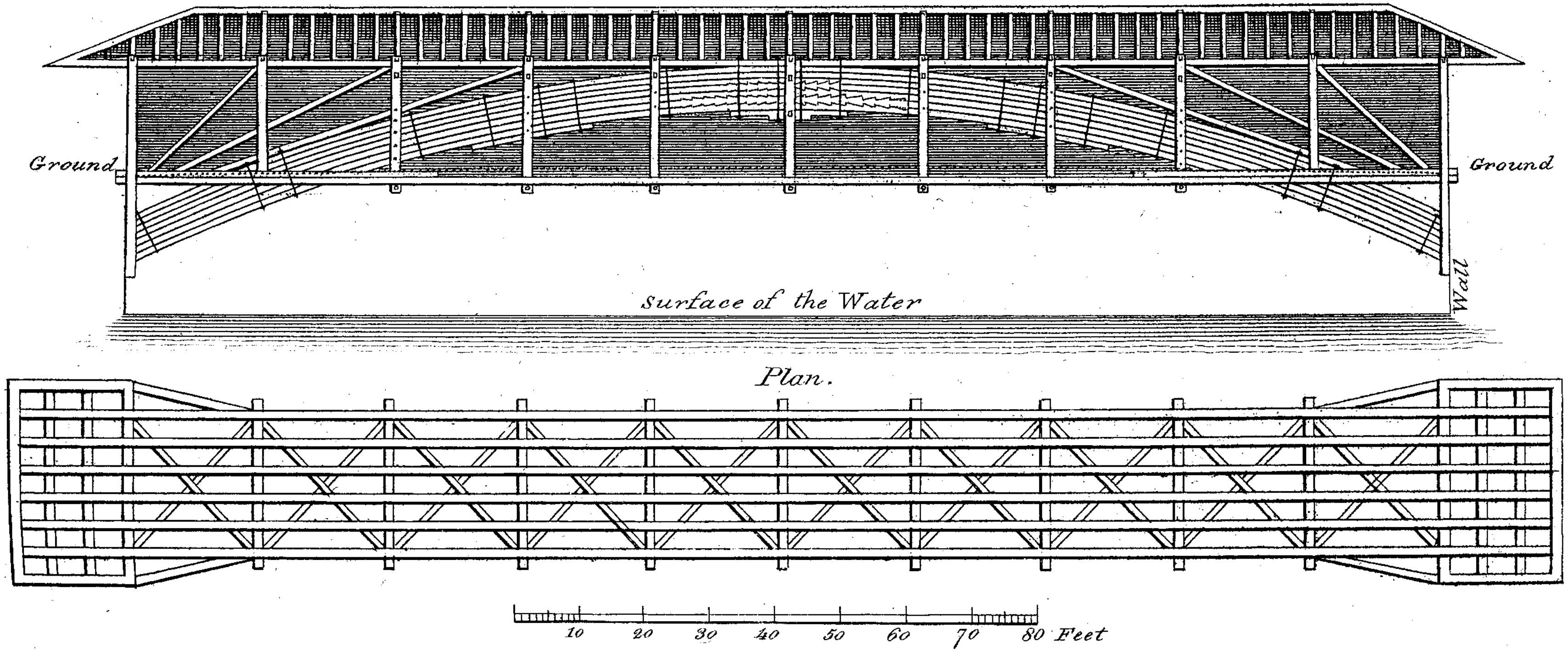
of "THE DEVIL'S BRIDGE," from a simple opinion that such a stupendous work must have been erected by the Devil.

A BRIDGE IN SWITZERLAND,

CONSTRUCTED ALSO OF TIMBER.

ULRICH GRUBENMAN, of Tuffen, in the canton of Appenzel, the same self-taught artist that erected the Bridge at Schaffhausen, afterwards built a wooden Bridge at Wettingen, a little more than a mile distant from Baden, which is allowed to be a most admirable piece of mechanism. The whole of the weight of this Bridge is carried by a single Arc composed of two circular ribs, one on each side of the Bridge. Each rib is made up of seven thicknesses of timber, belted together with iron hoops and keys, making in depth seven feet: these are placed in the form of a true segment of a circle of four hundred and fifty feet diameter, and the ends thereof rest in a timber shoe, walled into the abutment, so as to prevent the Bridge by its gravity from pressing out the curve. The platform on which the carriages pass is lowered down between these ribs about twelve feet from the level of the

Geometrical Elevation of the Timber Bridge at Wettingen



crown of the arc, and is supported by cross beams which hang on the external framing. The span of the arc by actual measurement is two hundred feet; the cradle, frame and shoe, that contain the ends of the ribs on each shore, and which support the continuation of the floor of Bridge above, advances twenty feet on each side; making the whole length of the floor, from end to end, two hundred and forty feet. This Bridge also, like that of Schaffhausen, is covered with a roof. For a further illustration of its form, see plate 7. Mr. Coxe, in the first volume of his travels in Switzerland, observes, that the waters of the Limmat flow under this Bridge with such rapidity, that in the moment he was admiring its bold projection on the one side, by the velocity of the current he was imperceptibly hurled to the other, in the twinkling of an eye.

BRIDGES IN AFRICA,

CONSTRUCTED OF TREES.

In different parts of Africa there are Bridges of a very singular construction. The sort most frequently preferred are built in the following manner. Several large trees are fallen with the principal part of their roots carefully preserved; the number intended to compose the Bridge are then launched into the river two at a time, one from each shore; the tops of the trees which float on the water are next fastened together with green bamboos; the roots of each tree rest in a hole dug in the bank on each shore, and when the Bridge is finished, they are covered over with the earth that was first dug therefrom; by which means the trees, though many of them are very large, often take root and grow luxuriantly. When this happens to be the case, the Bridge is sure to last for a much longer time than those that possess no tie in the banks of the river. The road-way over these Bridges is covered with dry bamboos, and the whole form a passage descending from each end toward the middle, like an inverted arc. In rainy seasons, these Bridges, where the roots of the trees have no hold in the banks of the river, are frequently carried away by the current; but a small tribute, collected from passengers, serves to rebuild them. Similar Bridges to these are to be found also in Norway.

BRIDGES IN NORWAY,

CONSTRUCTED OF MASTS.

Where the rivers in Norway are deep, and the rapidity of the current such that no timber pier can withstand its force, there Bridges of considerable extent, constructed of large masts, are frequently erected. The parts of the masts, which are to rest on each other, are first hewn to a flat surface, whereby to prevent them from rolling; one tier of the largest of these masts is then projected into the river from each side, with the thickest end fastened to the rocks: the first tier, making the width of Bridge, being thus laid in the water, the second is placed thereon, extending six or eight feet beyond the first; then a third, fourth, or fifth tier, in the same order, till they reach the middle of the stream, where they are joined by the connected masts from the opposite shore. The passenger, in crossing over this Bridge, is often alarmed by its swinging and cradling, especially in the middle, and which to strangers appear so extremely dangerous, that they always dismount from their horses, and prefer to lead them over.

BRIDGES IN NORWAY,

CONSTRUCTED WITH PIERS.

Over those rivers that are the most wide, and where the waters are also shallow, Bridges are erected with piers, formed of wooden cases, filled with stones, on which are laid the longitudinal breast-summers that carry the weight of the platform. The largest Bridge of this kind in Norway has forty stone cases, and is three hundred feet in length by twenty-eight feet wide.

BRIDGES IN SPAIN,

CONSTRUCTED OF STONE, AND SOME OF WOOD.

There is a handsome Bridge over the Guadianna, at Badajoz, consisting of thirty arcs, and more than fifteen hundred feet in length. At Saragossa are two noble Bridges over the Ebro, the one of stone, the other of wood, which latter is reckoned the finest of the kind in Europe ; and the Bridge over the Manzanarez, at Madrid, built by PHILLIP II, is very long and magnificent. To these we must add the fine Bridge over the Mondego, at Coimbra, in Portugal, consisting of a double range of arcs one above another, forming an extensive covered way, through which passengers pass, without being exposed to the weather.*

A BRIDGE IN PORTUGAL,

CONSTRUCTED OF STONE.

The Romans, while masters of Spain and Portugal, erected many magnificent structures: the remains of some of them are to be seen in sundry parts of the kingdom to the present day. Among the rest was a splendid Bridge over the Tagus, at Alcantara, which was built of stone, in the reign of the emperor TRAJAN. This Bridge consisted of six arcs, each one hundred feet span, the height thereof from the face of the water is said to be two hundred feet. About two miles above this Bridge is a modern work of art, which may vie with the noblest labors of the Romans; namely, the

AQUEDUCT BRIDGE OF ALCANTARA,

CONSTRUCTED OF STONE,

near the city of Lisbon. It is one of the most magnificent works of the kind ever executed, and

* Wonders of Nature and Art, vol. i, p. 272.

was begun in the reign of John V, king of Portugal, in the year one thousand seven hundred and thirteen, and finished the sixth of August, one thousand seven hundred and thirty-two. The architect, under whose inspection it was begun and finished, was the brigadier Mansel de Maya. The streams which pass through this duct, for the use of the inhabitants of the city of Lisbon and villages adjacent, have their chief supply from a spring near the Riberia de Caranque, about three leagues and a half from Lisbon, where the aqueduct commences; and the water is conveyed from thence through the hills by subterraneous passages, where some other springs unite with them, and cross many valleys on the tops of ranges of very magnificent arcs, of which that crossing the vale of Alcantara is the chief. From a subterraneous course the water is conveyed through the building on the top of the arcs, by means of two channels, which afford an abundant and never-failing supply of water to Lisbon.

The water-channel under the grand arc of Bridge is about twenty-four feet wide, and seven feet deep, but, except in very rainy seasons, no water passes through this channel; the small running stream constantly passing through the vale of Alcantara, till it empties itself into the Tagus at Alcantara Bridge, about the distance of two miles from the Aqueduct.

This immense building consists of thirty-five arcs, the centre one of which is one hundred and eight feet in span, and two hundred and twenty-seven feet high; the total length of the piers and arcs is two thousand four hundred and sixty-four feet."*

TRAJAN'S BRIDGE,

OVER THE DANUBE,

is one of the most celebrated structures of ancient times. If we may believe the description given of it by Dion Cassius, and we have no reason to doubt it, the Bridge was composed of twenty piers of squared stone, each of them one hundred and fifty feet high above the foundation, sixty-feet in breadth, and one hundred and seventy feet distant from each other, which was the width of the arcs,

* The preceding account of this Bridge we have extracted from that valuable repository of information which is now republishing in Philadelphia, with many important additions: DR. REES'S New Cyclopædia.

being twenty-one in number; the whole length of the Bridge being nearly four thousand five hundred feet.

THE BRIDGE OF NARNI

IN ITALY,

built by AUGUSTUS CÆSAR, over the river Nera, is often mentioned by the Roman writers, and was considered by them an extraordinary work of art. AGOSTINO MARTINELLI, who lived in one thousand six hundred and seventy-six, describes this Bridge to have been six hundred and thirty-seven feet in length, consisting of four arcs of immense and unequal dimensions. One of them, the first, was entire in the time of MARTINELLI, and measured seventy-five feet wide, by one hundred and twelve feet six inches high; the second was one hundred and fourteen feet wide, the third one hundred and thirty-five feet, and the fourth one hundred and forty-two feet. Mr. ADDISON, in his remarks on several parts of Italy, where he travelled in the years 1701, 2, and 3, says that he saw the remains of this Bridge, which joined two mountains together, and considered it one of the most stately ruins in Italy. It has no cement, and looks as firm as one entire stone. There is an arc of it unbroken, the broadest he had ever seen; and he concludes that this was the identical Bridge mentioned by MARTIAL, Lib. vii, Epig. 93,

Sed jam parce mihi, nec abutere Narnia Quinto;
Perpectuò liceat sic tibi Ponte frui!

BRIDGES IN FRANCE.

The first that we shall notice, is the famous Bridge over the Rhone, at St. Esprit, in Languedoc, which is reckoned one of the finest in Europe. This Bridge is of stone, and of a great length, consisting of twenty-six arcs, whose piers are secured by two pedestals that surround each, which have their projectures like rows of steps or stairs, the lowermost projecting most, the other less by degrees. Above these are several small arcs, which divide the feet of the great ones, and reach as low as the plane of the uppermost pedestal. As the Rhone is a very rapid river, this Bridge is admirably contrived to withstand its violence; for the unequal juttings of the pedestals serve gradually to break the force of the stream, and when the flood swells so high as to cover them, which it frequently does, the small arcs or openings in the piers give a free passage to the water, which otherwise endanger the fabric. Besides, the Bridge is not straight, but bent in several places, forming unequal angles, which are greatest where the current is strongest, and thereby its fury is opposed and broken.

DR. SMOLLET, mentioning this Bridge, observes, that it is a great curiosity from its length, and the number of its arcs; but that the arcs are too small, the passage above is too narrow, and the whole appearance too slight to resist the impetuous force of the river.*

THE BRIDGE, PONTNEUF,

AT PARIS,

CONSTRUCTED OF STONE,

was begun in the reign of HENRY III; that monarch having laid the first stone upon the thirty-first of May, one thousand five hundred and seventy-eight; but it was not completed till the year one thousand six hundred and four. It consists of twelve arcs; is one thousand and twenty feet long, and seventy-two feet broad, of which the carriage-

* Wonders of Nature and Art.

way is thirty feet, and the rest is taken up by a foot-path raised on each side. Over each pier is a semicircular parapet, round which there is a cornice, resting on lare consoles, and adorned with busts.*

BRIDGE AT ROUEN,

CONSTRUCTED OF BOATS.

This Bridge was built in lieu of the magnificent Stone Bridge erected there by the Romans, and is mentioned by a modern writer as one of the greatest wonders of the present age. It is nearly nine hundred feet long, and is paved with stone, so firm, that horses and carriages, with the greatest burthens, pass over it in perfect safety, although there are no rails on either side. It always floats and rises with the tide, or as the land waters fill the river. The boats are admirably moored with strong chains, and the whole is constantly repaired, though now very old.*

BRIDGE OF NEUILLY,

CONSTRUCTED OF STONE.

Several of the Bridges in France are remarkable for their size and boldness of construction; among

* Wonders of Nature and Art.

which may be mentioned the Bridgc of Neuilly, built by M. Perronet, over the Seine, on the alignment of the great avenue of the Champs Elysées, in front of the Palace of the Tuilleries. This Bridge, which is level at top, consists of five equal arcs of one hundred and twenty-eight feet in span, by thirty two feet rise. The arcs are oval, composed of eleven arcs of circles of different diameters ; thus the upper portion of the arc was formed with a circle of one hundred and sixty feet radius, which, by its settlement during the building, and after the striking of the ceintres, was flattened, till it became an arc of a circle of two hundred and fifty-nine feet radius, differing so little from a platband, that, as Perronet observes, the rise of the curve, in a length of thirty-three feet, amounted only to six inches nine lines. The piers are fourteen feet wide, and the breadth of the Bridge is forty-eight feet. It was begun in the year one thousand seven hundred and sixty-eight, and finished in the year one thousand seven hundred and eighty.*

* Rees's new Cyclopædia.

THE BRIDGE ON THE SEINE,

CONSTRUCTED OF STONE.

This Bridge is erected near Mantes, and consists of three arcs, the one in the centre having an opening of one hundred and twenty feet French, one hundred and twenty-eight feet English, and the two others one hundred and eight feet French, one hundred and sixteen feet English; the piers being twenty-five feet six inches wide, and the abutments twenty-nine feet. This structure was begun by M. Hupeau, in one thousand seven hundred and fifty-seven, and completed by Perronet.*

THE BRIDGE OF PONT-SAINTE-MAIXENCE,

CONSTRUCTED OF STONE,

over the river Oise, on the great road from Paris into Flanders, and is also a work of Perronet's. This Bridge, which is forty-one feet wide, has three arcs of seventy-seven feet opening; each being a segment of a circle described with a radius of one hundred and eighteen feet. Each pier is singularly composed of four cylindrical pillars, nine

* Dr. Rees's New Cyclopædia.

feet diameter, leaving, therefore, three spaces or intercolumniations between them, which are covered over with an arc, the two external ones closed up with a thin walling, and the middle one left open.*

THE BRIDGE OVER THE LOIRE,

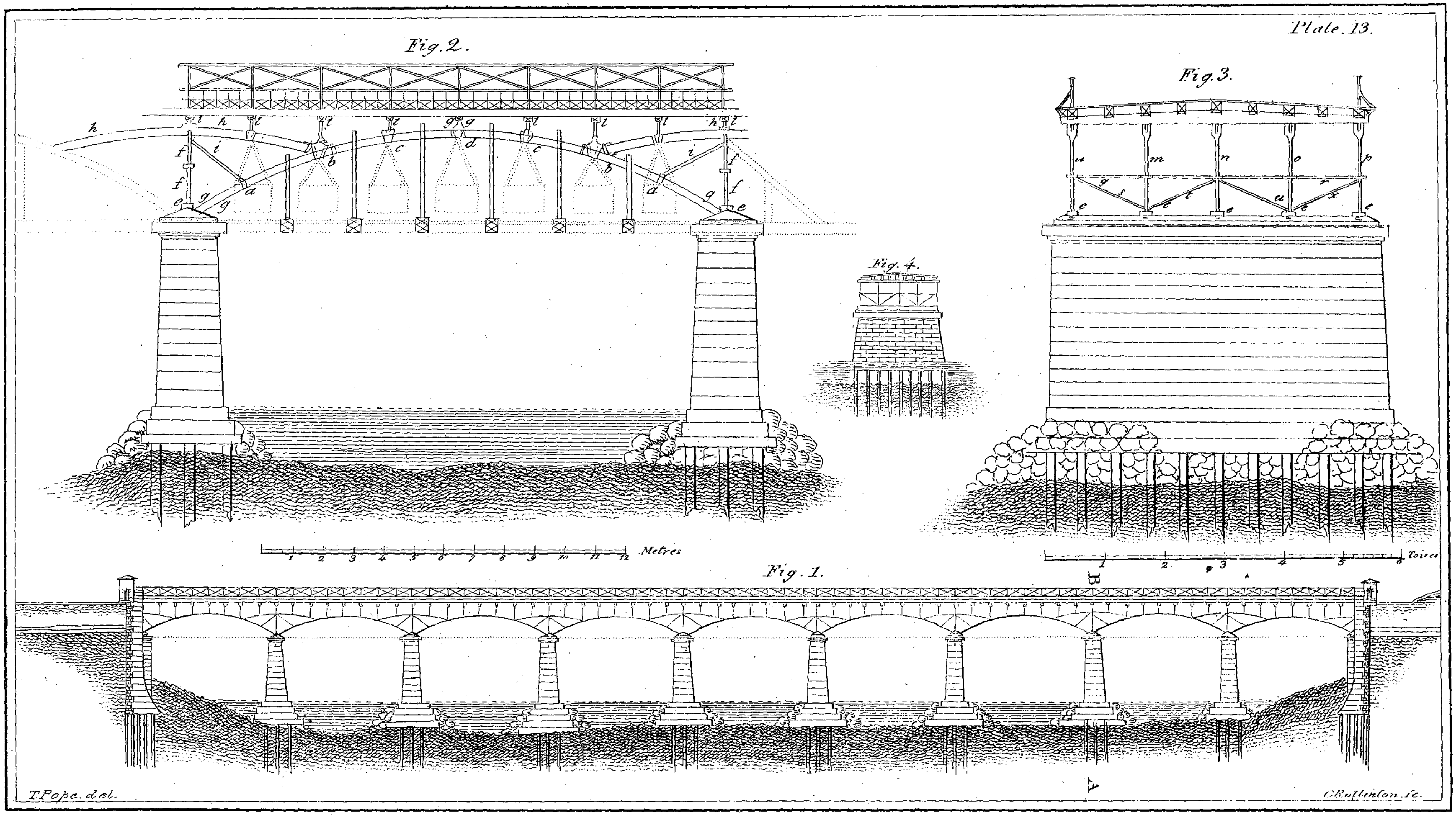
AT ORLEANS,

IS CONSTRUCTED OF STONE,

and is composed of nine arcs, which spring at twelve inches above low water; the middle arc is one hundred and six feet in span, with a rise of thirty feet; the two arcs at the extremities being ninety-eight feet wide and twenty-six feet high, and the others in proportion; the four middle piers are nineteen feet, the four others eighteen feet, and the abutments twenty-three feet six inches thick, making the whole length eleven hundred feet; the arcs are oval, described from three centres. This Bridge was built by M. HUPEAU, was begun in one thousand seven hundred and fifty, and finished one thousand seven hundred and sixty.*

Account of the Bridge which is constructed at Paris, between the Louvre and the Hotel de Quatre Nations, and of the experiments made to ascertain its stability.

* Dr. Rees's New Cyclopædia.



The Bridge of the Louvre over the Seine.

FROM THE BULLETIN DES SCIENCES.*

THE BRIDGE OF THE LOUVRE,

CONSTRUCTED OF CAST-IRON.

This will be the first Bridge in France in which the arcs have been made of iron, or rather of cast-iron. It is even the first which has been executed in Europe according to the system adopted in its construction; and this system has the advantage of greatly economizing the metal, in comparison with that used in England for iron Bridges. In fact, in that of Coalbrook Dale, on the Severn, constructed about twenty-four years ago, and which consists of a single arc one hundred feet in span, and twenty-five feet wide between the railings; the weight of metal that has been employed amounts to seven hundred and fifty-seven thousand pounds; whereas the weight of cast metal for the nine arcs of the Bridge of the Louvre will not amount to six hundred thousand pounds; whilst its length between the abutments is five hundred and sixteen feet, and its width between the railings, thirty feet. It is

* Repertory of Arts, 4 vol. second series, 1803.

true the English Bridge serves for carriages to pass over, whilst that of the Louvre is intended only for foot passengers. However, it has been ascertained, by the experiments which have been made, that by augmenting either the number of ribs, or the dimensions of the pieces of which they are composed, it would by no means have required so much metal, though it be five times as long as the Coalbrook Dale Bridge, and wider than it, in the proportion of one hundred to seventy-four. The Bridge of the Louvre, see plate 13, fig. 1, 2, 3, consists of nine arcs, and each arc is formed of five ribs. See fig. 1. To each rib there are two pillars, *ff*, *ff*, implanted into beds of cast metal, fastened to the piers; a large arc, *gg*, *gg*, consisting of two pieces, which join in the middle; two small arcs *hh*, *hh*; two spurs *i*, *i*, and eight supports *l*, *l*. The five ribs are joined together by braces at *a b c d*, *c b a*, and others between these; and the upright, bars *u m n o p*, are joined together by the brace *g r*, and the spurs *s t u x*.

The metal pieces, of which this Bridge is constructed, are cast near Toroude, in the department of the Orne. M. Dillon superintended the construction of this Bridge, and made the experiments of which we are about to give an account.

A rib of the Bridge, taken at a venture, had been fixed upon a frame of wood-work, so joined together in parts, that it could not sensibly lengthen; to it were adapted cast-iron beds similar to those fixed upon the piers, and upright bars, with forked tops, in order to prevent the rib from deviating from a perpendicular during its being loaded, and also to support it in case of its breaking, and seven boxes suspended at the same points, where every rib will experience the pressure of a part of the flooring, and of the persons who shall pass over the Bridge.

The boxes were filled at the same time, till they contained double the weight which each rib must bear, under the supposition of an extraordinary concourse of people upon the Bridge; and, during this operation, attention was paid to the changes of figure which took place in the great arc *gg*: it successively sunk at the key or summit *d*, and rose towards the haunches *bb*, as every other body possessed of a slight degree of elasticity would have done, and it returned to its former position in proportion as the load was diminished.

These experiments therefore prove, first, that the system adopted has a degree of solidity more than what is necessary for the purpose for which it is intended, since the ribs upon which the experiments were tried resisted a weight twice as great as that which they were required to bear, though deprived of the increase of resistance which they will acquire from the flooring, according to the the manner in which it will be connected with them; second, that the cast metal, though sufficiently soft to be engraved upon and pierced cold, in order to obtain a regular and solid combination of the parts, has yet sufficient tenacity, not sensibly to change its figure, nor to distort the symmetry of its form.

Account of Bridges in Ireland, extracted from that interesting work, the Statistical Survey of the County of Londonderry, by the Rev. G. VAUGHAN SAMPSON, A. B, M. R. I. A. 323 page.

BRIDGE OF LONDONDERRY,

CONSTRUCTED OF TIMBER.

It would be unpardonable not to mention that of the city of Londonderry in the first place. This Bridge was constructed by LEMUEL COX, of Boston, in North-America; it was completed in the space of thirteen months; in length it is one thousand sixty-eight feet, in breadth forty-feet; the piers consist of oak, from fourteen to eighteen inches square, and from fourteen to fifty-eight feet long; the head of each post is tenanted into a cap-piece, fourteen inches square, and forty feet long, supported by three sets of girths and braces: the piers, which are distant from each other sixteen and a half feet, are bound together by thirteen string-pieces, equally divided, and transversely bolted; on the string-pieces is laid the flooring; to each side of the platform is affixed a railing, four and a half feet high; inside railings are also made to guard the foot passengers; twenty-six lamp-posts are arranged along the sides of the Bridge.

Between the middle of the Bridge and the end next the city, a draw-arc has been constructed, of which all the machinery is worked under the floor of the Bridge. The greatest depth of the river at low water is thirty-one feet, and the rise of the tide is from eight to ten feet. 324 p. The construction of a Bridge over this river had long been a favourite object with the present Bishop of Derry (the Earl of Bristol), by whom, for this intent, the model of a wooden Bridge had been brought from Switzerland. Plans by Mr. MILNE and Mr. PAYNE, of London, had also been under consideration for the same purpose. Mr. Cox's bridge was opened for foot passengers in the latter part of the year 1790. A Bridge on the same plan has been constructed over the Bann, opposite Aghgivey, by a Mr. MITCHEL, of this country.

Others, somewhat on the same model, but diminutives, have been laid across rapid rivers, where stone Bridges had often been attempted without permanent success. But for such situations, without doubt, that construction is the best, which is hung over the channel, without any piers, which always obstruct the torrent, and endanger, of course, the whole Bridge. Of this kind, one over the Fahan, contrived under the direction of Mr. ACHESON, seems to be safe, solid, and not without an air of neatness, and even of some picture. It is hung on its own baluster, by means of braces and beams, the uses of which might be better understood by an inspection than by a concise description.

The Bridge of Colraine, over the Bann, is of wood and stone; the piers of stone; p. 325. The flooring, spur-pieces, and railing, of wood. Over the flooring lies a bed of gravel, and pavement over this. It is neither strong, elegant, nor convenient.

Among our stone Bridges, that of Toom, erected by the late Lord O'Neil, though it belongs more strictly to the county of Antrim, yet is too usefully connected with Londonderry, to be entirely unnoticed. Suffice it, however, to say, that it was built under an act of Parliament, conferring the toll on Lord O'NEIL, and that it is an erection equally beautiful and solid.

There is a strong and neat Bridge, lately built over the Roe, by Mr. GAGE, at the expense of the county. It consists of stone piers, covered and railed with timber.

There are also several Bridges in and near the city of Dublin worthy of remark. The one that ranks first in elegance is called

SARAH'S BRIDGE.

This Bridge is built of white mountain granite of a most firm, beautiful, and variegated texture, with a single eliptical arc, of one hundred and two feet span.

On the top of the said Bridge is erected a neat and ornamental iron railing, set in a firm plinth and sub-plinth, for the protection of the foot-passengers on each side. Mr. ALEXANDER STEVENS, an ingenuous mason from Edinburgh, completed this Bridge, in the year one thousand seven hundred and ninety-two.

CARLISLE BRIDGE

is constructed of Portland stone, has three arcs, and was built by the celebrated GANDON, Architect.

ESSEX BRIDGE

is constructed of white mountain stone, has five arcs, and was built in the year one thousand seven hundred and fifty-three, under the direction of the celebrated SEMPLE, Architect.

QUEEN'S BRIDGE

is also constructed of mountain granite, and is built with three arcs. These four structures, it is said, are alike distinguished for their strength and architectural symmetry.

BRIDGES IN GREAT BRITAIN.

In England and Wales are many Bridges of considerable note. The triangular Bridge at Croyland in Lincolnshire, which was erected about the year eight hundred and seventy, is said to be the most ancient Gothic structure remaining entire in the kingdom. There are two circumstances in the construction of this Bridge, which render it an object of great curiosity. First, it is formed by three semiarcs, whose bases stand in the circumference of one circle, at equal distances from each other. These unite at the top; and the triune appearance of the structure has led some to imagine that it was intended as an emblem of the Trinity. Secondly, the ascent on each of the semiarcs is by steps paved with small stones set edgeways, and is so steep that none but foot-passengers can go over the Bridge: horsemen and carriages frequently pass under it, as the river in that place is but shallow. For what purpose this Bridge was really designed, it is difficult, if not impossible, to determine. Utility, it is obvious, was one of the least motives to its erection. To boldness of design, and singularity of construction, it has more powerful claims; and these qualities it must be allowed to possess in as great a degree as any Bridge in Europe. Although this Bridge has been erected so many centuries, it exhibits no marks of decay: twelve months ago there were no fissures to be perceived in either of the arcs; and all that was missed were a mound and sceptre, which have been torn from a statue of king ETHELBERT by the ruthless hand of time.*

LONDON BRIDGE,

OVER THE RIVER THAMES.

This ancient Bridge was first erected with timber in the reign of ETHELRED, one of the Saxon Princes, between the years nine hundred and ninety-four, and one thousand and ten; it was rebuilt with the same sort of material in the year one thousand one hundred and sixty-three, but this second formation of timber not proving equal to the first in strength, and a considerable improvement taking place in the erction of Bridges; about thirteen years afterwards, in the reign of HENRY II, this last wooden structure was taken down, and a Bridge of Port-

* Rees's New Cyclopædia.

land stone was begun to be erected in its stead: to accomplish which, a tax was laid upon wool, which in the course of time gave rise to the notion, among the vulgar, that the said Bridge was built upon woolpacks. In the reign of King JOHN, about the year one thousand two hundred and nine, the Bridge was finished, having been thirty-three years in building, at the public expense. But, although it was now constructed of a material much less perishable than the former, yet we find that in the reign of EDWARD I, one thousand two hundred and eighty-one, the King, being informed of the ruinous condition of London Bridge, granted his letters patent, empowering the keeper of the said Bridge to receive a toll of such persons as should pass over it. The winter following, at the breaking up of a severe frost, five arcs of this Bridge were entirely swept away by the violence of the ice. Since that period it has undergone many alterations, repairs and improvements. This Bridge is erected in the old Gothic style, and had twenty arcs, but two of these having been thrown into one, in the centre, for the purpose of giving more water-way, there are now only nineteen remaining. The length of Bridge is nine hundred and thirty-two feet; the height from low water mark is forty-four feet. Formerly this Bridge was remarkable for the lofty houses and shops erected on each side of it, which gave it so much the appearance of a street, that a stranger scarcely knew he was crossing the river, till he discovered it by two openings near the middle; the whole width of Bridge from out to out of the houses on each side, was seventy-three feet; but the street between the houses was only twenty-three feet wide. The narrowness of this passage having occasioned the loss of many lives, from the number of carriages passing and repassing; likewise the enormous size of the sterlings, which took up one-fourth part of the water way, and rendered the fall at low water no less than five feet, having also occasioned frequent and fatal accidents; the city of London, in 1756, obtained an act of parliament for improving and widening the passage over and through the Bridge. This act was afterwards explained and improved by another; in consequence of which, this Bridge has now a passage of thirty-one feet for carriages, with a raised pavement of stone, seven feet broad on each side, for the use of foot-passengers, and the sides are secured and adorned by stone balustrades, enlightened in the night with lamps. The passage though the Bridge, as above remarked, is also enlarged, by throwing the two middle arcs into one, and by other improvements; yet London Bridge is still deemed so unfit for its situation, that it is intended to take it down, and to erect an elegant cast-iron Bridge in its stead.*

WESTMINSTER BRIDGE,

OVER THE RIVER THAMES,

CONSTRUCTED OF PORTLAND STONE.

Westminster Bridge is universally allowed to be one of the finest in the world. The first stone of this noble structure was laid on the 29th of January, one thousand seven hundred and thirty-eight, by the earl of Pembroke, and was finished and opened on the 17th of November, one thousand seven hundred and fifty. It is adorned and secured on each side by a very lofty and noble balustrade. Over every pier is a recess on each side, forming a semioctagon, and twelve of these are covered with half domes, four at each end, and four in the middle. Between those in

* Wonders of Nature and Art.

the middle are pedestals, which were intended to support a group of figures; and the whole is lighted in the night by a great number of lamps beautifully disposed. This magnificent structure is one thousand two hundred and twenty-three feet in length, and forty-four in breadth. The space allowed for passengers consists of a commodious foot-way, seven feet broad on each side, paved with broad moor-stone; and the intermediate road is sufficient to admit the passage of three carriages and two horses abreast. The Bridge consists of thirteen large and two small arcs, with fourteen intermediate piers. The arcs are all semicircular, and spring from about two feet above low water mark; the centre arc is seventy-six feet wide, and the rest decrease in width equally on each side, by four feet; and the free course for the water under the arcs is eight hundred and seventy feet, so that there is no sensible fall of water. The foundation is laid on a firm and solid mass of gravel, which lies at the bottom of the bed of the river, but at a much greater depth on the Surry, than on the Westminster side; and this inequality of the ground required the length of the several piers to be very different, as some have their foundations laid at five, and others at fourteen feet under the bed of the river. The piers are all four feet wider at their foundation than at the top, and are founded on the bottoms of the wooden cases on which they were built. All the piers consist of solid blocks of Portland stone, many of which are four or five tons weight, and none less than a ton, except the closers, or smaller stones intended for fastening the rest, one of which is placed between every four of the larger blocks. It is computed that the value of forty thousand pounds, in stone and other materials belonging to the piers and abutments are always under water. This magnificent structure was erected at the expense of three hundred and eighty-nine thousand pounds sterling, defrayed by the parliament. The caisson for the first large pier of this Bridge was reckoned to contain above one hundred and fifty load, or six thousand cubic feet of timber, and exceeded in tonnage a man-of-war of forty guns.*

BLACK-FRIARS BRIDGE,

OVER THE RIVER THAMES,

CONSTRUCTED OF PORTLAND STONE.

Black-Friars Bridge, though less magnificent

* Riou's Architecture of Stone Bridges.

than the former, has the advantage of much wider arcs and a lighter structure. The first stone of the north abutment was laid on the first day of November, one thousand seven hundred and sixty, by Sir THOMAS CHITTY, then lord mayor, attended by several aldermen and commoners of the committee, by his striking the stone with a mallet, and the officers laying upon it, at the same time, the city-sword and mace; several pieces of gold, silver, and copper coins of king GEORGE II, were also placed under the stone, with a Latin inscription.—The arcs of this Bridge, which are only nine in number, are eliptical, and the centre arc is a hundred feet wide; those on the sides thereof decrease in width in a regular gradation, and the arc next the abutment at each end is seventy feet wide. It has an open balustrade at the top, and a commodious foot-way on each side, with room for three carriages abreast in the middle. The centre arc is exceeded by very few in the world, and is considerably larger than that of the Rialto at Venice. This Bridge measures one thousand one hundred feet in length, and forty-two feet in breadth, and was completed in the year one thousand seven hundred and seventy; the expense of its erection is said to have amounted to one hundred and fifty-two thousand eight hundred and forty pounds, to be discharged by a toll upon the passengers. It is situated nearly at an equal distance between the Bridges of Westminster and London, and commands a delightful prospect of the river Thames, from the latter to Whitehall; it also affords a station suitably distant, from whence the intelligent traveller may explore the majesty of that incomparably grand piece of Architecture, St. PAUL'S Cathedral. *

It was formerly a reproach to England, among foreigners, that so capital a river as thc Thames should have so few Bridges; those of London and Kingston being the only two it had, from the Nore to the last mentioned place, for many ages. This inconveniency was in some measure owing to the dearness of materials for building stone Bridges in those days, and also perhaps more to the fondness which the English had for water carriage, and the preservation of navigation. Since that period, the great increase of riches, commerce, and inland trade

* Guthrie's Geography.

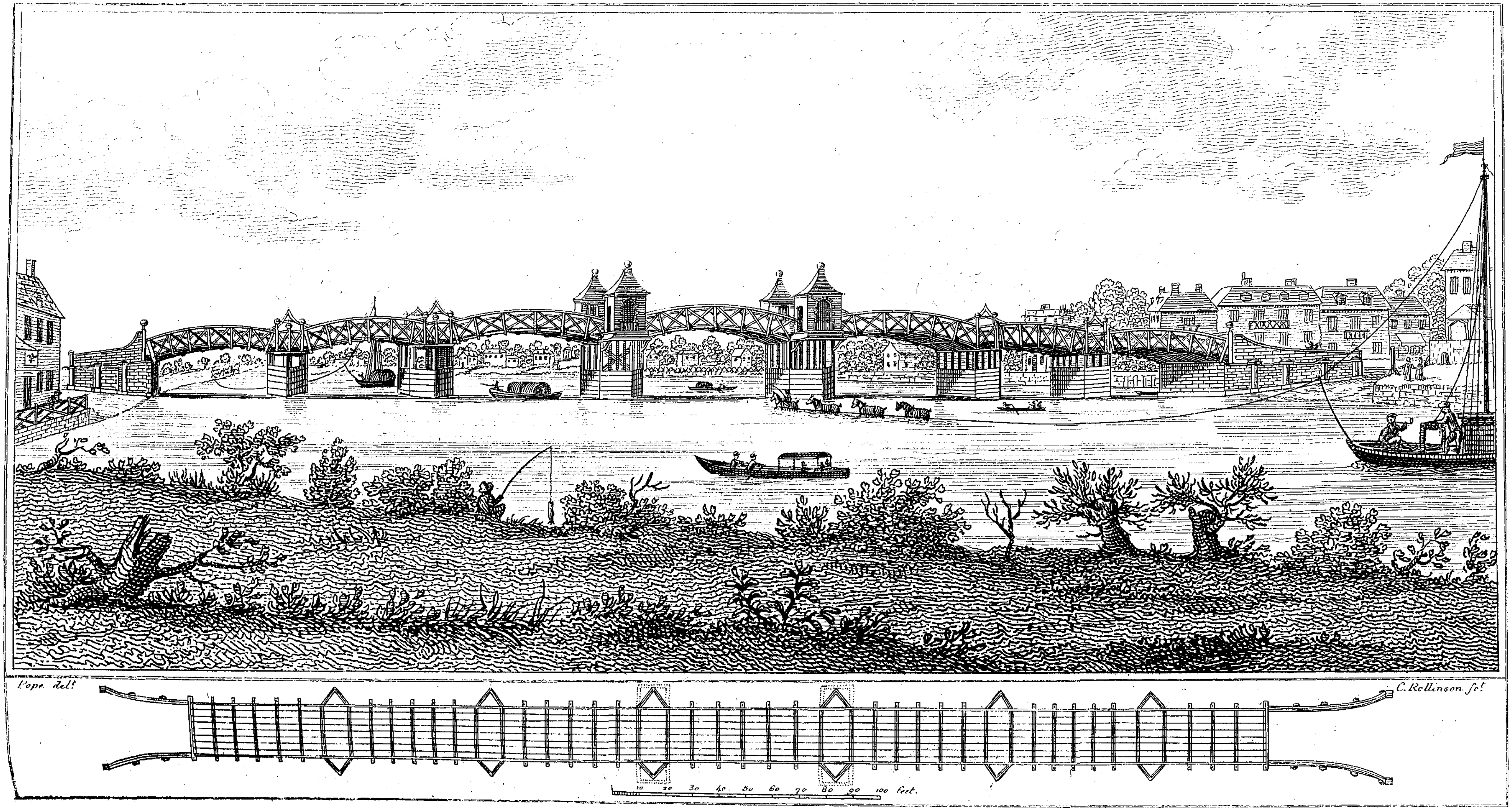
has caused many extensive and elegant Bridges to be erected in different parts of the kingdom; and the world cannot parallel, for commodiousness, architecture and workmanship, those erected at Westminster and Black-Friars. Battersy, Putney, Kew, Richmond, Walton, and Hampton Court, have now Bridges over the Thames, and many others are projecting by the public-spirited proprietors of the grounds on each side the same river.*

BRIDGE AT HAMPTON COURT.

This is a most beautiful and picturesque structure: the part which spans the river is constructed of timber, but the two abutments are built of stone: it furnishes a pleasing appearance in perspective from the adjoining shores of the river.† The length is five hundred feet, and has seven arcs. The piers are cases of timber filled with stone. Barges of one hundred tons burthen pass through this Bridge, by lowering down their masts; they are most commonly dragged by horses, which, on account of the shallow depth of water at certain times of the tide, are permitted to wade up the stream.

* Guthrie's Geography. † See plate XIV.

HAMPTON COURT BRIDGE



Having with hasty steps travelled over the Bridges of the great metropolis of England, and its environs, we shall now shape our course westerly to Bath and Bristol; and in our way glean some rich treasures from the luxuriant banks of the Thames and Avon, which are no less celebrated for works of art than for natural beauties. These might afford ample materials for our pen; but our limits forbid that we linger long on scenes over which Remembrance never tires. We must therefore proceed, without wandering to pluck the rich flowers which, in the course of our journey, will so frequently present themselves; and as we leave the golden vision, look back with fond regret, and say, farewell

> Ye distant spires, ye antique towers,
> That crown the watery glade,
> Where grateful Science still adores
> Her Royal Patron's shade;
> And ye, that from the stately brow
> Of Windsor's height th' expanse below
> Of grove, of lawn, of mead survey,
> Whose turf, whose shade, whose flowers among
> Wanders the hoary Thames along
> His silver winding way.*

* Gray.

As we trace the circuitous banks of this river, we find, at about twenty-four miles distant from London,

ETON BRIDGE,

a structure of little beauty or consequence. But a few miles further up the river we meet with one of a different character, over which passes the turnpike road from London to Bristol: it is constructed all of stone, with five arcs, and is a truly valuable and handsome erection. This is called

MAIDENHEAD BRIDGE.

As we pass on, fourteen miles further, we arrive at

HENLEY BRIDGE,

which is erected of soundstone and forms a pleasing façade. We now follow the winding stream for ten miles more and

CAVERSHAM BRIDGE

appears. This structure is of wood.

There are three other Bridges over the Thames before we arrive at the source of the river; one at

Whitechapel, another near Wallingford, and another at Dorchester; but neither of them merit a particular description.

We shall now take a leap from the head of the Thames to the banks of the Avon; and first notice that the river Avon, though inferior to the Thames, is one of the most notable, useful, and curious rivers in England. As the Thames hath on its banks the two finest cities of the East, London and Westminster, so the Avon hath on hers the two best and largest cities of the West: Bristol, the capital Kay and Mart of the country; and Bath, the most elegant city in the kingdom, without exception.—This river rises in the northern limits of Wiltshire, and runs on the West of Bredon Forest (according to Camden) to Malmsbury, where it receives another stream, which rises at Tetbury, in Glocestershire, and nearly encircles the town of Malmsbury; thence to Dantsey, six miles from which it receives a stream that runs through Caln, and grows considerably on to Chippenham, where it hath a a Bridge of sixteen arcs over it: thence it flows to Melksham; and having received a river that rises near the Devizes, and a brook called Baron's brook, thus increased, goes through the middle of Bradford, under a Bridge of eight arcs. The author of the tour through Britain observes in vol. ii, p. 31: "The river Avon, a noble and large fresh river, branches itself into many parts, and receiving almost all the rivers on this side of the hill, waters the whole fruitful vale: and the water of this river is particularly qualified for dying the best colours, and for fulling and dressing the cloth; so that the clothiers generally plant themselves on this river; but especially the dyers, as at Trowbridge and Bradford, which are the two most eminent clothing towns in that part of the vale, for the making Spanish cloths, and for the nicest mixtures." From Bradford it leaves Wilts and enters Somerset; then receiving the Froom from Froom-Selwood, and another river, it comes towards Bath. Here it runs through a fruitful vale, bounded on each side by lofty and magnificent hills; whence the subjacent prospect of the country, the Serpentine river, the fair beautiful buildings of Bath, and its sublime and venerable Cathedral, are quite enchanting. Here it runs under two elegant Bridges; the first has three equal arcs, with shops and houses on it, handsomely constructed; and the other has five arcs, with a balustrade of stone on each side.

On the western side of this Bridge is the Kay of Bath; whence the river is navigable to Bristol; so that Bath is a proper inland port. Barges that have one mast and sail, and carry from forty to one hundred and twenty tons, bring heavy goods from Bristol; iron, copper, wine, deals, and many other articles; and generally return laden with large blocks of freestone, the use of which is increasing here. The river, though quite fresh, is deep, of a good width; beautifully winds on towards Bristol, in an exquisitely delightful and happy vale, between verdant hills, rural scenes and villages; and swarms with fine fish; trout, roach, dace, perch, eels, and others. About two miles and a half from Bath, it runs under a noble Bridge of stone of several arcs, the principal of which is one hundred feet in diameter, and for height and expansion seems to rival the Rialto at Venice. A little farther on is a lofty eminence, beautifully impending over its northern back; on which are pleasantly situated the elegant mansion and park of Sir CÆSAR HAWKINS, Bart. Seven miles from Bristol, between Saltford and Bitton, at Swineford, it becomes the boundary between Glocestershire and Somerset, and so continues till it falls into the Bristol channel. On the eastern side of the town of Keynsham, it receives the river Chew, over which is a Bridge on the Bath road; and below the Bridge are considerable mills and manufactories for copper.

KEYNSHAM BRIDGE,

has nine arcs over the Avon, and near it is a lock, to facilitate the navigation to Bath: at the highest tides the salt sea flows up to this town. At Brislington, the Avon receives another stream; and flowing on by two works for smelting copper at Crew's-hole, it enters the eastern suburbs of Bristol, between the glasshouses, iron-foundries, distilleries, breweries, and sugarhouses; goes on to the city, and runs under its last and most eminent Bridge. Here the Avon is clear and shallow at low water, deep and muddy at high water; but one of the deepest, safest, and most convenient for navigation in England. It is two hundred feet wide at the Bridge; at high tides it rises from twenty-five to thirty feet perpendicularly, exceeding the Thames in depth, which seldom rises more than fifteen feet, often overflows the Kay, has an agreeable effect when full, renders the port very pleasant, and will waft the largest merchant-ships, and even ships of war, up to the Bridge, in the heart of the city. This river has large banks of mud down to its mouth, in the soft beds of which the ships lie securely at low water; and it yields some salmon, shad, plaice, flounders, sand-dabs, plenty of eels, and immense quantities of elvers.

The two greatest churches of Bristol were so situated by our ancestors as to be eminently conspicuous from its port. Below Redcliff, at the Kay, is the mouth of the river Froom; below which, on each side of the water, are delectable views of Bristol, Clifton, and the Somerset hills, down to Rownham Ferry, a mile farther, where the river at high water is three hundred feet broad, and the tide rises thirty-two feet. Here it begins to flow between two rising hills, Clifton and Rownham, the former adorned with elegant piles of building, and the latter with trees and verdure. Beyond the hot-well-house commence the lofty rocks of St. Vincent, between which the river has a winding course of about two miles. The height of those rocks (about three hundred feet), the stupendous manner in which they are left by Divine Power to let the water pass through, some being nearly perpendicular, others impending, some bare and craggy, and others covered with trees up to the summit, afford scenes which perhaps England cannot parallel, and which richly merit the imitative powers of the painter, and the skill of the engraver. The shores are elevated and beautiful down to Hungroad, a safe harbour for large ships, and where some are unloaded into lighters. Below this is Pill, a sort of port-town for the habitation of pilots and others. Here the river is about five hundred feet wide, and the tide rises forty feet at least. From Pill, it flows through a level country for about three miles, to its mouth in the Severn sea, eight miles below Bristol. Here is Kingroad, whence the ships take their departure, which is reckoned a good open harbour, with safe anchorage.

The river Froom rises at Doddington and Rangeworthy, not far from Tetbury in Glocestershire; and, running through Acton, Winterbourne, Hambrook, and Stapletown, through Babtist-mills, enters Bristol at Froom Bridge, and goes all through the city. Before the present Kay was formed and built, in one thousand two hundred and forty-seven, the Froom ran from

FROOM BRIDGE,

through the site of the present Baldwin-street, beneath the walls, and emptied itself into the Avon under St. Nicholas's church.

The Kay of Bristol is upwards of a mile in extent, or circuit, reaching from

ST. GILES'S BRIDGE,

down to the mouth of the Froom, and up the Avon to Bristol Bridge; being one uninterrupted spacious wharf, of hewn stone, having sufficient depth of water before it for ships of the greatest burden, and fully laden to come up close to the walls, and discharge their cargoes. It has different names, as the head of the Kay, Tontine-Kay, Broad-Kay, Gibb, Mud-Dock, the Grove, and the Back. At this Kay lie safely, on a soft bed of mud, a considerable number of ships at all times of the year, which make a pleasing appearance; and the large quantities of different merchandize seen on the wharfs, prove the very great trade of the port of Bristol

N. B. The word Quai, from the non-usage of K. The word Kay is derived from Welch-Gallic and Irish, signifies to enclose, or fence: hence Cahir, Câër, a walled place, town, &c.

On the western side of the Mud-Dock is the great Crane erected on fourteen pillars cased with iron, by the ingenious Mr. PADMORE; a curious piece of mechanism, and worthy of observation. Cranes of the same internal construction are erected in proper situations for loading and unloading, which are all numbered, for the more readily finding the subjacent vessels.

Some merchants of Bristol have for many years had it in contemplation to keep the water up, and the vessels constantly afloat in both rivers, by damming the Avon, at the Redcliff, above the hot-wells. Several plans for this purpose have been proposed, and one is now adopted. And if this scheme can be executed, without any inconvenient delay in the passage of ships and boats, by lock or ice in winter, or danger of muddy sediments that might tend to fill up the channels, it will be a most important and desirable improvement. The plenitude of the rivers will afford safe riding for the ships, render the maritime parts of the town extremely pleasant, and facilitate the passage of boats and barges up the river towards Keynsham and Bath. The objections of stench and infection are utterly nugatory. The rivers of Bath, Exeter, and many other places, are dammed up without offence or complaint, which cannot be occasioned here, as the river will be ever in motion. To all other advantages will be added a communication between Clifton and Ashton parishes, and the counties of Somerset and Glocester.

On the banks of both rivers are several dock-yards, and dry and floating docks for building and repairing the ships. There are two or three by the Froom, besides the various docks at Wapping by the Avon, where is also a spacious wet-dock with double gates, lately built to keep ships constantly afloat. Below these, beyond Limekiln-dock, towards the Hot-wells, is a large floating-dock, that will contain forty sail of stout ships deeply laden, and which in January, one thousand seven hundred and sixty-nine, received a sixty-four gun-ship with ease through its gates. Here are also other docks:

a dry-dock, that will hold a seventy-four gun-ship; and dock-yards, where have been built several ships of war for government. At all these places ship-building and repairing are carried on with great spirit, skill and industry. There was a spacious dock lower down the river at Sea-mills, but it has long been disused, and is now in ruins.

We have now to remark that there was a Bridge over the Avon in one thousand one hundred and seventy-three, which was probably of wood; for in one thousand seven hundred and sixty-seven, when the workmen perforated the old piers, to try if they were fit to support the new Bridge, they found in the middle of Redcliff-pier, a cill of oak, about a foot square and forty feet long, with two uprights near each end, about nine inches square and nine feet high, morticed into the cill, which they concluded to be the remains of the old wooden Bridge, walled up into the pier, to prevent the trouble of taking them out. The old Bridge of stone had four Gothic arcs, lofty houses on each side, and a gateway in the middle, with a chapel over it; was built in one thousand two hundred and forty-seven, and was five hundred and fourteen years old when it was taken down in one thousand seven hundred and sixty-one. The present

BRISTOL BRIDGE

was opened in one thousand seven hundred and sixty-eight; was built of hewn stone brought from Court-field in Monmouthshire; consists of three arcs: the centre arc is eliptical, and of fifty-five feet span; the side arcs are semicircular, and of forty feet each.—The piers are forty-two feet long and ten thick. On each side is a balustrade of Portland-stone, six feet high, and a raised way for foot-passengers, defended by small iron pillars and chains: at each end are two buildings of stone for Toll-houses, now converted into shops. The Bridge presents an agreeable prospect of Bridge-street buildings, St. Nicholas's church, part of the river, and vessels lying at the Kay, called the Back. This is the only Bridge over the Avon at Bristol.

The lowest Bridge over the Froom has two arcs of stone, and (as it crosses the Kay) a Drawbridge to admit coasting vessels and Severn trows to pass through it. It is raised by a curious subterranean mechanical contrivance of iron wheels, with cogs;

and requires only two people, one on each side, to elevate it. There is a little octagon house at each end of this Bridge, from which the masts of the ships appear as thick as trees in a forest. The next Bridge over this river, is St. Giles's, at the head of the Kay, which has two arcs of stone; as also has Froom Bridge, just above, and to this day encumbered with houses on each side. Then follow

ST. JOHN'S BRIDGE,

BRIDEWELL BRIDGE,

NEEDLESS BRIDGE,

PITHAY BRIDGE,

UNION BRIDGE,

MERCHANTS BRIDGE,

PHILADELPHIA BRIDGE,

ELL BRIDGE, AND

PENN'S BRIDGE.

All one-arched Bridges of stone, of various dimensions. So that over this little but useful river, which drives several mills, there are no less than twelve Bridges of stone and four of wood, in the city and suburbs.

Blenheim is a country palace of the Marlborough family, near Woodstock, eight miles from the University of Oxford.

THE BRIDGE AT BLENHEIM

is built over a spacious canal in the park; and consists of three arcs; the chief of which spans one hundred and two feet six inches; and is constructed of beautiful stone. It is impossible to give a competent idea of the effect produced on the mind by the view of this Bridge as we enter Blenheim park from the town of Woodstock. After passing for several hundred yards through an inclosed walk, the traveller is struck with amazement, as the porter at the park gate admits him to a sudden prospect of the surrounding scenery. To the left rises, in majestic show, the magnificent domes of the palace. To the right stretches the extensive canal at the foot of verdant slopes, which nature must have formed in her choicest mood.

The Bridge, with fairy sweep, directs the view to the Obelisk, erected to the memory of CHURCHILL, the celebrated warrior, and the first duke of Marlborough; whilst at intervals the eye is regaled with a richness of foliage and grandeur of *paysage*, which to describe chastely might expose us from some to the accusation of dealing in romance and deception.

Blenheim was built for CHURCHILL, and a domain of sixty miles in circumference ceded to him by the Queen and parliament, as a small part of their acknowledgment of his services as commander-in-chief of the allies, in the war of the Low Countries against LEWIS XIV. The palace receives the name of Blenheim, from the signal victory he obtained over the enemy, at a village of that name.

THE BRIDGE OF ST. MARY MAGDALEN,

OVER THE ISIS AT OXFORD,

is one of the handsomest structures of the kind in England. It is built of Heddington stone, of uncommon whiteness. The balustrades are of the same material as the Bridge, exquisitely wrought and corresponding with the elegance which distinguishes Oxford from almost every other city. A beautiful model of this Bridge, in ivory, is deposited in the picture-gallery of the University.

THE BRIDGE AT ROCHESTER

is built somewhat like unto London Bridge, and is five hundred and fifty feet long, by thirty feet wide, has eleven arcs, with ten piers and the two abutments, all of stone.

The late Bridge at Newcastle-upon-Tyne, was likewise a model of London Bridge, and was built of stone; but in the year one thousand seven hundred and seventy-one, this Bridge was carried away by a great flood, through the breaking up of the arcs for want of sufficient space for the water to pass.*

BRIDGE AT BURTON,

OVER THE RIVER TRENT.

The Trent rises in the Moorlands of Staffordshire, and running south-east by Newcastle-under-Line, divides that country into two parts; then turning north-east on the confines of Derbyshire, visits Nottingham, running the whole length of that county to Lincolnshire, and being joined by the Ouse and several other rivers towards the mouth, obtains the name of the Humber, falling into the sea, south-east of Hull.*

* Guthrie's Geography.

The longest Bridge in England is that over the Trent, at Burton, built by BERNARD ABBOT, of Burton, in the twelfth century. It is all of squared freestone, and is very strong. The length of the Bridge is fifteen hundred and forty-five feet, having thirty-four arcs. The piers are lofty and well executed.*

IRON BRIDGES.

Iron being the most abundant, cheap, and generally the most useful of all metals, has of late been employed in many works where great strength was required, in proportion to the weight of the material: hence cylinders, beams, and pumps for steam-engines, boats, and barges for canals and navigable rivers, pillars for warehouses and other large buildings, and at length Bridges, have been constructed of Iron.

Iron Bridges are the exclusive invention of British artists. The first that has been erected on a large scale is that over the river Severn, at Coalbrook dale, in Shropshire.

* Dr. Rees's New Cyclopædia.

COALBROOK DALE BRIDGE.

This Bridge is composed of five ribs, and each rib of three concentric arcs, connected together by radiating pieces. The interior arc forms a complete semicircle, but the others extend only to the cills under the road-way. These arcs pass through an upright frame of iron at each end, which serves as a guide; and the small space in the haunches, between the frame and the outer arc, is filled in with a ring of about seven feet diameter. Upon the top of the ribs are laid cast-iron plates, which sustain the road-way. The arc of this Bridge is one hundred feet six inches in span; the archivolt, rings or interior circles, are cast in two pieces, each piece being seventy-two feet in length. It was constructed in the year one thousand seven hundred and seventy-nine, by Mr. ABRAHAM DARBY, iron-master at Coalbrook dale, and must be considered as a very bold effort in the first instance of adopting a new material. The total weight of the metal is three hundred and seventy eight tons and a half.*

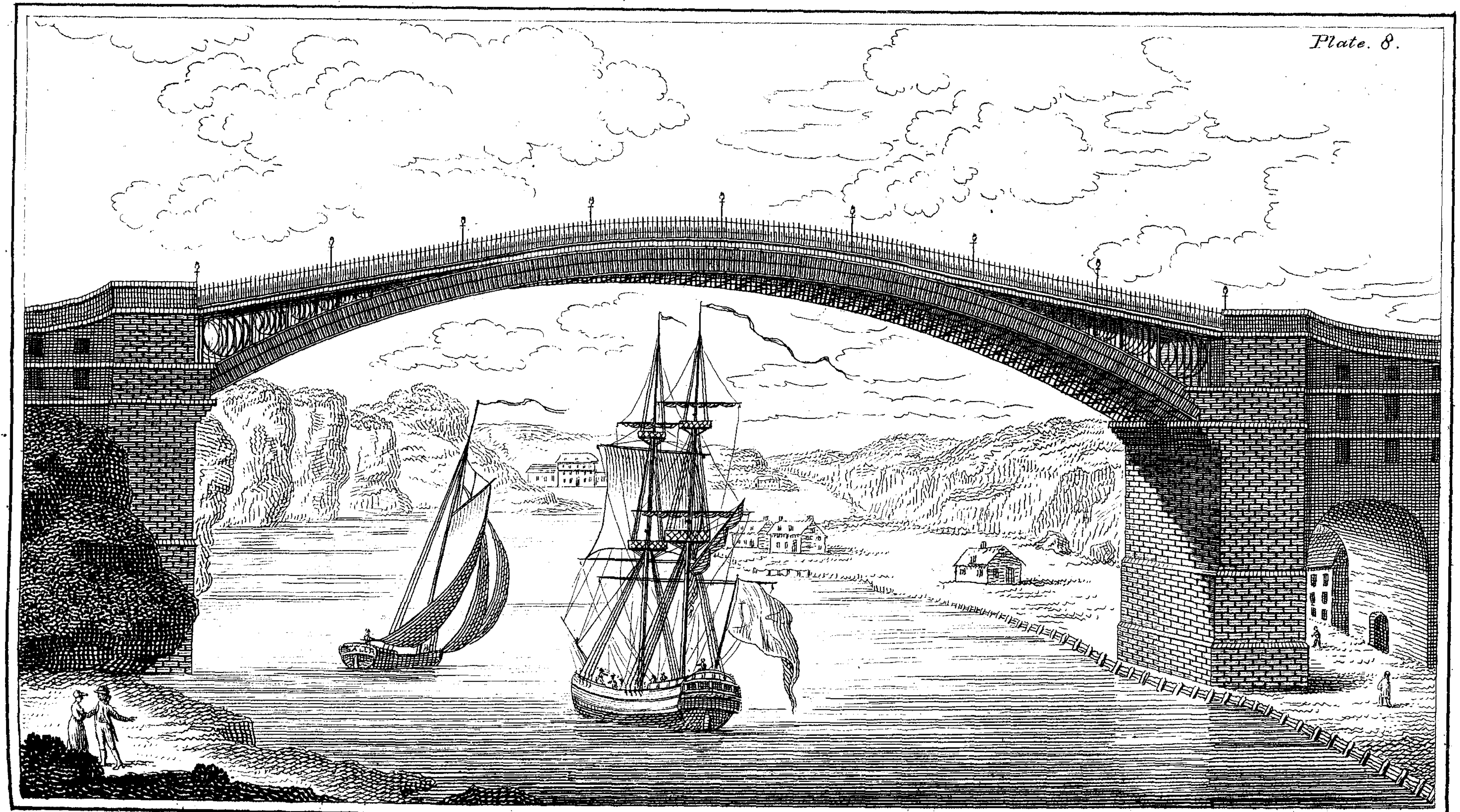
* Dr. Rees's New Cyclopædia.

WEARMOUTH BRIDGE,

CONSTRUCTED OF CAST IRON.

The second iron Bridge of importance, erected in Great Britain, was that over the river Wear, at Bishop Wearmouth, near Sunderland, the chief projector of which was Rowland Burdon, Esq. M. P. As this is the most considerable structure of the kind, it may be proper to give a brief sketch of its history. In consequence of the increasing trade and population of Sunderland and the two Wearmouths, the ancient ferry, which was almost in the middle of the harbour, had become very insufficient and unsafe, so that, besides frequent delays and disappointments, several instances had occurred of the loss of lives.

About the year one thousand seven hundred and ninety, in which Mr. Burdon was returned to parliament by the county of Durham, some gentlemen interested in the welfare of the town and neighbourhood of Sunderland, united for the purpose of removing the evils arising from the ferry, and Mr. Burdon was appointed one of the committee. Conceiving at first that a stone Bridge would be proper,



Pope del.t

Etch'd by Leney

WEARMOUTH-BRIDGE.

they began to adopt measures for its erection. An Architect was chosen to carry on the necessary works, who in due time produced plans, estimates, and a model of the intended edifice. But as the work was of considerable magnitude and importance, it was thought expedient to refer the design to the opinion of some gentlemen of celebrity for scientific and practical knowledge in and near the metropolis; their report being unfavorable, the scheme of erecting a stone Bridge was abandoned. The committee, however, being now warmly engaged in the business, continued to prosecute their enquiries; and Mr. BURDON in particular being frequently called by his parliamentary duty to London, was very diligent in his endeavours to obtain information and hints, from various quarters, as to the peculiar advantages and disadvantages of different materials, as well as of various modes of construction. Mr. BURDON had the good fortune to be assisted in the maturing of his plans by Mr. THOMAS WILSON, a truly ingenious man, and at the same time to learn much of the construction of iron Bridges from Messrs. WALKERS, of Rotherham, so that at length he became persuaded that iron would be the most proper material of which to form the proposed Bridge. He thought it best, however, to adhere to the ancient construction, by dividing the arc into portions, in the manner of arc stones, and taking advantage of the ductility and tenacity of iron to produce an arc of that metal at least fifteen times lighter than a corresponding arc of stone, and capable of being put together upon an ordinary scaffolding, instead of an accurate cintre, in a much shorter space of time.

Mr. WILSON, in conjunction with Messrs. WALKERS, constructed and set up an experimental rib at Rotherham, which being found to answer expectation, the success of the experiment was communicated by Mr. BURDON to the town of Sunderland and the county; and his proposition for the erection of an iron Bridge was acceded to. The first stone was laid in September, seventeen hundred and ninety-three; and Mr. WILSON was appointed to the superintendance of the work. The iron-work was cast by Messrs. WALKERS, of Rotherham, and the arc was turned upon a very light but firm scaffolding, so judiciously constructed that not any interruption was given to the passage of the numerous vessels which navigate the busy river of Sunderland. The mode of bracing the ribs was so simple and expeditious, that the whole was put together and thrown over the river in ten days; the scaffolding was immediately removed, and the Bridge opened for general use, on the ninth day of August, seventeen hundred and ninety six.

During the period occupied in erecting the Bridge, Mr. BURDON took out a patent to secure the invention of " a certain mode or manner of making, uniting and applying cast-iron blocks to be substituted in lieu of keystones, in the construction of arcs." He thus proceeds to describe his invention, which " consists in applying iron or other metalic compositions to the purpose of constructing arcs upon the same principle as stone is now employed, by a subdivision into blocks easily portable, answering to the keystones of a common arc, which being brought to bear on each other, gives them all the firmness of the solid stone arc, whilst, by the great vacuities in the blocks, and their respective distances in their lateral position, the arc becomes much lighter than that of stone, and by the tenacity of the metal the parts are so intimately connected that the accurate calculation of the extrados and intrados, so necessary in stone arcs of magnitude, is rendered of much less consequence.

The Bridge consists of a single arc, whose span is two hundred and thirty-six feet; and as the springing-stones at each side project two feet, the whole opening is two hundred and forty-feet. The arc is a segment of a circle of about four hundred and forty-four feet diameter; its versed sine is thirty-four feet, and the whole height from low water about one hundred feet, admitting vessels of from two to three hundred tons burthen to pass under, without striking their masts. A series of one hundred and five blocks form a rib; and six of these ribs compose the breadth of the Bridge. The spandrels, or the spaces between the arc and the road-way, are filled up by cast-iron circles, which touch the outer circumference of the arc, and at the same time support the road-way, thus gradually diminishing from the abutments towards the centre of the Bridge. There are also diagonal iron-bars, which are laid on the tops of the ribs, and extended to the abutments, to keep the ribs from twisting. The superstructure is a strong frame of timber planked over to support the carriage-road, which is composed of marl, lime-stone and gravel, with a cement of tar and chalk immediately upon the planks, to preserve them. The whole width of the Bridge is thirty-two feet. The abutments are masses of almost solid masonry, twenty-four feet in thickness, forty-two in breadth at bottom, and thirty-seven at top. The south pier is founded on the solid rock, and rises from about twenty-two feet above the bed of the river. On the north side, the ground was not so favourable; so that it was necessary to carry the foundation ten feet below the bed. The weight of the iron in this extraordinary fabric amounts to two hundred and sixty tons; forty-six of these are malleable, and two hundred and fourteen cast. The entire expense for it was twenty seven thousand pounds.

From this account of the Bridge, across the Wear, the attentive reader will see much to admire in its construction. It is not, however, totally free from defects. We conceive that the spandrels are very improperly filled up. It is true that it is done in such a manner as is exceedingly light and pleasing to the eye; but the iron hoops may, we think, be easily compressed at the points of contact, and changing their shape will oppose very little resistance. As the arc forms so small a portion of a circle (about sixty-four degrees and three quarters), the weight at the spring of the arc need not, according to the theory of equilibration, be double to that at the crown, to support, without danger of rising, any pressure derived from the mass of the structure itself: but, in so flat and light an arc, an overload on any part must have a great tendency to bend it, and consequently tend considerably to break it, at a distant part, with all the energy of a long lever. We think, therefore, that a better form might have been adopted than what has been put in practice at Wearmouth Bridge.

BRIDGES AT BRISTOL,

OF CAST-IRON.

There are also two elegant cast-iron Bridges lately erected over the New Cut, for the improvement of the harbour of Bristol by float. The span of the arch of each Bridge is one hundred feet, by thirty feet high. These were built under the direction of Wm. Jessup, Esq. engineer, and are admirable for their simplicity of construction and strength.

A BRIDGE OVER THE SEVERN,

CONSTRUCTED OF CAST-IRON.

Another iron Bridge is that over the Severn at Buildwas, about two miles above Coalbrook Dale. An old stone Bridge, of three narrow arcs, having been carried away by a high flood in one thousand seven hundred and ninety-five, the present iron Bridge was planned and built by the Coalbrook Dale company, under the superintendance of Mr. THOMAS TELFORD, the county surveyor, in one thousand seven hundred and ninety-six. It consists of a single arc, one hundred and thirty feet in span; the rise, from the springing to the soffit being twenty-seven feet; and as it was thought necessary to keep the road-way as low as possible, the outside ribs are made to go up as high as the railing; they are connected with the ribs that bear the covering plates, by means of pieces of iron dovetailed in the form of king-posts. The plates which compose the covering over the lower ribs are cast with deep flaunches; they are laid close to each other, and form an arc of themselves. These side ribs, or arcs, would have added much more to the strength of the Bridge than they now do, had the materials been of a substance that would not expand or contract: but that not being the case, they, in warm weather, when they expand, rather tend to derange the other parts of the Bridge than strengthen them; and the appearance of the whole is by no means pleasing.

BRIDGES OF CAST-IRON,

OVER THE RIVERS PARROT, AND THAMES.

The splendid example of the Bridge at Wearmouth gave an impulse to public taste, and caused an emulation among artists, which has produced many examples and more projects of iron Bridges.

The Coalbrook Dale Company have constructed several, among which is a very neat one, over the river Parrot, at Bridgewater. Mr. WILSON, the engineer, employed by Mr. BURDON, has also built several, and has lately finished a very elegant one over the river Thames at Staines, which is by far the most complete in design, as well as the best executed of any that has hitherto been erected. This Bridge consists of a single arc, one hundred and eighty-one feet in span, and sixteen feet six inches in rise; being a segment of a circle of four hundred and eighty feet. The blocks, of which the ribs are composed, are similar to those in the Wearmouth Bridge, except that these have only two concentric arcs instead of three, as at the latter. The arcs are cast hollow, and the blocks connected by means of dowels and keys; thus obviating the great defect observed at Wearmouth, of having so much hammered iron exposed to the action of the air. Four ribs form the width of the arc, which are connected together by cross frames. The spandrels are filled in with circles, which support a covering of iron plates an inch thick: on this is laid the road-way, twenty-seven feet wide. Two hundred and seventy tons are the weight of the iron employed in the Bridge, and three hundred and thirty of the road-way.

A BRIDGE OVER THE TAFF,

CONSTRUCTED OF STONE.

But the most extraordinary Bridge in Great Britain is, doubtless, the one over the river Taff, near Llantrissent, in Glamorganshire, called in Welch *Pont y ty Prydd.* This is the work of

William Edwards, an uneducated mason of the country, who was only indebted for his skill to his own industry and the power of his genius.—He had engaged, in one thousand seven hundred and forty-six, to build a new Bridge at this place, which he executed in a style superior to any thing of the kind in this or any other part of Wales, for neatness of workmanship and elegance of design.—"It consisted of three arcs, elegantly light in their construction. The hewn stones were excellently well dressed and closely jointed. It was admired by all who saw it. But this river runs through a very deep vale that is more than usually woody, and crowded about with mountains. It is also to be considered that many other rivers, of no mean capacity, as the Crue, the Bargoed Taff, and the Cunno, besides almost numberless brooks, that run through long, deep, and well-wooded vales, or glens, fall into the Taff in its progress. The descents into these vales from the mountains being in general very steep, the water, in long and heavy rains, collects into these rivers with great rapidity and force, raising floods that, in their description, would appear absolutely incredible to the inhabitants of open and flat countries, where the rivers are neither so precipitate in their courses, nor have such hills on each side to swell them with their torrents. Such a flood unfortunately occurred after the completion of this undertaking, which tore up the largest trees by the roots, and carried them down the river to the Bridge, where the arcs were not sufficiently wide to admit of their passage. Here, therefore, they were detained. Brushwood, weeds, hay, straw, and whatever lay in the way of the flood, came down, and collected about the branches of the trees, that stuck fast in the arcs, and choaked the free current of the water. In consequence of this obstruction to the flood, a thick and strong dam, as it were, was thus formed. The aggregate of so many collected streams being unable to get any further, rose here to a prodigious height, and with the force of its pressure carried the Bridge entirely away before it. William Edwards had given security for the stability of the Bridge during the space of seven years; and of course he was obliged to erect another; and he proceeded on his duty with all possible speed. The Bridge had only stood about two years and a half. The second Bridge was of one arc, for the purpose of admitting freely under it, whatever incumbrances the floods might bring down. The span or chord of this arc was one hundred and forty feet, its altitude thirty-five feet, by a segment of a circle whose diameter was one hundred and seventy feet. The arc was finished, but the parapets not yet ereted, when such was the pressure of the unavoidable ponderous work over the haunches, that it sprung in the middle, and the keystones were forced out. This was a severe blow to a man who had hitherto met with nothing but misfortune in an enterprize which was to establish or ruin him in his profession. WILLIAM EDWARDS, however, possessed a courage which did not easily forsake him; he engaged in it a third time, and by means of cylindrical holes through the haunches, so reduced their weight, that there was no longer any danger from it. The second Bridge fell in one thousand seven hundred and fifty-one; the third, which has stood ever since, was completed in one thousand seven hundred and fifty-five." (Mr. MALKIN's tour in South Wales). The present arc is one hundred and forty feet in span, and thirty-five feet high, being a segment of a circle of one hundred and seventy-five feet diameter. In each haunch there are three cylindrical openings running through from side to side; the diameter of the lowest is nine feet, of the next six feet, and of the uppermost three feet. The width of the Bridge is about eleven feet. To strengthen it horizontally, it is made widest at the abutments, from which it contracts towards the centre by seven offsets, so that the road-way is one foot nine inches wider at the extremities, than at the middle.*

A BRIDGE OVER THE PEATHS,

CONSTRUCTED OF STONE.

The Bridge over the Pease, or rather Peaths, on the road from Dunbar to Berwick upon Tweed, is rather an uncommon structure. This Bridge crosses a deep ravine called the Peaths. It consists of four semicircular arcs. That at the east side of the ravine is fifty four feet span; the second fifty-five feet; the third fifty-two feet, and the further or western arc forty-eight feet. The height of the Bridge, from the bottom of the ravine to the surface of the road, is one hundred and twenty-four feet. The situation is beautiful, and has a most romantic appearance. It was designed and built by

* Dr. Rees's New Cyclopædia.

the late Mr. DAVID HENDERSON, architect in Edinburgh, and does him considerable credit.*

A BRIDGE OVER THE LUNE,

CONSTRUCTED OF STONE.

The aqueduct Bridge, constructed by Mr. RENNIE on the river Lune at Lancaster, is one of the most magnificent works of the kind which has been erected for the purposes of navigation. At the place where it is built the water is deep and the bottom bad. It consists of five arcs of seventy feet span each, and about thirty-nine feet above the surface of the water. It has a handsome cornice, and every part of it highly finished. The foundations are laid at the depth of twenty feet under the surface of the water, and stand on a flooring of timber, supported by piles. The foundation alone cost fifteen thousand pounds. The superstructure cost above twice that sum, although the stone was found within about a mile and a half of the place where the aqueduct was built. Barges of sixty tons burthen navigate the canal. The total height from the surface of the river to the surface of the canal is fifty-one feet.*

* Dr. Rees's New Cyclopædia.

AMERICAN BRIDGES;

It is a notorious fact that there is no country of the world which is more in need of good and permanent Bridges than the United States of America. Extended along an immense line of coast on which abound rivers, creeks and swamps, it is impossible that any physical union of the country can really take place until the labours of the architect and mechanic shall have more perfectly done away the inconvenience arising from the intervention of the waters. Nature, ever provident for man, has, however, afforded us ample means of remedy.—Our forests teem with the choicest timber; and our floods can bear it on their capacious bosoms to the requisite points. Public spirit is alone wanting to make us the greatest nation on earth; and there is nothing more essential to the establishment of that greatness than the building of Bridges, the digging of canals, and the making of sound turnpike-roads. Necessity has already produced some handsome and extensive specimens of Bridge-building in the United States, agreeable to ancient models; and we shall proceed to mention a few of them.

CHARLESTON BRIDGE,

Over the Charles river at Boston, in Massachusetts, stands on seventy-five piers, is one thousand five hundred and three feet in length and forty-two broad. It was completed in one thousand seven hundred and eighty-seven, and cost fifty thousand dollars.*

WEST BOSTON BRIDGE,

on the same river, stands on one hundred and eighty piers; is three thousand four hundred and eighty-three feet long, and forty feet broad. It cost seventy-six thousand dollars. Both these Bridges have conveniences for the passage of vessels; and are well lighted at night.*

BRIDGE OVER LAKE CAYUGA,

The Bridge over the Cayuga lake, in New-York state, on the turnpike-road from Albany to Niagara, stands on two hundred and ten trestles, each consisting of three posts connected by four girths and four braces. The posts are sunk to hard gravel,

* Dr. Rees's New Cyclopædia.

which is generally about thirty feet from the surface of the water. They are twenty-five feet apart. The whole length of the wood-work is one mile; and it cost twenty thousand dollars.*

BRIDGE AT SCHENECTADY.

A large and elegant Bridge was lately erected over the Mohawk, at Schenectady; and another, said to be of a new construction, over the Delaware at Trenton, N. J. In the latter, the road-way is suspended from the arcs, which serve to support a roof. Mease, in his geological account of the U. S. gives the following description, of it.*

BRIDGE AT TRENTON.

"On the twenty-first day of May, one thousand eight hundred and four, the first corner stone was laid. The front of the abutment, on the Pennsylvania side, being sixty-five feet in advance from the bank, it was thought prudent to make it thicker than the one on the opposite shore. Accordingly, this abutment is fifty feet in front and eighteen feet thick, with the back part supported by an horizon-

* Dr. Rees's New Cylopædia.

tal arc from its foundation. On the third day of July, the stone-work was commenced, and continued without much further interruption, except from the water flowing in, until it arrived at the level of the ground.

The fronts of the abutments, from the surface of the ground, and the ends, and about forty feet of the wing walls above the banks, are carried up with cut stone in courses of range-work, varying in depth as they proceed upwards, from twenty to six inches, and *battering* half an inch in the foot: and although no ornament was sought for, this masonry exhibits a solidity of work, and neatness of execution, that reflect great credit on the workmen who constructed it. The cut stone in the abutments are all clamped together with iron clamps, as high as is presumed the ice or other floating substances will ever assail them; and in every tier of stone are a number of branch clamps extending diagonally and crosswise the abutment, connecting the whole together. The interior is made up of large rough stone, many of half a ton weight and upwards, compactly filled in with smaller stone, and the whole laid in good lime and sand mortar, and forming one entire solid mass of masonry. These abutments are nineteen feet above the ordinary flow of the tide; six feet above the highest freshes from ordinary causes, and at least four feet higher than the water has ever been known to rise, from obstructions by ice on the bars below. Besides this, the travelling-way is raised nearly three feet higher; so that no injury can possibly be sustained in the wooden superstructure, by any substances floating on or carried down the river in the highest freshes.

The wing walls on the east side, at the distance of sixty feet fromthe front of the abutments spread or splay, seventy-eight feet; and for the first twenty feet they run into the bank and are laid as deep as the foundation of the abutment, and seven feet wide in the bottom. From the end of the angle, they are continued in a parallel line with each other, one hundred and three feet farther, on a gradual taper to four feet, where they terminate. The exterior of this masonry is battered half an inch to the foot, while the interior is rather more perpendicular; so that the filling has little or no pressure on the side walls, but will settle in perpendicular lines. The wing walls on the west, or Pensylvania side, are eighty-five feet in length from the front of the abutment, extend about eighteen feet in the bank, and spread or splay sixty-six feet; being the width of the street leading to the Bridge.

In laying the exterior courses of the foundations of the piers, great care was taken to select flat and long stones, running many feet into the piers. On these, and throughout the whole interior, are laid large rough stone of vast weight, and the whole closely filled in with building stone. The depth of these foundations vary several feet in different parts of the piers, owing to the irregular surface of the rock (in some places forming a pretty regular bason), and this is an additional security against their being removed by ice, rafts, or other floating substances coming against them.

An offset of six inches is made on these foundations, when the cut stone commences; the pier here receiving its proper shape and dimensions, which, in this place, is sixty-eight feet in length, and twenty-two in breadth, with the end up stream, of a semicircular form. The levelling up of the foundation, and all the cut stone, are laid in terras mortar. On the pier next to the Pennsylvania shore, three courses of cut stone are laid, of twenty and twenty-two inches in depth; in which situation, ice and every other floating substance will run over them during the winter and spring seasons.

The span between the Pennsylvania abutment and the first pier, as also between each of the other piers, is one hundred and ninety-four feet; and from the New-Jersey abutment to the first pier, the span is one hundred and fifty-six feet, leaving a water-way of nine hundred and thirty-two feet, out of eleven hundred, the distance across the river from the top of one bank to the other.

The piers are all carried up with cut stone, in courses of range-work, varying in depth, as they proceed upwards, from twenty-five to eight inches, until they rise to the top course, which is twelve inches, with the sides and lower end battering half an inch in the foot: these stones extend into the body of the work, from eight inches to five feet.—The exterior or cut stone, as high as the water has ever been known to rise, is laid in terras mortar; and throughout the whole extent, lengthwise, every second or third course, clamped together with iron clamps. Crosswise, also, of the piers, every third or fourth course, eight or more iron clamps are extended from side to side, and let into the courses of cut stone. These, together with a vast number of brass clamps, it is presumed, will effectually secure the whole from spreading or giving way in any direction. The ends of the piers, up stream, are semicircular, and after rising four and a half feet from their foundations, with the usual batter of the sides, they recede or batter at an angle of sixty-seven degrees, until they rise to the further height of ten perpendicular feet, when they are again carried up with the former batter to the square, where they terminate, and receive their finish with a coping of cut stone, in the form of a half dome. The stones of which this angular part is composed, are all deep in their bed, extending from two to five feet into the pier, and are each secured with a clamp of iron. At this point the cut stone ceases, and the dimensions of the pier are here sixty-two feet in length, and twenty feet in breadth.

An offset of eight inches is then made on the sides, and the square part of the piers again carried up, with a skue back, to the further height of three feet nine inches. The feet of the arcs rest on this offset, and spring from this angle. The height of the piers next the shores, from the foot of the arcs to ordinary low water mark, is twenty-seven feet five inches, and of those in the middle twenty-eight feet seven inches each. The distance between the abutments is one thousand and eight feet, and the whole length of the Bridge, including the wing walls, will be one quarter of a mile.

The whole of the stone work done consists of one hundred and sixty-nine thousand, two hundred and twenty-three feet of cut stone, contained in sixteen thousand six hundred and fifty perches of masonry.

On the execution of this branch of the work commited to their care, the board of managers rely with the fullest confidence, and do not hesitate to pronounce it as solid and complete a piece of masonry as is any where to be found in the United States.

The superstructure consists of five arcs, or five sets or series of arcs, each composed of five sections or ribs, as they are usually called, and rising from the chord line, in the proportion of thirteen feet in one hundred. These sections or ribs are formed of white pine plank, of from thirty-five to fifty feet in length, four inches thick, and twelve inches wide (except the middle section, which is thirteen), and repeated one over the other, breaking joints, until they form a depth of three feet through. This mode of constructing wooden arcs is considered as a great improvement in Bridge architecture, and we are told was first introduced in practice by Mr. BURR, the architect of this Bridge. Be this as it may, it is supposed to possess many advantages over those formed of solid and massy pieces of timber. The relative situation of these sections is such as to leave two openings of eleven feet each in the centre for carriages, and two of four feet six inches each on the sides, for foot-walks. The general width of the Bridge is therefore thirty-six feet from out to out, and the travelling ways will be on the chord-line between these sections. Outside of the two exterior sections, wing arches of fifty feet in length, and of the same convexity and depth, are placed, which inclining toward the centre, are united to these sections, and securely bolted through them. This gives the Bridge an additional base of fifteen feet, and a bearing of fifty-two feet on each pier. On the top or circumference of these sections and wing-arcs, beams or ties and diagonal braces are laid and let into each other, in the form of lattice-work, and the whole firmly connected with the arcs by iron bolts with screws going through them at the distance of every eight feet.— Thus they are made to form one entire connected arc, which can neither admit of any sideway or intestine motion between the sections, nor be readily injured or endangered by high winds.

The platform on which the travelling is performed is suspended from these arcs, by means of iron chains or links, which hook into the eye-bolts, firmly fixed through the arcs, at the distance also of every eight feet, in the three middle sections, and sixteen feet in the two exterior ones. To the lower ends of these chains is appended a stirrup, in which the beams lay, which sustain the joists and flooring. To prevent the platform from having any swinging motion, wing-chords and diagonal braces are again interposed, which effectually perform this service.

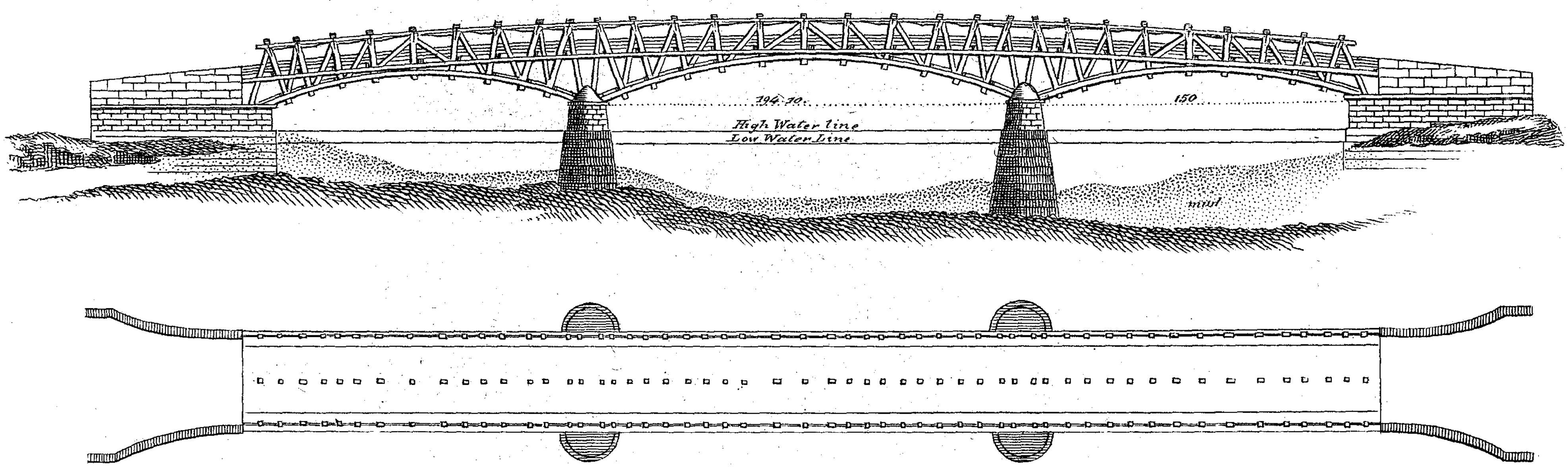
The expansion of the arcs (were not the solidity and weight of the piers and abutments of themselves sufficient) is completely guarded against by the intervention of wooden chords, which embrace and connect the several feet of those arcs together. These serve also a further important purpose, to wit, of stiffening and strengthening the arcs by means of upright bracing, which takes place between them and the chords; so that by the application of great weights to either end of the arc, no vibratory motion can ensue, as the pressure is by this means distributed throughout the whole extent of the segment.

The three great objects, convenience of *travelling*, *strength*, and *durability*, are all happily united in the model adopted—nor has *ornament* been wholly thrown aside. The access to the Bridge, on either side, and throughout the whole extent of the platform, presents to the traveller a plane, without any sensible rising.

With regard to *strength* we can only speak by a comparison with other structures upon a similar principle. The two Bridges across the Hudson river, at Waterford and Fort Miller, constructed under the superintendance of Mr. Burr, and the one across the Connecticut river at Springfield, by Mr. Walcott, are all spoken of in terms of high approbation. Our Bridge, we are assured by Mr. Burr, combines double the strength of either of

Plate. 11.

Frame of the Bridge over the River Schuylkill at Philadelphia



T. Pope. del.

C. Hollinton. sc.

them; but what constitutes the greatest excellence of the Delaware Bridge is the prospect of its durability. The permanency of the stonework is not to be questioned; and by the proposed covering, the stamina or main parts of the wooden superstructure will be effectually protected from decay by the wet, while those parts exposed to injury from the weather are all susceptible of the most complete repair."*

SCHUYLKILL BRIDGE,

The permanent Bridge lately erected over the Schuylkill at Philadelphia is also a strong and elegant piece of architecture. It is composed of three arcs of wood, supported by two stone piers, with two abutments and wing-walls. The western pier is sunk in an astonishing depth of water, perhaps greater than ever any Bridge pier was before sunk, in any part of the world; the surface of the rock on which it is placed being forty-one feet nine inches below common high tides. The piers were built with coffer dams. The dam for the western pier was curiously constructed, from a design furnished by

* American Additions to Dr. Rees's New Cyclopædia.

Mr. William Weston, a celebrated hydraulic engineer of Gainsborough in England. We may have some conception of its magnitude when we are told that eight hundred thousand feet of timber were employed in it.

The masonry of this Bridge was executed by Mr. Thomas Vicker, on an uncommon, if not a novel plan. The walls of the abutments and wings are perpendicular, without buttresses, and supported by interior offsets. These are found completely competent to support the pressure of the filling, without *battering* or *contreforts*. The abutments are eighteen feet thick. The wing-walls nine feet at the foundation, retiring by offsets, till at the parapets they are only eighteen inches. The eastern abutment and wing-walls are founded on a rock.— Those on the western side are built on piles. There are upwards of seven thousand five hundred tons of masonry in the western pier. Many of the stones composing both piers weigh from three to twelve tons. A number of massive chains are stretched in various positions across the piers. These are worked in with the masonry; the exterior of which is clamped, and finished in the most substantial and workmanlike style.

The frame of the superstructure was designed and erected by TIMOTHY PALMER of Newburyport, Massachusetts. It is a masterly piece of workmanship, combining in its principles that of king-posts and braces with that of a stone arc. Half of each post, with the brace between them, will form the voussoir of an arc; and lines through the middle of each post would describe the radii or joints.

The platform for travelling rises only eight feet from a horizontal line; and the top or cap pieces are parallel to this. Of the sections, the middle one has the most pressure, owing to the weight of transportation being thrown nearer to that section than towards the sides, to which the foot-ways prevent its approach. These foot-ways are five feet wide, elevated above the carriage-ways, and neatly protected by posts and chains. T. PALMER is the original inventor of this kind of wooden Bridge architecture. He permitted, with much candour, considerable alterations in the plan on which he had erected several Bridges in New-England. These were accommodatory to the intended cover, and were so much approved by him, that he considered the Schuylkill Bridge superstructure the most perfect of any he has built.

The workmanship of the covering was performed by O BIDDLE, of Philadelphia, agreeably to a design furnished him. The underwork is done in imitation of masonry, by sprinkling it with stone dust after being fresh painted.

Commodious wharfs, on each side of the river, have been made, not only to protect the foundations of the abutments and wings, but with a view to profit. They co-operate with other improvements to give a new and interesting front to the city.

This Bridge was six years in building, and cost about two hundred and seventy-five thousand dollars, including the cash moiety of the purchase of the site, for which forty thousand dollars were paid to the city corporation, half in cash, and half in Bridge shares.

The following are the proportions of the Bridge.

	FT.	IN.
Length - - - - -	550	00
Abutments and wing-walls - -	750	00
Total length - - - - -	1300	00

Span of the small arcs each - -	150	00
Ditto the middle arc - - -	194	10
Width of the arc - - -	42	00
Curvature of the middle arc - -	12	00
Ditto of the small arcs - - -	10	00
Curvature or rise of the carriage-way	8	00
Height in the clear over the carriage-way	13	00
Height from the surface of the river to ditto	31	00
Thickness of the pier - - -	20	00
Length of ditto - - -	62	00
Depth of water to the rock at the western pier	41	00
Ditto at the eastern pier - -	21	00

Amount of toll when the work began, for the year one thousand seven hundred and ninety-nine, arising from the floating Bridge - - $ 5000

Amount of toll on an average (1805), the rates of toll in several instances being lower than over the old floating Bridge. - - $ 13,600.*

JEDEDIAH MORSE, in his Universal Geography of one thousand eight hundred and five, has given the following account of sundry Bridges erected in different parts of the United States.

* American Additions to Dr. Rees's New Cyclopædia.

A BRIDGE

IN THE DISTRICT OF MAINE.

Over York River, about a mile from the sea, was built, in the year one thousand seven hundred and sixty one, a Bridge two hundred and seventy feet long by twenty-five feet wide, exclusive of the wharfs at each end, which reach to the channel. The Bridge stands on thirteen piers, and was planned by Major SAMUEL SEWALL. In the year one thousand seven hundred and ninety three, this Bridge was rebuilt on the original plan. The model of Charles-river Bridge was taken from this, and was built under the superintendance of the same gentleman. It has also served as the model of Malden and Beverly Bridges, and has been imitated even in Ireland, by those ingenious American Artists, Messieurs COX and THOMPSON.

BRIDGES

IN NEW-HAMPSHIRE.

In Hanover, opposite Dartmouth College, is erected a Bridge with a single arc, two hundred and thirty feet chord. The abutments are built with stone, and the whole length of Bridge is four hundred and fifty-three feet, the width is thirty-six feet. In the winter of one thousand eight hundred and five, this Bridge fell, and has not since been rebuilt.

BRIDGE AT WALPOLE.

Over Bellows Falls at Walpole was erected, in the year seventeen hundred and eighty-four, by COL. HALE, a timber Bridge, three hundred and sixty-five feet long, supported in the middle by a great rock.

WINDSOR BRIDGE.

This Bridge connects Windsor and Cornish, and is five hundred and twenty-one feet long, by thirty-four feet wide. It consists of two arcs, each one hundred and forty-four feet chord. The pier in the centre is forty-six feet by forty-one. This Bridge cost twenty thousand dollars.

A BRIDGE

OVER THE MERRIMACK RIVER.

A little below Amoskeag Falls, is erected a Bridge five hundred and fifty-six feet long and eighty feet wide, supported by five piers and two abutments. The top of this Bridge is thirty feet from the river. It contains two hundred tons of timber, and was built in fifty-seven days.

PISCATAQUA BRIDGE.

In the year one thousand seven hundred and ninety-four, a Bridge was built over the River Piscataqua, seven miles above Portsmouth. Its length is twenty-six hundred feet; of which twenty-two hundred feet are planked. The greater part of this Bridge is built of piles driven into the bed of the river in the common way. But that part which engages the attention of travellers, is an arc nearly in the centre of the river, uniting two islands, over water forty-six feet deep. This stupendous arc of two hundred and forty-four feet on the chord, is allowed to be a masterly piece of Architecture, planned and built by the ingenious Mr. TIMOTHY PALMER, of Newburyport. This Bridge cost the proprietors sixty-eight thousand dollars.

MALDEN BRIDGE,

IN THE STATE OF MASSACHUSETTS.

This Bridge is built across Mystick River, connecting Charleston with Malden. Its length is twenty-four hundred and twenty feet; the breadth of Bridge is thirty-two feet, and its height from the water is twenty-three feet. This Bridge cost in building fourteen thousand dollars.

ROWLEY BRIDGE.

On the post-road between Boston and Newburyport is a Bridge across PARKER's River, eight hundred and seventy feet long, and twenty-six feet wide, consisting of nine solid piers and eight wooden arcs.

DEER'S ISLAND BRIDGE.

Over the Merrimack River, in the county of Essex, near Newburyport, is a Bridge that was planned by Mr. TIMOTHY PALMER, in the year one thousand seven hundred and ninety-two, constructed with two arcs; the one is one hundred and sixty and the other is one hundred and thirteen feet chord, and is erected forty feet above the level of high-water.

ESSEX BRIDGE

is fifteen hundred feet long, has a convenient draw, and is admired by travellers as a very elegant Bridge.

HAVERHILL BRIDGE,

is six hundred and fifty feet in length and thirty-four feet wide. It has three arcs, each one hundred and eighty feet chord supported by three handsome stone piers, forty feet square. It has also as many defensive piers and sterlings extending up the river, fifty feet above the Bridge.

MERRIMACK BRIDGE,

between Newbury and Haverhill Bridges, is of ingenious and elegant workmanship. It is the longest of any on Merrimack River, by several hundred feet. It consists of four long arcs, with five piers, and also has a draw.

BRIDGES

IN THE STATE OF RHODE-ISLAND.

The assembly in this state, in their session of May seventeen hundred and ninety-two, passed an act incorporating three companies for the purpose of erecting three Bridges, one over the upper, and another over the lower ferry of Seckhonck river, and a third over Howland's ferry. This last mentioned Bridge is nine hundred feet long, thirty-six broad, has forty-two piers, and a sliding draw. The greatest depth of water at this place is fifty-one feet.

WEYBOSSET BRIDGE.

The great Bridge in the town of Providence, formerly called Weybosset, from a high hill of that name, which stood near the west end of the Bridge, but which is now removed, and its base built upon, was, till lately, the only Bridge of considerable note in this state. It is one hundred and sixty feet long, and twenty-two feet wide, supported by two wooden tressels, and two stone pillars. It unites the eastern and western parts of the town, and is a place of resort in summer, affording a pleasant prospect of all vessels entering and leaving the harbour.

MOHAWK BRIDGE.

A Bridge over the sprouts of Mohawk River was finished in seventeen hundred and ninety-five. It is about ten miles north of the city of Albany, and opens an easy and direct communication with an extensive and thriving country to the north-west. It is nine hundred and sixty feet in length, twen-four in breadth, and fifteen above the bed of the river, which for the most part is rock. It is supported by thirteen solid stone pillars, and makes a fine appearance as you approach it from the south. About a mile west of the Bridge are the Falls called the Cohoez, in full view, forming a grand spectacle to the eye of the traveller, while on the east a different scene is presented, the river below the Bridge spreading into three branches, and pouring its waters into the Hudson by as many mouths.

BRIDGES

IN SOUTH AMERICA.

The Bridges made by art are generally far from being commodious. Of these there are two kinds, besides those of stone, which are very few. The most common are wood, and the rest of the bejucos. With respect to the first they choose a place where the river is very narrow, and has on each side high rocks. These Bridges only consist of four long beams laid from one precipice to the other, forming a path about a yard and a half in breadth, just sufficient for a man to pass over on horseback; and custom has rendered them so familiar, that people pass them without any apprehensions. Those formed of bejucos are never used but where the breadth of the river will not admit of beams being laid across. Several of these bejucos are twisted together, in order to form a large cable of the length required; and six of them are drawn from one side of the river to the other; two of which being considerably higher than the other four, serve for rails. Across those at the bottom are wattled sticks of bejucos, and the whole is not unlike a fishing-net, or Indian hammock, stretched from one side of the river to the other; but as the meshes of this net are very large, and the foot would be in danger of slipping through, they cover the bottom with reeds, which serve for a floor. The mere weight of this kind of basket Bridge, and much more the weight of a man passing over, must cause it to make a prodigious bend; and, if it be considered that the passenger, when in the midst of his course, especially if there be a wind, is exposed to be swung from side to side, a Bridge of this sort, sometimes above ninety feet long, must appear extremely frightful; yet the Indians run over it, loaded with the baggage and pack-saddles of the mules, laughing to see the Europeans afraid of venturing. The greatest part of these Bridges are only for men and women; the mules swimming over the rivers; for their loading being taken off, they are driven into the water about a mile and a half above the Bridge, in order that they may reach the opposite shore near it; they being usually carried so far by the rapidity of the stream.

Instead of a bejucos Bridge, some rivers are passed by means of a tarabita, which is a single rope either made of bejucos or thongs cut from the hide of an ox, and consisting of several strands, which, when twisted, form a rope of six or eight inches in thickness. This is extended across the river, and fastened on one side to a strong post, and on the other to a wheel, that it may be straitened or slackened as occasion serves. From the tarabita hangs a kind of leathern hammock, large enough to contain a man, and suspended by a clue at each end, hanging in a loop over the tarabita. A rope is also fastened to it, and extended over the river, for drawing the hammock to the side intended; which, with a push at its first setting off, sends it quickly to the other side. This not only serves to carry over persons, but the burthens of beasts, and also the animals themselves, where the rapidity of the current and the prodigious stones continually carried along by it, render it impracticable for them to swim over. For carrying over the mules, two tarabitas are used, one for each side of the river; and these are much thicker and slacker. On this rope is only one clue or loop, which is of wood; and by this a beast is suspended, being fastened to it with girts round the belly and neck. When this is performed, the creature is pushed off, and almost immediately landed on the opposite side. Animals that are accustomed to be conveyed over in this manner never make the least opposition, but come of themselves to have the girts fastened round them; yet they are at first brought with great difficulty to suffer this to be done, and on their finding themselves suspended in the air, kick and plunge violently during their short passage.

THE NATURAL BRIDGE,

in the county of Rockbridge, Virginia, is a stupendous curiosity. It unites two hills, between which passes a small stream called Cedar Creek. The height of the Bridge from the water is about two hundred and ten feet. The bases of the abutments are, in different places, from forty-eight to seventy feet apart; the mean distance being about sixty feet. One of these walls, or abutments, is nearly perpendicular; the other falls back, so that the top of the arc is from eighty to ninety feet wide; the covering of the arc is from forty to fifty feet thick. It is of limestone, forming one entire mass, with two abutments. This is thought by some to contradict the idea that this fissure was produced by some great convulsion. Its surface, over which is a considerable road, is a gentle slope and stony; but generally covered with earth, which supports many large trees. The under side is lower at one end than at the other. Both ends rise like an arc; but in the middle extend horizontally nearly in a straight line. The walls which support the arc, and those which form the sides of the Bridge, are very irregular. In some parts they are smooth and perpendicular; in others there are cavities; while other parts exhibit a protuberant and craggy surface. The Bridge crosses the vale obliquely. In the middle, it is sixty-five feet in breadth; but much wider at the ends. The banks which support the Bridge extend with the same height several hundred yards on each side of the stream; but do not correspond with each other as if rent asunder. The course of the fissure, for a considerable distance above and below the Bridge, resembles an ill-formed S, spreading wider as it extends either above or below. Few persons have courage to approach the sides of this Bridge. Those who do are instantly seized with terror. They involuntarily fall to the ground, cling to a stone or a tree, look down on the frightful abyss, gaze with astonishment at the massy walls, the deep winding valley, the rushing stream and the distant hills. To persons below, a prospect not less awful is presented; the lowering arc, the frightful precipice, and the gloomy forest relieved by the distant sky.

We cannot refrain from gratifying ourselves here with the insertion of some lines written on this Bridge, by Mr. JOHN DAVIS, who some time ago published in England a humorous volume of Travels in America.

When Fancy, from the azure skies,
  On earth came down, before unseen,
She bade the wondrous structure rise,
  And haply chose this sylvan scene.

The Graces too, with spritely air,
  Assisted in the work divine;
The arc they formed with nicest care,
  And made the murm'ring stream incline,

Then Fancy, from the pile above,
Would gaze, with rapture bending o'er;
And, charm'd, behold the streamlet rove,
While Echo mock'd its sullen roar.

And here, perhaps, the Indian stood,
With uplift hands, and eye amaz'd,
As, sudden, from the devious wood,
He first upon the fabric gaz'd!

See Tadmore's domes and halls of state,
In undistinguished ruin lie;
See Rome's proud empire yield to fate,
And claim the mournful pilgrim's sigh.

But while relentless Time impairs
The monuments of crumbling art,
This pile, unfading beauty wears,
Eternal in its ev'ry part.*

* The Editor of the Port Folio has affixed a Note to these verses, which were published in that work, in January, one thousand eight hundred and nine, and we shall take the liberty to insert it here.

"The Bridges in America, whether they be *natural* or unnatural, have been so imperfectly if not injuriously described by European travellers and tourists, that no foreign reader has an adequate idea of these structures, which, from Solomon's Bridge over the brook Cedron to Roman magnificence, displayed on the Tiber, have contributed so much to the convenience and the character of nations.

THE NATURAL BRIDGE,

in the county of Lee, Virginia, is a great curiosity. This Bridge is one hundred and thirty-four feet higher than the one just described, being three hundred and thirty-nine feet in perpendicular height. Its summit projects eighty-seven feet over its base; it fronts to the south-west, and is arched as regularly as could be by the hands of art. The arc in front is about two hundred feet high, and slopes off to sixty feet, at the distance of one hundred and six feet from the entrance. From its mouth, in a straight direction, it measures four hundred and six feet; thence at right angles three hundred feet; thence crossing the second line at eighty feet from the wall to the other end, three hundred and forty feet. The roof is regularly arched, and gradually descends to eighteen feet, which is the lowest part at the intersection of the second angle; it then rises to twenty, thirty, forty, and seventy-five feet, which is the height of the north-east entrance. The stream of the water which runs under this Bridge is from thirty-five to fifty-five feet wide, at its common height. The head of this stream (Stock Creek) is from three to four miles above the Bridge, rising out of a knob or spur of Clinch mountain, and emp ties itself three miles below, into Clinch river. It is suddenly swelled by rains sometimes to fifteen and eighteen feet perpendicular; but soon exhausts itself. There is a waggon-road over the Bridge, which is only used in time of freshes, and is then the only part that can be crossed. On approaching it to the south-west front, it produces the most pleasing awful sensations: the front is a solid rock of limestone, the surface very smooth and regular, formed in a semicircle, the rock of a bright yellow colour, which is heightened by the rays of the sun; the arc is partly coloured by a spur of the ridge, which runs down the edge of the creek, in front of the arc. Across the creek stand several beautiful trees; the most elegant and luxuriant is a cucumber tree, teeming with fruit; the leaves from two to two and a half feet in length, and one foot in breadth. This, with some white-cedars and walnut-trees, adds very much to the beauty of the scene.

If the view below creates such pleasing sensations, what must that from above be! It fills the mind with horror! From the level of the summit of the ridge, where the road passes to the verge of the fissure, the mountain descends about forty-five degrees of an angle, and is nearly fifty feet in perpendicular height. You involuntarily slide down, feet foremost, holding by every twig you pass, until you reach the verge, which is for six or eight feet less steep; the rock is covered with a thick stratum of earth, which gives growth to many large trees. From this landing-place to the verge is a descent of nine feet, so steep that it cannot be approached near enough to look over. To the west of the arc, about four hundred yards, the ascent to the verge is much leveller, where you may look into the abyss below. "My guide," says the gentleman who furnished this account, was an old hunter, who had for many years been accustomed to clambering over steepest mountains. On approaching the verge, the horror of the scene below intimidated him for a few moments; but he could presently walk along the verge with composure. This Bridge may be passed by thousands without a knowledge of it, unless attracted by the roaring of the waters below.*

* Morse's Geography.

We have given the foregoing descriptions of two *natural* Bridges, because we have found them under the head of Bridges, in other works; but what they have to do, as mere *lusi naturæ*, with Bridges of Art we are not able to conceive. The authority of Dr. MORSE is sufficiently respectable; but his correspondent, who gives the account of the first natural Bridge, must have been composed of far different *stuff* from any other traveller we have ever heard of. On his approach to the sides of the Bridge he is instantly *seized with terror*, *involuntarily falls to the ground*, then *clings to a stone or a tree*, and, whilst he is *gazing with astonishment at the massy walls*, *the deep winding valley and the rushing*, *stream** he very deliberately takes a *sang-froid* view of *the distant hills*. But, *verbum sat*. Our criticism, we trust, will be pardoned.

There are many other Bridges which might as well have been left out of this work as the *natural* Bridges; but as our design is to compare *our* Bridge with all others (for the test of every thing must be made by comparison) they become a necessary *part* of our great *whole*.

* A little dribbling rivulet.

PENDENT BRIDGES.

Pendent, or hanging Bridges, called also *philosophical Bridges*, are those which are not supported by posts or pillars, but hang at large in the air, being sustained only at the two ends or abutments. Bridges of this kind are used by the Spaniards for passing the torrents in Peru, over which it would be difficult to throw more solid structures either of stone or timber. Some of these hanging Bridges are formed so strong and broad, that loaded mules pass along them. Ulloa, tom. i, page three hundred and fifty eight. Dr. WALLIS gives the design of a timber Bridge, seventy feet long, without any pillars, which may be useful in places where pillars cannot be conveniently erected. Phil. Trans. No. one hundred and sixty three, p. seven hundred and fourteen. Dr. PLOTT informs us that there was formerly a large Bridge over the castle-ditch at Tutbury in Staffordshire, made of pieces of timber, none much above a yard long, and yet not supported underneath, either with pillars or archwork, or any other sort of prop whatever.*

* Dr. Rees's New Cyclopædia.

PORTABLE BRIDGES.

Under this article of Bridges we may also mention *portable Bridges*, easily taken asunder, and put together again. M. COUPLET mentions one of this kind, two hundred feet long, and which forty men may carry. See Du Hamel. Hist. Roy. Acad. Scienc. C. iii, S 5, C. 4.*

In the middle ages Bridge-building was reckoned among the acts of religion; and a regular order of hospitallers was founded by St. Benezet, towards the close of the twelfth century, under the denomination of *Pontifices* or Bridge builders, whose office was to assist travellers by making Bridges, settling ferries, and receiving strangers in hospitals or houses built on the banks of rivers. We read of a hospital of this kind at Avignon, where the hospitallers dwelt under the direction of their first superior, St. Benezet. The jesuit Raynaldus has a treatise expressly on St. John the Bridge-builder.*

BRIDGE OF AVIGNON,

CONSTRUCTED OF STONE.

The Bridge of Avignon was begun in the year one thousand one hundred and seventy-six, and

* Dr. Rees's New Cyclopædia.

finished in one thousand one hundred and eighty-eight. It consisted of eighteen arcs, and was about three thousand feet in length. Several of its arcs have been destroyed by the rapidity of the current, together with the force of the ice.*

M. MONTUCLA, in his Recreations in Mathematics, translated into English by CHARLES HUTTON, L L. D. and F. R. S. Vol III, Page 426, has proposed the following problem.

PROBLEM XII.

How to construct a wooden Bridge of one hundred feet and more in length, and of one arc, with pieces of timber, none of which shall be more than a few feet in length.

We shall here suppose that the pieces of timber intended for a Bridge of this kind are twelve or fourteen inches square, and only about twelve feet in length: or that particular circumstances have prevented rows of piles from being sunk in the bed of the river, to support the beams employed in constructing the work. In what manner must the architect proceed to build the Bridge, notwithstanding these difficulties?

* Dr. Rees's New Cyclopædia.

The execution of this plan is not impossible: for it might be accomplished in the following manner. First trace out, on a large wall, a plan of the projected Bridge. By describing two concentric arcs at such a distance from each other as the length of the pieces of timber to be employed will admit, which we shall suppose, for example, to be ten feet, giving them the form of an arc of ninety degrees from one pier to another: then divide this arc into a certain number of equal parts, in such a manner, that the arc of each shall not exceed five or six feet.

On the supposition here made, of the distance of one hundred feet between the two piers, an arc of ninety degrees which covers it would be one hundred and ten feet in length, and its radius would be seventy feet. Divide, then, this arc into twenty-two equal parts, of five feet each, and with the above pieces of timber, joined together, from a kind of voussoir eight or ten feet in height, five feet in breadth at the intrados, and five feet eight inches six lines at the extrados; for such are the proportions of these arcs, according to the above dimensions. Fig. 20 represents one of these voussoirs, which, as it is evident, consists of four principal pieces of strong timber, at least ten inches square, which meet two and two at the centre of their respective arcs ; of three principal cross bands at each face, as A C, B D, E F, *a c*, *b d*, *e f*, which must be exceeding strong, and therefore ought to be twelve or fourteen inches in height, and ten inches in breadth ; and, lastly, of several lateral bands, between the two faces, to bind them together in different directions, and to prevent them from giving way. A voussoir of this kind may be about six feet in length; that is between the two faces A E, F B, and *a e*, *f b*.

An arc must then be formed of these voussoirs, exactly in the same manner as if they were stone, and when they are all arranged in their proper places, the different pieces may be bound together according to the rules of art, either with pins or braces. Several arcs or ribs of this kind must be formed, close to each other, according to the intended breadth of the Bridge ; and the pieces may be bound together in the same manner as the first, so as to render the whole firm and secure. By these means we shall have a wooden Bridge of one arc, which it would be very difficult to construct in any other manner.

It now remains to be examined whether these voussoirs will have sufficient strength to resist the pressure which they will exert on each other. The following calculation will shew that there can be no doubt of it:

It appears, from the experiment of Muschenbroeck,* and the theory of the resistance of bodies, that a piece of oak twelve inches square and five feet in length, can sustain, in an upright position, without breaking, two hundred and sixty-four thousand pounds; hence it follows that a cross band, as A C, or E F, five feet in length and twelve inches by ten, can support two hundred and twenty thousand pounds; but, for the greater certainty, we shall reduce this weight to one hundred and fifty thousand; therefore, as we have six bands of this length, a few inches more or less in each of these voussoirs, it is evident that the effort which one of these voussoirs is capable of sustaining will be at least nine hundred thousand pounds. Let us now examine what is the real effort to be resisted.

* Essais de Physique, vol i, chap. ii.

We have found, by calculating, the absolute weight of such a voussoir, and even supposing it to be considerably increased, that it will weigh at most between seven or eight thousand pounds or seven thousand five hundred. The weight, then, resting on one of the piers, most loaded, having ten voussoirs to support, will be charged only with the weight of seventy-five thousand pounds; a weight, however, which, on account of the position of the voussoirs, will exert a pressure of one hundred and fifteen thousand pounds; but we shall suppose it to be even one hundred and twenty thousand. There is reason therefore to conclude, from this calculation, that such a Bridge would not only have strength to support itself, but also to bear, without any danger of breaking, the most ponderous burthens: it even appears that it would not be necessary to make the pieces of timber so strong.

If the expense of such a Bridge be compared with that attending the common method, it will perhaps be found to be much less; for one of these voussoirs will contain no more than one hundred and forty or one hundred and fifty square feet of timber, which, at the rate of two shillings per foot, would be only fifteen pounds; so that the twenty-two voussoirs of one course or rib would cost three hundred and thirty pounds; consequently, if we suppose the breadth of the Bridge to consist of four courses or ribs, the whole would amount only to one thousand three hundred and twenty pounds. It must indeed be allowed that, to complete such a Bridge, other expenses would be required; but the object here proposed was to shew the possibility of constructing it, and not to calculate the expense.

The idea of such a Bridge first occurred to me in consequence of a dangerous passage I met with in the province of Cusco, in Peru; where I was obliged to cross a torrent, that flows between two rocks, about one hundred and twenty-five feet distant from each other, and more than one hundred and fifty feet in height. The inhabitants of the Country have constructed there a *Travita.** where I was in danger of perishing. When I ar-

* This is an Indian Bridge, the very idea of which is enough to make one shudder. A man is placed in a basket fastened by a pulley to a rope, which is extended from the one side of a torrent to the other. The basket and rope are both constructed of those creeping plants which the inhabitants of America employ in almost all their work. As soon as the man is got into the machine, it is drawn over to the opposite side, by means of a rope fastened to the pulley.

rived at the next village, I began to reflect on the best means of constructing in this place a wooden Bridge, and I contrived the above expedient. I proposed my plan to the Corregidor, DON JAYME ALONZO Y CUNIGA, a very intelligent man, who being fond of the French, received me with great politeness. He approved of my idea, and agreed that, at the expense of a thousand piasters, a Bridge of twelve feet in breadth, which all Peru would come to see, through curiosity, might be constructed in that place. But, as I set out three days after, I do not know whether this project, with which this worthy man seemed highly pleased, was ever carried into execution.

It may here be remarked that it would be easy to arrange the voussoirs of a Bridge of this kind in such a manner that, in case of necessity, any one of them might be taken out, in order to substitute another in its stead, which would afford the means of making all the necessary repairs.

If the rope used for dragging over the machine should break, the man must remain suspended for some hours, until means have been found to relieve him from his painful situation.

An Account of a New Method of constructing Wooden Bridges: Extracted from the Philosophical Magazine, No. CXLVIII, for August, one thousand eight hundred and ten.

M. Wiebeking, director of roads and Bridges to the king of Bavaria, has discovered a method of constructing wooden Bridges, which, in point of strength and solidity, promise a duration of several centuries. They are also remarkable for the elegance of their form and the width of the arcs. A Bridge has been constructed on the above plan over the river Roth, five leagues from Passau, (Germany) consisting of a single arc two hundred feet wide: another has been made for a large city, two hundred and eighty-six feet wide.

These arcs may be so constructed as to admit of ships of war or merchant vessels passing through them, an aperture being made in the centre, which can be opened or shut at pleasure. Another advantage possessed by these Bridges is that of being speedily taken to pieces: if it be necessary to stop the progress of an enemy, the arc may be removed in one day, and the abutments in another, without cutting the smallest piece of timber.

With respect to the advantages in point of œconomy resulting from the adoption of M. Wiebekin's plan, it has been estimated that a stone Bridge of similar dimensions to a wooden one of a given size would cost two millions of florins, whereas the latter would cost only fifty thousand florins; and on the supposition that a wooden Bridge will only last one hundred years, it follows that, taking the interest on the principle sum into the computation, there will result a saving of eleven millions six hundred and eighty thousand florins.

CHAIN BRIDGE.

The chain Bridge lately thrown over the Merrimack, three miles above Newburyport, in the state of Massachusetts, is now in constant use. This Bridge consists of a single arc, two hundred and forty-four feet span. The abutments are of stone, forty-seven feet long, and thirty-seven high; the uprights, or framed work, which stand on the abutments, are thirty-five feet high, over which are suspended ten distinct chains, the ends of which on both sides of the river are buried in deep pits and secured by large stones: each chain is five hundred and sixteen feet long; and, where they pass over the uprights, they are treble, and made in short links, which is said to be more secure than saddles made of plates of iron. The four middle joists rest on the chains; all the rest are suspended to the main chains to equalize the floor. This Bridge has two passage-ways of fifteen feet in width each, and the floor is so solid as to admit of horses, carriages, &c. to travel at any speed, with very little perceptible motion of the floors. The railing is stout and strong, which adds much firmness to the floor. There are three chains in each range on each side, and four in the middle range: they are calculated to support nearly five hundred tons. From the surface of the water to the middle of the floor is forty feet; and from the top of the abutments to the top of the uprights is thirty-five feet high, making seventy-two feet. The magnitude and power of the abutments, the width and length of the floors, the elevation of the work, the evident powers of the chains, &c. all conspire to make it a wonderful work. Every expense attending it did not amount to twenty-five thousand dollars. The abutment being of stone, the uprights covered, and the chains painted to prevent rust, leaves nothing but the flooring to decay. This Bridge was constructed by JOHN TEMPLEMAN, Esq. of the district of Columbia, whose talents for the productions of such work, and the various improvements suggested and used by him, have been highly beneficial, and do him great credit.

A BRIDGE,

OVER THE POTOWMACK,

CONSTRUCTED OF TIMBER.

This Bridge is near a mile in length, and affords a considerable convenience by shortening the distance from the city of

WASHINGTON,*

to Alexandria. It is supported with a number of timber piles, driven into the bed of the river, and beams are laid thereon to form the carriage road, which is planked from end to end. The expense of building this Bridge, we are told, was one hundred thousand dollars.

* We cannot help here remarking that, among the many vast plans which the illustrious WASHINGTON conceived for his country's welfare, the

establishment of this City, appeared to occupy no small share of his attention; and experience has proved that the seat of government could not have been placed in a more convenient situation for all the purposes of correct state policy. Besides this, it is impossible for the imagination to conceive a site more appropriate for the capital of a great nation than the one in question. The commanding mount, on which the Capitol rests, is truly emblematic of Legislative authority; the finely diversified hill and dale of the surrounding country, the magnificent banks of the Potowmack, and its waters boldly meandering through scenery of unequalled grandeur, combine to fill the spectator with awe, and give him a presentiment of the future high destinies of this embryo metropolis.

When national spirit and prosperity shall have attained a proper height, and miserable speculation give way to a generous encouragement of the arts, a Vitruvius and a Palladio may be found. The domes of science will then be seen raising their heads where now the stinkweed rattles in the breeze; the broad arc, embracing the Potowmack with its friendly arms, shall disencumber its tide from the mean pile-work with which it is now obstructed; and the Tiber of America may rank gloriously among nations.

There are many other Bridges erected in the United States, and in other parts of the world; that we have not here noticed, most of them being of a character not very interesting; and as we have already exceeded the bounds allotted us in this work for the History of Bridges, we shall now pass on to a recapitulation or index of those we have cited, and offer some critical remarks thereon.

BREADTH, FT.	HEIGHT, FT.	ARCS,	CHORDS,	MATERIALS.
36	-	1	660	Brick
-	-	-	-	Boats
-	-	-	-	Boats
-	-	-	-	Boats
-	-	-	-	Ships
30	12	-	-	Timber
4	-	-	-	Bamboos
6	80	-	-	Trees
3	70	-	-	Two Ropes
5	42	-	-	Seven Chains
2	60	-	-	Seven Chains
4	20	-	-	Two Chains
8	-	-	-	Beams
9	34	-	-	Logs of Fir
-	-	-	-	Stone and Wood
-	750	1	600	Stone
-	-	-	-	Barges
25	-	301	-	White Stone
25	-	100	-	White Stone
50	-	-	-	Brick and Stone
-	-	1	98	Timber
-	24	1	95	Marble
23	-	2	-	Timber
-	-	1	-	Stone
-	-	1	-	Timber
-	-	1	-	Timber
-	-	-	-	Trees

BREADTH,	HEIGHT,	ARCS,	CHORDS,	MATERIALS.
FT.	FT.			
-	-	-	-	Masts
28	-	-	-	Stone and Wood
-	-	30	-	Stone
-	-	-	-	Stone and Wood
-	200	6	100	Stone
-	227	35	108	Stone
60	150	21	170	Stone
75	112	4	142	Stone
-	-	26	-	Stone
72	-	12	-	Stone
-	-	-	-	Boats
48	-	5	128	Stone
-	-	3	128	Stone
41	-	3	77	Stone
-	31	9	106	Stone
30	40	9	57	Cast Iron
40	10	-	-	Timber
-	-	1	102	Granite
-	-	3	-	Stone
-	-	5	-	Granite
-	-	3		Granite
-	-	3	-	Stone
45	44	19	-	Stone
44	52	15	76	Stone
42	48	9	100	Stone
-	-	7	-	Stone and Wood
-	-	5	-	Stone

BREADTH, FT.	HEIGHT, FT.	ARCS,	CHORDS,	MATERIALS.
-	-	5	-	Stone
-	-	16	-	Stone
-	-	8	-	Stone
-	-	5	-	Stone
-	-	3	-	Stone
-	-	7	100	Stone
-	-	9	-	Stone
30	30	3	55	Stone
20	-	3	102	Stone
-	-	1	-	Stone
30	-	11	-	Stone
-	-	34	-	Stone
25	-	-	-	Cast Iron
32	100	1	236	Cast Iron
28	30	1	100	Cast Iron
26	32	1	130	Cast Iron
20	22	1	110	Cast Iron
30	29	1	181	Cast Iron
11	35	1	140	Stone
28	124	4	55	Stone
36	51	5	70	Stone
42	-	-	75 piers	Timber
40	-	-	180 piers	Timber
40	30	-	210 piers	Timber
-	-	-	-	Timber
36	-	5	4 piers	Timber and Stone
42	72	3	194 feet	Timber and Stone

* By the foregoing Index, the reader will not only be assisted to find more readily any particular Bridge he may wish to refer to, but also he will at once learn, what is the

BREADTH,	HEIGHT,	ARCS,	CHORDS,	MATERIALS.
FT.	FT			
25	-	-	13 piers	Timber
36	-	1	230	Timber and Stone
-	-	-	1 pier	Timber
34	-	2	144	Timber
80	30		5 piers	Timber
-	-	1	244	Timber
32	23	-	-	Timber
26	-	8	9 piers	Timber
-	-	2	160	Timber
-	-	-	-	Timber
34	-	3	180	Timber and Stone
-	-	4	-	Timber
36	-	-	42 piers	Timber
22	-	-	-	Timber
24	15	-	13 piers	Timber and Stone
4	-	-	-	Bejucos
-	-	-	-	Single Rope
-	210	-	170	Rock
406	339	-	-	Rock
-	-	-	-	Timber
-	-	-	-	Various
-	-	18	-	Stone
-	72	1	244	Chains
-	-	-	-	Timber

greatest length, breadth, height, or number of arcs, contained in any Bridge recorded in history; as also the greatest altitude and span of any single Arc heretofore erected.

REMARKS,*

ON THE BRIDGE AT BABYLON, PAGE 36.

* This Bridge is the first that we have any account of in ancient history, as being erected with a single arc and of durable materials, and perhaps, with some of our modern sceptics, who agree to believe in nothing but what their eyes have seen, a question like this may arise, namely, who gave the plan? or taught the sons of NOAH, in those early days, to build a Bridge with a single arc? The answer with every wise man will be, as follows: HE that set his Arc or Bow in the clouds, man's great PRECEPTOR; he alone could furnish him with the most correct and suitable plan for his Bridges.

Whether this be the first specimen of an arc being applied to a Bridge, it matters not; for although some mathematicians, since those days, have dreamt of such wonderful discoveries in the science of arcs of lateral pressure, whereby they have partly filled volumes with their bewildered notions and complicated rules, to find the arc of various forms, yet, there is no question but the arc of this Bridge possessed all those requisites that are to be found in any that are built in the present day. For we naturally infer, that if it had not been erected upon correct principles, its extensive span would have procured so speedy a downfall, that the historians who furnished us with the account of its erection would also have added the time of its destruction.

The bricks wherewith the arc in question was built, we read, were of large dimensions, and, instead of the sorry stuff profanely called *mortar*, or *cement*, which our modern builders use in the present day for the setting of their brick and stone-work, these ancients had skill to prefer the bitumen, a glutinous slime, which, as soon as it was set, became so united to the materials, that, by the time the arc was closed, or keyed, the whole composed one solid mass of equal firmness.

The vast dimensions of this arc far exceed any built of brick or stone, in Europe or America.

REMARKS,*

ON CÆSAR'S TIMBER BRIDGE.—PAGE 40.

* This kind of scaffolding in water, which by some in the present day is profanely called Bridge Architecture, is supposed to have been first introduced by JULIUS CÆSAR, as a temporary expedient to transport his army across the Rhine. Whether this be the fact, or not, is quite immaterial: one thing is evident at first sight, namely, that by the timber piles or scaffold-poles of this, his formation, being drove obliquely into the bed of the river, not only CÆSAR's mechanical skill was here somewhat manifested, but also his skeleton structure was sure to prove much stronger for its intended purpose, than any of those erected in the United States, with their posts perpendicular. And as a certain strength in these silly formed structures is highly necessary to their existence, and which strength is alone to be derived from the degrees of strut or brace which the standards possess, we are led to conclude that there has been a great falling off in this *sublime* mode of Bridge building. However, if this defect or decay in the building of these structures be the signal for the speedy abolition of such *Bridges* in this country, the public ought greatly to rejoice. It has long been the author's most fervent wish that the period may not be far distant, when the beautiful rivers of America shall no longer be annoyed with these and other nuisances,† which are every year endangering the lives of men, and proving to their unskilful inventors their unsufficiency to withstand the natural effects of winter seasons.

† Such as the North River and Elizabeth-Town ferry boats.

REMARKS*

ON THE ROPE AND CHAIN BRIDGES,

ERECTED IN THE EAST-INDIES—PAGE 44, 45, 46, 47.

* Ancient History furnishes us with several correspondent accounts of the invention and use of the Rope and Chain Bridge in ages past; and we have selected an interesting sample in this our brief narration, for the purpose not only of proving the old adage true, that experience makes the master, but also that necessity is often the parent of invention. The origin of these sort of Bridges we find illustrated in a way and manner that would do credit to our modern inventors, could they possess the like honesty and candor. The ancient Norden richly proves that he was in possession of both these valuable requisites, when he on this subject thus observed: "We beheld with wonder and amazement the busy spider dancing in an autumn morn, upon a slender thread of her own spinning, fastened from tree to tree at several feet distance; this gave us our plan for a Rope and Chain Bridge, by which we soon found a way to pass many deep and dangerous rivers."

The first expedient of this kind made use of by the ancients was a single rope made of twisted creepers stretched from shore to shore, with a netting or hammock attached thereto; but they soon found it needful to improve on this plan, by adding another rope, and placing them both within a hoop, in such a way that, by the passenger seating himself within the circle, he was enabled by his hands to facilitate his approach to the opposite shore. But as the duration of these creepers proved very uncertain, and often endangered the life of the traveller, they quickly abandoned the use of them for a much stronger material, namely, links of iron, of which they formed chains of various strengths and numbers, for rivers of different span. The Bridge at Bootan, called Chuka-cha-zum, we find was constructed of five chains for the road, or platform, and two more for the hand-rail or fence for the protection of the passengers. The same informant also gives us an account of others in a different part of the world, of a similar kind to this first mentioned. But, in page 47, he particularizes the mode of construction of the Chain Bridge, so exactly similar to those we see erected lately in the United States, that we are ready to conclude the ancients lived yesterday. The Bridge referred to is called Selo-cha-zum, and is constructed of two chains.

After so particular an account as the foregoing being recorded in history for many years, it was not easily to be expected that we should find, in any publication of modern date, an account of this self-same invention being recently patented in the United States; but, as it is the fact, we shall, for the promotion of fair play, give the reader the words of the wise patentee, and then proceed to compare notes with the former relation of the ancient Bridges in the East-Indies, erected many hundred years ago on the self same plan, and shall point out in some brief particulars not only their similarity, but also what the author conceives to be real defects contained in all such Bridges.

PORT FOLIO, No. 6.

A description of the Patent* Chain Bridge; invented by James Finley, Esq. of Fayette County, Pennsylvania.

DESCRIPTION.

The Bridge is solely supported by two iron chains, one on each side, the ends being well secured in the ground, and the chains raised over piers of a sufficient height erected on the abutments at each side, extended so slack as to describe a curve, so that the two middle joists of the lower tier may rest on the chains. The other joists of the same tier are attached to the chains by iron pendants of different lengths, so as to form a level of the whole. In order that the chain may support as much weight as it could bear, when hung with the weight attached to the end of it, the piers must be so high as

* This patent was granted by the United States in the year one thousand eight hundred and eight.—See Port Folio for June, 1810.

to give the chain a sinking or curve of the one full seventh of the span. The ends of the chains must descend from the tops of the piers with the same inclination that they take inwards, until each end reaches the bottom of a digging, large enough to contain stones and other materials sufficient to connterbalance the weight of the Bridge, and what may chance to be thereon. The chains, if only one to a side, must be made with four branches, at each end, to be let down through as many stones, and to be bolted below. These stones are laid flat on the bottom of the digging; other flat stones may be placed thereon, to bind and connect the whole, that they may have the same effect as a platform of one piece; four or more joists will be necessary for the upper tier—to extend from end to end of the Bridge—each will consist of more than one piece; the pieces had best pass each other side by side, so that the ends may rest on different joists on the lower tier. The splice will then extend from one joist to another of the lower tier, and must be bolted together by one bolt at each end of the splice. The plank flooring is laid on this tier. It will be probably found most convenient that the chains be made with links as long as the space between the joists: every other suspender must attach to a link of the chain edge upwards; perhaps this may best be done by a clevis to go through the upper link of the suspender, and embrace the link of the chain and receive a key above—the other suspenders will come up through the flat links of the chain and receive a key above—the lower end of the lower link of the suspender may be made so wide as to receive the end of the lower tier of joists.

The author further observes there are eight of these Bridges, erected since the year one thousand eight hundred and one; the largest is at the falls of Schuylkill, three hundred and six feet span,* one pier ten feet wide; supported by two chains of inch and a half square bar.

One at Cumberland, (Maryland) one hundred and thirty

* If the ten feet pier is in the centre of the three hundred and six feet length, the span of each division is one hundred and forty eight feet.

feet span, no pier, fifteen feet wide, supported by two chains of inch and a quarter bar.

One over Potowmac above Federal City, of same dimensions with the last.

One do. over the Brandywine at Wilmington, 145 feet span, no pier, thirty feet wide, supported by four chains of inch and three-eighths bar. Two carriage-ways, and one foot-path.

One do. at Brownsville, Fayette County, one hundred and twenty feet long, eighteen feet wide, one inch and a quarter bar.

One do. near same place, one hundred and twelve feet long, fifteen feet wide, one inch and a quarter bar.

Having gone through the above description, and also examined the account of one of the Chain Bridges erected in the East-Indies, called Selo-cha-zum, page 47, we find, by comparing them together, they perfectly agree in the following essential particulars, viz: the number of the chains, their inverted curve, the mode of fastening them in the ground, their horizontal platform, and the presumptive means of repairing, all prove similar.

But the Chain Bridge at Chuka-cha-zum, in the East-Indies, and an other like unto it at Durham, (see page 45) being built with seven chains, must of course be allowed to be of a better kind than those erected with two only.

Were the Chain Bridges erected of late in the United States the product of a new invention, the notorious defects contained in the system would remain the same. We shall now attempt to point out, in a few instances, wherein they exist.

It is an axiom that where a structure of any kind depends wholly on two parts, if one of those parts fail, and the other is not fully competent to support the whole, a downfall must ensue; hence we infer there can be no security in a Bridge wholly dependent on two chains, for the following obvious reasons.

First, the sudden vibratory motion which is created by even an animal of small weight passing over these structures, is sure to produce a friction sufficient to destroy the same in a short period of time.

Second, as every piece of iron differs more or less from another in strength, by the superior soundness or fineness of its grain, so it is impossible to furnish a chain, the links of which shall be of equal strength throughout.

Third, if the former position was possible, yet, as the strength of each link so much depends upon the goodness of the workmanship in the tempering and forming of the same, it would be altogether erroneous to assert that every link in a chain would be made alike sound.

Fourth, could these two last objections be cancelled, there yet would remain another important truth behind, that must greatly conspire to prevent any sound calculation on the strength and durability of a Bridge constructed of chains; namely, the inequality of strain or longitudinal pull on the different links composing each chain.

Fifth, may be added another important defect, attendant on this kind of Bridge, namely, the natural and certain tendency that frost produces upon all iron, to make it brittle, and consequently to lessen its strength, derived by cohesion. If this be a fact, we may naturally infer that, were the chains for a Bridge made strong enough to carry all the weight required, in Summer, yet they are liable to break down with half that weight in Winter, and as it is also a fact that we have a right to calculate on double the weight being on such a Bridge in Winter, more than in Summer, through rain, ice, and snow; then, quere, whether a Bridge of this kind, if it even possessed four times the strength it required in Summer, could in any wise be depended upon in Winter, while it was subject to the unfriendly embraces of an enemy so capable of effecting its destruction? and as the breaking of one link would not only endanger the whole fabric, but, very probably, utterly destroy it, how easy is it to prove that a structure so easily affected cannot be of long duration, and that, at the best, they are but mere temporary expedients.

REMARKS*

ON THE BRIDGE AT WANDIPORE.—PAGE 49.

* The construction of this Bridge differs widely from all others that are cited in this work. We shall make a few remarks on its formation. First, that part of the Bridge, which is of the greatest span, is composed of four ribs, or arms, two on each side, one of which is inserted in every pier, each side of the door-ways, in the two abutments. Each arm is made up of four logs in depth; projecting over each other in equal succession. The span between the two abutments is one hundred and twelve feet in the clear, which, if divided into three equal parts, would furnish thirty-seven feet four inches to each part, but allowing each side arm to project forty feet from each abutment, then the length of each log composing one rib will be as follows: The undermost log will project from the abutment ten feet, the second, or next, above twenty feet, the third log thirty feet, and the fourth log forty feet; each projecting over his fellow ten feet. As the butt end of each log is placed in the stone abutment, at an altitude of at least five degrees, they furnish a strength, for such a small distance as forty feet, far more than the proportion needed, so long as the logs remain sound. And the historian from whom we have extracted the account in Page 49, informs us, that, at the period when he passed over this Bridge, it had then been erected more than one hundred and forty years; though the logs were all of Fir. What a strange contrast with the Bridges of art erected in the United States of America! But, it is not too late, if we are not too wise to learn of the ancients, as far as they excel, how to build Bridges. We purpose in the sequel of this work to show, that though the above Bridge does indubitably possess, from sundry causes, a considerable strength, for a plan so simple to furnish, yet that a rib of the same length, built on the author's patent plan for Bridges, with one sixth part of the timber here used, will not only be much stronger for its intended purpose, but will, also, be able

to carry triple the weight; and as we shall have occasion to refer to this Bridge again more particularly in another part of this work, for the purpose of exposing the insolence of certain sceptics, we shall for the present decline any further observations thereon.

REMARKS*

ON THE BRIDGE IN CHINA WITH A SINGLE ARC.—PAGE 52.

* The account of this wonderful production of art, at first sight, exceeds what may be termed the human probability of the day. The immense span, the awful height of this unexampled arc, must, of necessity, produce a grandeur in appearance somewhat resembling the great BUILDER's Rainbow. And it being built with stone must at once stagger the unintelligent sceptic, and add one more to the number on the list of his impossibilities. But the author hopes to improve the subject of this Bridge also to his advantage in another part of this work.

REMARKS †

ON THE RUSSIAN PEASANT'S BRIDGE MODEL.—PAGE 55.

† Whether, in the year 1789, there existed so many half taught theorists and pretenders to science as now infest society, we know not; but it seems evidently proved, by those who undertook to describe the Russian peasant's model of a Bridge, that there was at least a sample to be found in those days. Hence, we observe nearly two pages of an octavo volume taken up with a professed intention to describe the Russian peasant's ingenuity; but, alas! all that can be understood by the relation is, that the man made a Bridge Model. This circumstance tends to prove the fact that many tourists, and others, who set about describing works of art, by the non-descripts they produce, very much resemble the conduct of three kinds of characters, viz. a boy of dull capacity sent to a col-

lege to learn Latin, the captain of a dull-sailing ship, and a foreign ambassador, who has been a long time from his own country. These persons all suppose, that when they arrive at home, their friends will expect to hear many wonderful things; and perhaps the ambassador may have some expectations of his being questioned about Bridges. An illustration of this observation occurred to the author when he first undertook to make known his invention to the public. Being invited to wait on a company of gentlemen in New-York, who were desirous of hearing the invention explained, among the rest was a certain *cunning* ambassador, who, before the author could have an opportunity of disclosing the nature of the mystery, abruptly observed, "ah! this is the very plan of a Bridge that I have seen erected in Germany. I can tell you, gentlemen, all about it; it is made so and so, so and so, and so and so," added this wonderful sage, twisting his hands about, and pointing out the plan with his fingers!! Here the author could not but lament that men who are called to fill exalted stations and, who by their influence and affluence might cherish and promote the useful arts, should, by their ignorance and arrogance often prove themselves the chief enemies of its welfare; as the Bridge this sage person referred to, had no more likeness to the author's Bridge than that of Cæsar, as we shall hereafter demonstrate.

REMARKS

ON THE BEAUTIFUL BRIDGE OF THE RIALTO, AT VENICE.

* It is sufficient to know that Michael Angelo planned this Bridge, to be convinced of its beauty. The masonry is executed in the best style; and the material of which it is built, being native, affords more durability than if it were brought from afar, and in a greater degree attracts the attention of intelligent artists.

The Rialto is justly considered by travellers as one of the greatest ornaments of Venice. When viewed from the canal, it strikes the beholder with wonder, that a single arc of so great a span should support the immense weight of an entire street crowded with houses and passengers. It must be acknowledged, however, that if the Bridge of the Rialto had had the disadvantage of heavy waggons, carts, coaches, &c. constantly rattling over its surface, like other Bridges, there is no doubt but ere this it would have felt some of the diseases which are sooner or later inseparable from arcs of lateral pressure.

REMARKS*

ON THE LATE BRIDGE AT SCHAFFHAUSEN.

* There is a glaring incorrectness in the account of this Bridge, which I am astonished that so many travellers have repeated. That the carpenter of Appenzel might have offered to build his Bridge with a single arc may be true; but that there could be any doubt, after he had built it with two arcs, whether it was supported by the middle pier or not, is an absurdity not to be equalled in the most wonderful chapter of the wonderful magazine; particularly as the bridge described an elbow up the stream, and was sure to fall if the pier had been taken away. Enlightened men have much cause to lament the weakness of those compilers, who, having obtained a certain credit in society, dwell upon wonderful stories, like that of the Schaffhausen Bridge, with all the fondness of dotards.

REMARKS*

ON THE BRIDGE AT WETTINGEN, PAGE 60.

* Much has been said by some writers on the excellence of this timber Bridge; and we confess that a Bridge of this kind is far preferable to any built with piers or crutches; but when the most is said in its favor, it still remains a bridge, whose strength depends on the lateral grain of the timber, and cannot be so easily repaired as men have heretofore asserted; especially the circular ribs, on which the whole fabric depends. A specimen of this Bridge may be seen at Trenton.

REMARKS*

ON THE CAST IRON BRIDGES CITED IN THIS WORK.

* We conceive that Bridges erected with this sort of material, on a plan suitable for the valuable purpose, is well worthy the attention of those who wish to add durability to the strength of structures, that are of so much importance.

The bridge at Wearmouth, no doubt, ranks first upon the list of bridges that has been erected with this sort of materials; and it would be gratifying to those concerned in its welfare, if we could add, that it is now in as sound a condition as it was when first erected; but the reverse is the fact. The last account, received from respectable authority, states that it was then contemplated to make a ceintre immediately, to take it down before it fell down. The cause stated was, that the abutment on one side resting on infirm strata had sunk by the thrust which the arc by its weight had produced. This, with numberless other past instances, conspires to prove, that whether an arc of lateral pressure be built with wood, stone, or cast iron, it matters not; if any part of the structure rests on infirm strata, it is sure to become a wreck; which fully demonstrates that an arc of this kind is wholly unsuitable for a Bridge.

It would be a waste of time and paper to descant further on the various absurd modes of Bridge-building, which emanate from the old system, where strength is made to depend solely on the lateral grain of timber; and although many persons will, no doubt, deem it presumptuous in the author to make the assertion, yet he does *confidently* assert, and fears not he shall very soon be able to prove, that every other manner of Bridge invented before the present day, whether the work of a VITRUVIUS or a *Burr*, is but chaff or dross comparatively with that of the author's invention. When prejudice and infatuation can be overcome, and a proper encouragement given to ingenuity and sound knowledge, the "baseless fabrics" which are every year thrown over, or rather *into*, our rivers, will vanish, and "leave not a wreck behind." We shall only remark on one Bridge more.

REMARKS.*

ON SCHUYLKILL BRIDGE PAGE 139.

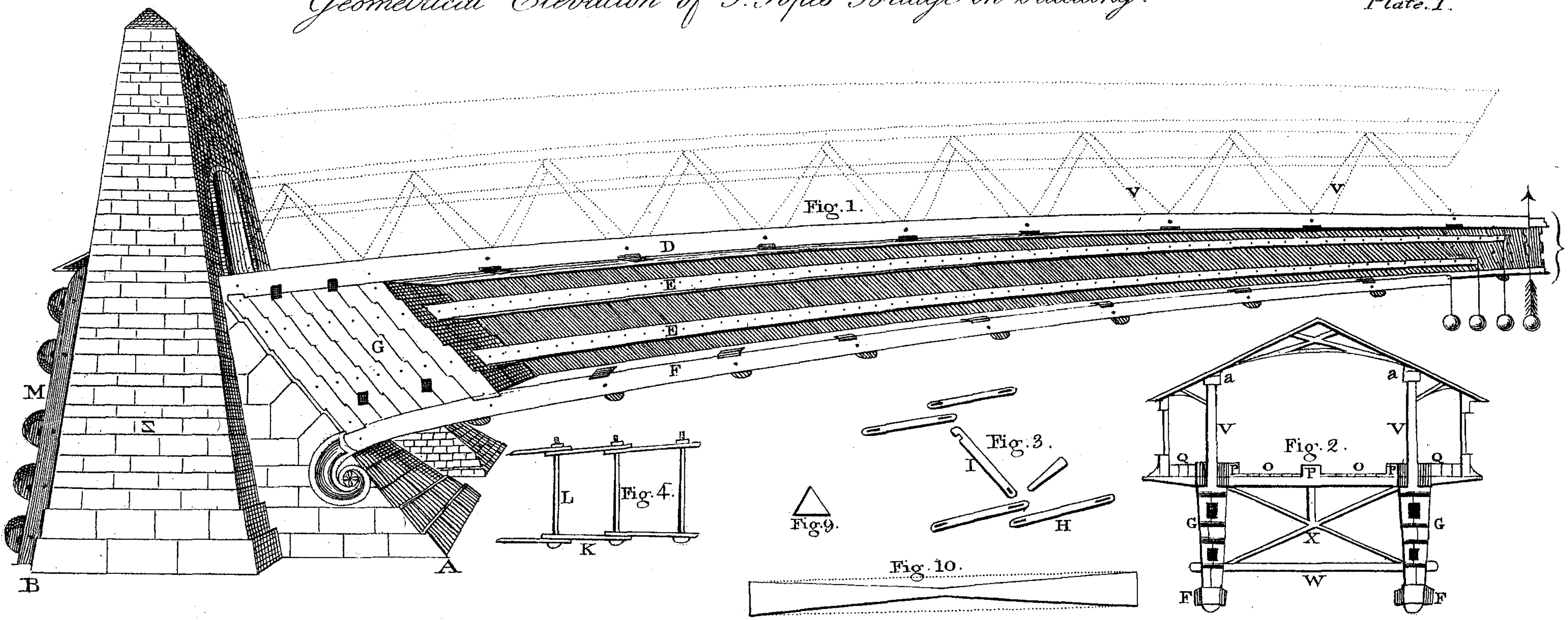
* This bridge will no doubt be allowed by all who have ever understood the fundamental laws of Architecture, to rank the first on the list of bridges in the U. S. on account of its strength and true symmetry; and widely differs from those trifling, complex formations, that we witness erected in other parts, and yet which are so much admired by some, as to obtain from them the *important* name of *pretty* Bridges: but we cannot stop to waste our time on these last unimportant fabrics, but must hasten with regret to observe, that though the Schuylkill Bridge be justly entitled to the aforesaid preeminence, yet the dire defect attendant on all Bridges with piers and arcs of lateral pressure, it is said, has made some small impression on this expensive structure. But we earnestly hope, for the encouragement of those concerned in the welfare of this Bridge, and who by their perseverance, in the first instance, accomplished the bold enterprise of its erection; daring to surmount every obstacle to the final attainment of their wishes. For the sake of such persons alone we hope the fabric may not in any wise prove ruinous, as to its strength, till they have in some good degree realized a return of their capital with an interest suited to reward such spirited exertions.

Such men, as the "Schuylkill Bridge Company," have proved themselves to be, are alone suitable to carry into execution great plans.

We shall now leave, for the present, any further remarks on the different Bridges described in this work; and proceed to the illustration of a more important invention for Bridges, than has ever before been recorded in history. And the author has no doubt of proving to the satisfaction of those to whom this work is dedicated, and who are alone worthy of the information it may afford, that this his invention for Bridges, does not only possess all and every the requisites suitable to prevent the failures attendant on all other Bridges through the defective mode of their construction, but also furnishes many other important advantages never before realized in any Bridge.

Geometrical Elevation of T. Popes Bridge in building.

Plate. 1.



T. Pope. del.

C. Pollinson. sc.

INDEX

OF THE TECHNICAL NAMES

OF EACH PART BELONGING TO

T. POPE'S FLYING PENDENT LEVER BRIDGE,

ALPHABETICALLY ARRANGED.

[A.] THE FULCRUM.

(Plate 1, fig 1.) In a lever of the first order is the part called the Fulcrum, or prop, on which point also the Bridge would pivot, or turn, were the abutment of lesser weight in proportion to the projecting arm.

[B.] THE WEIGHT

(Plate 1, fig 1.) In a bar or beam, wholly-balanced on the fulcrum A, would be termed the weight: but, as the abutment of this Bridge is supposed to rest regularly on the land from A to B, so the whole length of the abutment is to be considered as composing the weight.

[C.] THE POWER

(Plate 1, fig. 1,) Is the part, in a crow-bar, as a lever of the first kind, where the hand is applied, and would be called the power; but as the whole of the distance from the perpendicular of A to C is the part which makes up the arm of the Bridge, so in like manner, by its extra length, it becomes the power.

[DDD.] THE CAP PLATES

(Plates 1 and 2) are the cap-plates for the top of each rib, composed of sundry pieces of timber spliced and tabled together, and are of such magnitude as the extent of the Bridge may require.

[E E E.] THE HORIZONTAL LEVERS

(Plates 1 and 2, fig. 1, and 7,) are the horizontal levers, which are also termed longitudinal needles, as they pass in the interior of each pair of angular levers, and are of such number and magnitude in each rib, as the extent of the Bridge may require.

[F F F.] THE ARCHIVOLT RAILS

(Plate 1, fig 1 and 2,) are the archivolt (or soffit) rails, which are placed at the bottom edge of each rib, spliced and tabled like the cap-plates at D, and are of such magnitude as the extent of each Bridge may require.

[GGG.] THE ANGULAR LEVERS

Plates 1, and 5, fig. 1. G and R,) are the angular Levers or Voussoirs. These perpendicular logs are to be framed in bents or pairs, as they support and enclose the longitudinal levers by resting in each other on their end-grain tusks, cut out of the solid timber.

[H.] THE IRON CHAIN BANDS

(Plate 1, Fig. 3) are the Iron Chain Bands to fasten the angular levers together, as they are lowered down from off the top of the Bridge in building, and by which means also the Bridge is easily repaired.

[I.] THE RESTING-PLATES

(Plate 1, Fig. 3) are the end-grain resting plates of the angular levers, on which the above chain-bands are fastened.

[K.] THE CHAIN-PLATES

(Plate 1, Fig. 4) are chain-plates, intended for screw-bolts, that may, in some cases, be used instead of the above chain-bands and keys, or where the said chain-bands will not suit, such as for cap-plates and archivolt-rails.

[L] THE SCREW BOLTS

(Plate 1, Fig. 4) Screw-bolts and nuts for the same. The above chain-plates, and bolts, that pass through the angular levers, may be taken out, and locust trunnels inserted in their stead, when the two arms of Bridge are united in the centre.

[M.] THE BUTTRESS TIES

(Plate 1, Fig 1) Rear Buttress Ties, which are to prevent the weight of the projecting arm from lifting partially any part of the stone abutment.

[N N N.] THE DECK BEAMS

(Plate 2, Fig. 6 and 8) Are the deck Beams, on which the longitudinal deck or floor is cogged down and secured; and by which the circular shape of the outside ribs is regulated.

[O O O.] THE CARRIAGE DRIVES

(Plate 1 and 2, Fig. 6 and 2,) are the spaces allotted for the carriage drives, when it is intended that the wheels shall run on iron skids, to save the deck. These are secured by fenders of whole timber partly rising above the deck, by the sides of which the said cast-iron skids are affixed, for the wheels of carriages to run on; also, the said carriage-drives to be covered with rough plank, for the horses to trample on, to save the lower deck.

[P P P P P P.] THE CARRIAGE FENDERS

(Plate 1 and 2, Fig 6 and 8) are the aforesaid carriage Fenders, which, by being cogged down on the deck-beams, afford a longitudinal tie.

[Q Q Q Q.] THE FOOT PATHS

(Plate 1 and 2, Fig, 6 and 2) are the overhanging Gallery Foot-Paths, placed on the outside of the ribs, and supported by the projecting ends of the deck-beams, on which each log that composes the foot-path, on each side of the Bridge, is tabled to gether and cogged down like the carriage-fenders at P, P, P, P, P, P.

[R S T U Y.] SIGNS OF DISTINCTION.

(Plate 6, Fig 1) are signs of distinction, to illustrate, by the laws of the inclined plane, in what proportion the gravity of the angular levers in the building of each arm presses back towards the abutment from whence they sprang; also what portion of that gravity rests on the end-grain of the said angular levers.

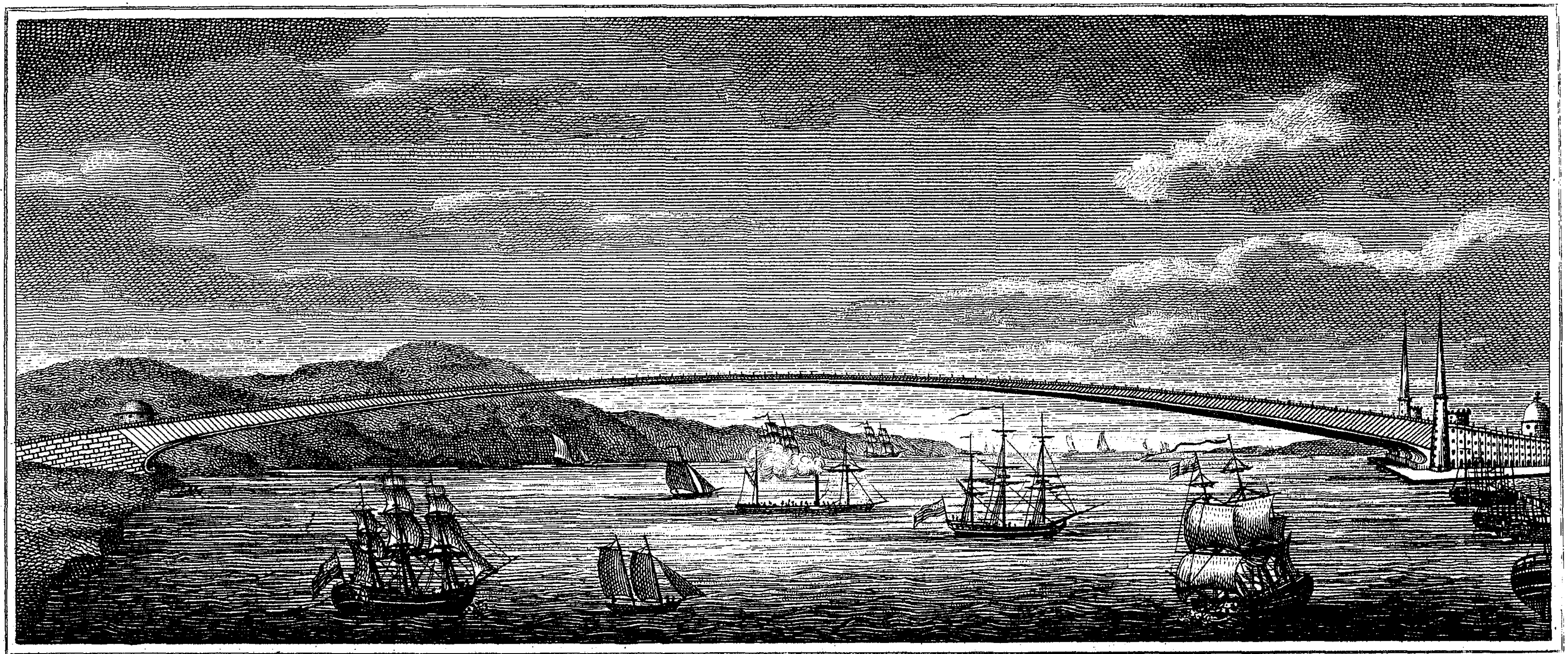
[V, V, V, V.] THE STANCHEONS.

(On Plate 1, Fig. 1 and 2) are the stancheons in the section of a roof that may or may not be added to a Bridge on the author's plan, formed out of and belonging to every king-bent, or sixth angular lever, for the purpose of supporting the purlin-plates, on which the rafters of the roof are to rest; consequently they stand at the same angle with the angular bents or levers.

[W.] THE ARCHIVOLT SPAN BEAMS.

(On Plate 1, Fig. 2, 9 and 10)are the Archivolt span beams, which may be of the form of a double isosceles wedge, as Fig 10, or that of a prism, as Fig. 9, in either shape, one half the quantity of

VIEW OF T. POPES FLYING LEVER BRIDGE.



Pope del. Leney sc.

Let the Broad Arch the spacious Hudson stride,
And span Columbias Rivers much more wide,
Convince the World America begins,
To foster Arts the ancient work of Kings.

A

MATHEMATICAL DESCRIPTION

OF THE

FLYING PENDENT LEVER BRIDGE,

INVENTED BY THOMAS POPE,

ARCHITECT AND LANDSCAPE GARDENER, NEW-YORK;

PATENTED

BY THE UNITED STATES OF AMERICA.

PROPOSITION 1.

The PRINCIPLES, SHAPE, CONSTRUCTION and EXTENT of this Bridge differ wholly from all others before invented; and it may with propriety be termed, a Flying, Pendent, Lever Bridge.

SCHOLIUM.

First, because the arms of this Bridge spring from the abutment on each side, and extend over a river or space, till they meet in the centre, and form one single arc, without ceintres, or support of any kind, while building, save the abutments from which they spring.

Secondly, They fly out and are suspended in the air. Thirdly, they hang or jut over. Fourthly, they are supported above the ground.

NOTE.

These terms are to be understood, as chastely applying only to this sort of Bridge in particular, as it differs wholly from the ancient military flying Bridges, which were constructed of pontons, leather boats, beams, hollow casks, blown bladders, and the like, commonly called *pont volant*, or *pons ductarius*.

PROP. 2.

PRINCIPLES. 1st, The principles of this Bridge, as a whole, are founded on the Lever, No. 1.

SCHOLIUM.

Each half Bridge, before it is united in the centre, is to be considered one body; then the fulcrum, or prop, if it were intended to move, would be between the weight, which is the abutment, and the power, which is the projecting arm of the half Bridge.

COROLLARY.

Therefore the abutment, on all occasions, must be of such weight as will be more than sufficient to counterpoise the said projecting arm while building, and also all the men and materials employed in the erection of the same.

PROP. 3.

2nd, The manner in which the arms of a Bridge on this plan are constructed in the internal part also constitutes each rib distinctly a compound lever of the first order, with continuity.

SCHOLIUM.

The above proposition is obviously true, whilst the arms of the Bridge, which are finally to compose the arc, remain disunited in the centre; as every last pair of angular levers lowered down on each rib, in the building of this Bridge, by their gravity, not only contributes to the locking back, and perfectly securing those logs or levers previously added, but they furnish also new fulcrums or supports for the succeeding levers to rest on: (see plate 1, fig. 1, at G. also plate 5, fig. 1, at R) but as soon as the arms of this Bridge are united in the centre, then the said levers are wholly relieved from that gravity which before constituted them in action. But although this be the case, there cannot ensue a lateral pressure from the abutment to the centre, as exists in all other arcs, for two obvious reasons: first, the two arms and the two abutments of the Bridge are now become one perfect whole. Second, they are tied together, longitudinally, by more strength than their own weight could tear asunder perpendicularly.

COR. 1.

Hence, were it not the fact that a space or vacuum did exist in the joint between each log at this period, instead of a medullary substance, the whole might be then well compared to an arc cut out of the end grain of one immense log of timber: as each of the logs composing the whole of an extended arc are so tabled or indented into each other, that no one single log can of itself move out of its place.

COR. 2.

Therefore it cannot be true, in any degree, that either the arms, distinct, or the arc, as a whole, depend in any measure for strength, or can derive any essential support from their being united in the centre, as must be the case in all arcs on the old plan of lateral pressure.

For the only advantages to be derived from such an unity in this plan is, first, the preventing that vibration which the gravity and motion of bodies create in passing over any extended arm; secondly, By the unity of this Bridge in the centre, the arcs on the sides thereof, which are perpendicular to the horizon, are perfected. This last article is a valuable acquisition in the author's Bridge, and not possessed by any other. We shall explain it more particularly under our next proposition.

PROP. 4.

SHAPE. The external shape of all Bridges on this invention will of necessity be as various as the sites on which they are required to be built; and will also differ widely in this respect from all other Bridges heretofore invented, especially as security against the extra pressure produced by wind and tempests is hereby furnished.

SCHOLIUM.

The shape of Bridges on this plan, that are required to be built in exposed situations, is regulated according to the exigency of the case, in the following order.

RULE. 1.

1. If the foundations for the abutments on either shore should be unsound, then the under part of the said abutments must be concave, either in an eliptical, conical, or spherical form, according to circumstances. See foundations, plate 4.

2.

According to the degree of infirmness in the said foundation, so will the width of the lowest part of the abutment be increased; such increased width to be lost or expended perpendicularly in a battering concave circle, on the external sides of the said abutment walls, by the time they are erected to their full height; or the said extra width may be lost or diminished in the side buttresses thereof, where they occur.

3.

The abutments in such like foundations as the last mentioned may be built in various forms, suited to the requirements of the local situation, one of which may be on the plan of two plane triangled stone pyramids on each shore, the bases of each to be concave, on the under side thereof, to a certain height. See plate 5, fig 1.

4.

Where a Bridge on this sublime plan is required to be built in or near a commercial city, then the abutments may profitably be appropriated to so many warehouses, stores or even dwelling, houses, as the walls requisite to furnish gravity for the counterpoising of the arms will allow. See the eastern abutment of a Bridge represented over the Hudson, in the Frontispiece of this work.

5.

The importance of the shape of this Bridge is particularly illustrated in the side arcs of that part which extends over a river by which security is furnished against the pressure which the wind and tempest often produces.

The degrees of brace necessary to a Bridge of vast extent, on this plan, built in the most exposed situation, need not exceed a segment of a circle, the versed sine or conjugate diameter of which is one to twenty: but there are few situations wherein a Bridge of this kind would require so great a brace; as it is so compacted together in its own formation as to render it capable of resisting a vast pressure was it even on the old plan of parallel width from end to end.

6.

The next interesting part we shall describe, is the various forms which the spacious vault of these Bridges may be built on. And first the author would observe, that he is in no case confined to any particular shape; but the most favourite form for an extended arm to be framed in, is that of an isosceles wedge, extended from each side, the small ends of course joining in the middle, terminating towards the fulcrum with intersecting circles of different radii, according to the proposed height the archivolt is intended to finish above the wharf; ending finally with a scroll, see plate 5. fig 1, which when completed is sure to furnish a grand parabolic arc. But, as the sine and co-sine of the arcs of Bridges on this plan will differ according to their various situations, so also will the form of the arc of each Bridge be diverse from each other.

PROP 5.

CONSTRUCTION. The mode of constructing a Bridge on this important invention is, perhaps, the most singular, and also the most simple, of any that has ever entered the mind of man. We shall illustrate its peculiarities in the following order.

PRELIMINARIES.

First. A Bridge on the principles of this invention may be erected wholly of timber, or of stone, or of cast-iron, without ceintres or support of any kind, while building: but each Bridge will be subject to a different shape.

Second. A Bridge on this plan may be erected of any altitude required, as also with or without a roof.

Third. The abutments of this Bridge, in appropriate situations, may be erected with warehouses, stores, or dwelling-houses, that would pay well for the expense of their building, in a short time.

Fourth. The front pedestal or wharf to the Bridge is so constructed as to furnish a grand accommodation of shelter to the landing of costly goods from shipping, that are intended to be housed in the warehouses.

Fifth. The arms of a Bridge on this plan, if built with timber, are also so constructed, that each part can be repaired with greater ease and less expense than any other regular built Bridge heretofore invented.

Sixth. The timber in those parts which form the stamina of this Bridge are placed in so advantageous a position, that, agreeably to the laws of nature, it cannot decay so soon as the timber in other Bridges.

Seventh. A Bridge on this plan, not having a roof, may, on any emergency, be disunited in the centre, forty or fifty feet, or more, in the space of four or five hours, and, at a future period, be replaced as before, without the addition of new timber.

Eighth. The arms of this Bridge are built with as many ribs as the extent and situation demand. If the situation be much exposed to strong wind and tempest, and the extent be also great, then the Bridge is supplied with a brace suitable to withstand its force; which brace is acquired on all occasions by an extra width being added to the abutments, and which width is lost or diminished to the centre of the Bridge, by a concave segment of a circle, back to back. See plate 3, fig 1. The length of the deck and archivolt span-beams being therefore wholly dependent on the extra width of the Bridge at the abutment, the number of the ribs to each Bridge will also of necessity be regulated by the same cause. Therefore, if the width of the arms of the Bridge at the abutment exceed from thirty to forty feet, then there must be three ribs to each arm; if more than sixty, then four; if more than eighty, then five ribs. But the extra width of the abutment, which is alone for the procuring a brace to the flying arm of the Bridge by an arc on each side, perpendicular to the horizon, will in no instance affect the width of the Bridge at the centre; as that will invariably remain the same, and need not on any occasion exceed twenty-eight feet. No Bridge on this plan will be materially stronger, on account of an extra number of ribs, as the strength will always be proportionate to the strain. Every rib built of timber is made up of two logs or thicknesses.

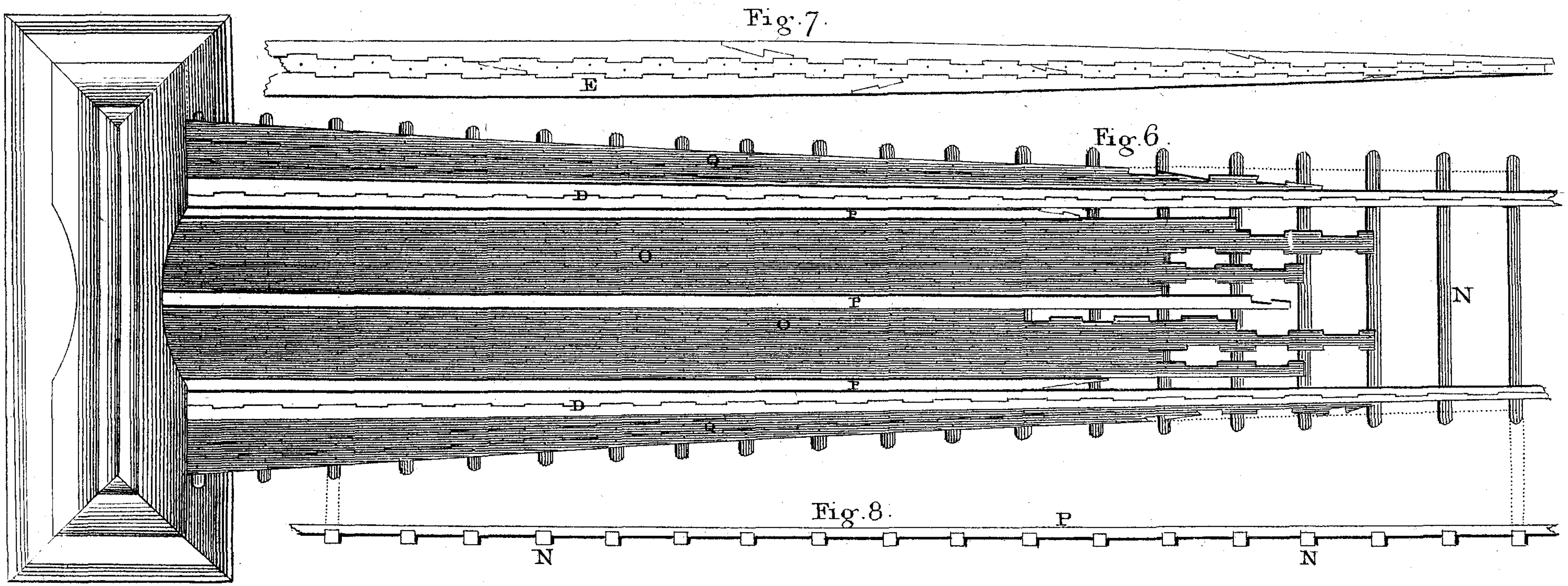
Ninth. A bill of scantling for the timber of a Bridge on this plan being first ascertained according to the rule laid down in this work, for all Bridges not requiring a greater altitude on the upper surface of the structure than four and a half degrees, (see schedule of bills of scantling for Bridges), the logs are hewn to their size in the forest where they are procured. If a Bridge is to be built with two ribs, then eight logs must be of one size. If three ribs, twelve; if four ribs, then sixteen, and so on in succession; being four logs of one size to each rib, throughout the Bridge beginning at the shortest length, which, for all Bridges on this plan, is six feet neat when framed. We shall now, for the sake of perspicuity, confine ourselves to the illustration of a Bridge, the arms of which are supposed to be built with two ribs of timber, and the abutments of stone; being the materials most eligible, for the purpose in this country, in the present state of arts and sciences.

Tenth. The length and number of the first set of angular levers for the centre of a Bridge being described in the preceding preliminary, we now proceed to show that every succeeding set of logs, for nine tenths of the distance from the centre to each abutment, which is to be used in the same order, will be increased in length, one inch to a foot of the breadth of the end of said logs on the line of the archivolt; being the proportion of the isosceles wedge, or form fixed on for an arm of the degrees of altitude first mentioned. But the logs making up the remaining tenth part of the length of the arm next to the abutment will be increased in their length more suddenly on account of the eliptical eye of the arc which forms a parabola of handsome appearance and important strength. See Plate 5, fig. 1.

Eleventh. Every timber rib is made up of two thicknesses, as before remarked, whereby the horizontal levers, E, E, E, on Plate 1, fig. 1, and Plate 2, fig 7, are inclosed in the internal part thereof. The thickness of each rib at the abutment is three feet (if the length of the arm be one thousand), or as much as the largest logs that are sound will average, the thickness of the extreme end of each rib where they join in the centre of the Bridge is

Plate. 2.

Geometrical plan of T. Popes Bridge in building.



T. Pope. del.

C. Rollinson. sc.

one foot neat, the whole length diminishing from the abutment to the said centre, in regular gradation. Two logs, on all occasions, being hewn exact to one size for each semi-rib. The thickness of the cap-plates D. D. D, on Plate 1, fig 1, and Plate 2, fig 6, are the same thickness as the top edge of each rib from end to end, except where the Bridge has a roof, then they will be of greater thickness, as the stancheons of said roof will always pass through them. The archivolt rails F. F. F, on Plate 1, fig 1, and 2, are also of the same thickness as the under edge of the rib, except as above mentioned. The thickness of the horizontal levers E. E. E, on Plate 1, fig 1, and Plate 2, fig 7, are upon all occasions full one third of the thickness of every rib from end to end, but the depth thereof is regulated by the magnitude and extent of the arm.

From this last, and the two former preliminaries, it may clearly be seen that a bill of scantling for the timber of a Bridge on this plan may be easily supplied; as it furnishes a greater variety of dimensions than a bill for any other formation could afford. The length of the shortest pair of logs for each rib never need exceed six feet, by eight inches thick, and whatever width any two may be found to average. From this size every succeeding pair of logs, or levers, throughout the arm of a Bridge, be the extent what it may, will increase only one inch in the whole length, to a foot of the breadth of the end of said log, on the line of the archivolt, as specified in the tenth preliminary.

Twelfth. The carriage-drive over a Bridge on this plan may be either on the top of the structure, or between the ribs. In the latter position, if it be covered with a roof, the deck towards the centre will hang below the archivolt, or soffit of the arc, suspended by stirrups. This deck or floor will be partly of thick plank and partly of whole timber. But the deck which is level with the top edge of the ribs must be cogged down on each beam throughout the arm, by which a strength is added to the longitudinal tie; far exceeding all that could be needed, were each arm of the Bridge wholly dependent thereon.

Having designated certain circumstances necessary to be accurately ascertained, previous to the commencement of the particular and final modelling of each part of the Bridge, prior to its erection, we shall now commence our operations in the field, on the site where the Bridge is proposed to be built.

The materials suitable and sufficient for the structure being collected on the spot, the first thing of importance to be considered is a suitable foundation.*

* This is a subject very little explored at the present day by builders in general, and consequently as little understood; it being considered by the unskilful part of that profession, as an idle nicety, not worth their attention: therefore it follows that they are perfectly unacquainted with any remedy whereby to prevent the sinking of a heavy structure through the unfavourable dispersion of the infirm strata on which the fabric rests, or the direful effects of inclined planes when called to build under water.

As to the subject of foundations, whether for this or any other sort of Bridge, or building, it matters not; one fact will be alike certain, namely that different situations produce, in general, different degrees of sound or unsound strata, which at times the architect is obliged to build on. For instance, it often occurs that one side of a river supplies a foundation of solid rock, while the opposite shore is nothing better than a bed of soft mud or a bank of loose sand, to build on; which from time to time has been drifted from some neighbouring part of the river through a change of the current, or some other cause or causes incident to rivers, especially where the channel thereof is crooked. The incapability of such infirm strata affording equal resistance to the pressure, which buildings by their grav-

This subject being among the number of valuable considerations which the author's attention has long since been called to explore, he intends to dilate more fully on this subject in a contemplated treatise on civil and marine architecture, including the practice of landscape-gardening suitable to this country, as also the best and only sure plan of making sound turnpike-roads over bogs, or unsound strata, and which plan he doubts not will, on the first trial, seal the final reprobation of those unskilful and expensive methods, which have so long been in practice amongst us. One of these sorry schemes has been tried for many years, to the injury of the public, across the swamps on the road from Powles-hook to Newark. In the said treatise the author will include an entire new and interesting plan for Canals, on a more simple construction and perfection of strength than any heretofore suggested, and shall as above hinted point out particularly the nature and tendency of different infirm strata, as also some sure remedies furnished alone by art and experience.

ity must furnish, imperiously call for the interference of art, to make up the deficiency that nature in this instance has produced. The author has by this his proposed plan done away the necessity in general of building any part of the abutments of a Bridge on said plan in water, and by which circumstance nine tenths of the difficulties, and also the expense, that in general occurs, in the erection of the abutments and piers of Bridges on the old delusive plan, is totally avoided. But he is also aware that some particular local circumstance may occur which may render it somewhat impolitic to build the abutments of his Bridge wholly out of the water, according to his first wish and intention. He therefore considers it of no small importance, that a remedy in every way suitable be provided, whereby the said abutments may be erected even in situations the most unfavourable, with far greater certainty, and speed, than any other heretofore built on the usual plans.

PROP. 6.

(Plate 4, fig 11, and 12, is the section of two abutments for Bridges on the author's improved plans for building on infirm strata, either in or out of the water. Illustrating by two examples the shape suitable to the under part of abutments resting on different degrees of infirm strata, that shall be equal to prevent either abutment from sinking more, than may be previously ascertained, by demonstrative rule.

Plate 4.

Sections
of abutments of
Bridges
on T. Popes patent plan.

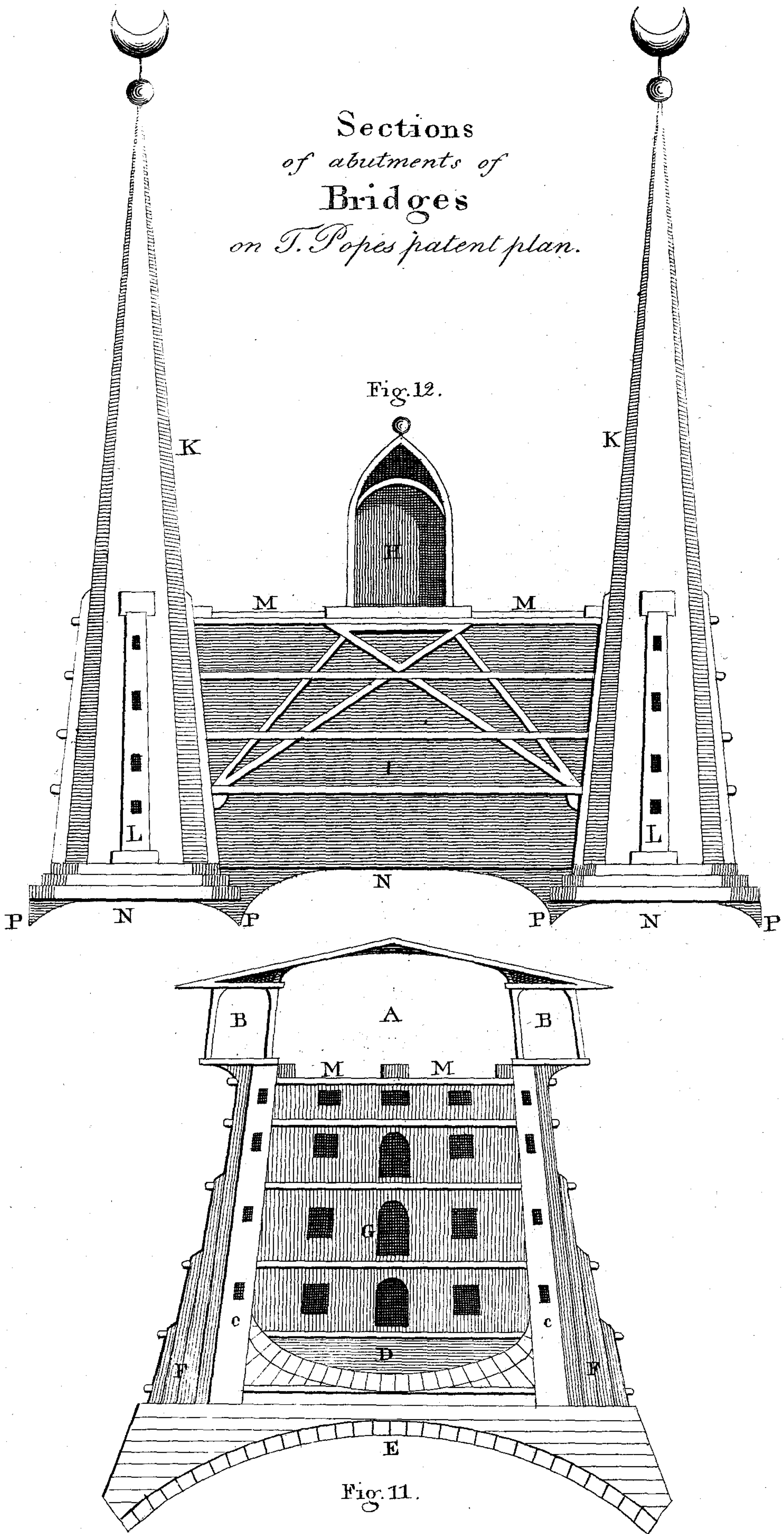


Fig. 12.

Fig. 11.

T. Pope. del.

C. Rollinson. sc.

SCHOLIUM.

The concave arcs, suited to the under part of each abutment of the different Bridges, will vary according to the defects evident in the foundation. Some will be most suitable, if in the shape of a concave segment of a circle, as at E, on Plate 4, fig 11. Others will be preferable in an eliptical form, with more concave arcs than one to each abutment, as at N N N. on Plate 4, fig 12. Others again will accomplish an equal security, by the under part of the abutment being in the form of a concave groined arc, suited to a stone pyramid, see Plate 5, fig 1. And for an abutment in a spherical form, no shape more appropriate to the grand object than a hollow cone. The side belts of these arcs, where they are used as at P P, P P, P P, Plate 4, fig 11, and 12, are for the express purpose of detaining and compressing so much of the yielding strata as may be inclosed immediately under the abutment, but which upon the old plan of level foundations was sure to escape in a horizontal direction, and be dislodged from time to time not only by the gravity which the building afforded, but also by the ground scour which the various currents in rivers often produce; and which also must inevitably make way for the constant sinking of any structure thus situated. But by the plan now proposed, the infirm strata is sure to be so compacted together as to be capable of resisting the pressure of any proportional weight that may be laid thereon.

EXPLANATION OF PLATE 4.

[D.] on Plate 4, fig 11. Is an inverted arc built between the side walls of abutment with its convex side downwards and its spandrel springings terminating in said abutment walls, by which the pressure that the gravity of the structure affords is regularly dispersed through the whole internal space of ground occupied by the aforesaid abutments.

[F F.] Fig 11. Is the external side buttresses, which tie the stone or timber walls of abutment together and prevent their being separated partially by the power of the projecting arm as has been before described.

[G.] The apertures in the front abutment walls for windows and doors, where the vacuum thereof is appropriated to the use of warehouses or any other purpose.

[A.] The carriage drives under roof.

[B B.] Foot paths under the same

Plate 4, fig 12, is a section of the abutment of a bridge without a roof.

[K K.] Are two spires of the foundation of which are intended by their additional diameters to afford strength to the fulcrums or props to the arms of Bridge.

[L L.] Are the abutment walls that pass through the said spires, and to which the ribs for the arm of Bridge are united.

[I.] Shews the section of the cross beams and accompanying braces thereto.

[H.] Is a covered path in the centre of the Bridge for foot passengers.

M M.] Are the carriage drives with skids for wheels as described in Index.

PROP 7.

The building of the stone abutments and the framing of the timber arms for a Bridge of this kind commence on each side of the river at one and the same time; so that, by the period the abutments are completed, the timber arms are also ready to be lowered down; and as the whole of the ribs are first completely fitted and put together on the field, a vast extended arc may be erected in a very short space of time.

SCHOLIUM.

The under part of the abutment being framed suitable to the foundation on which it is to rest, an oak skeleton of a suitable form is secured to the ground cradle in a perpendicular direction, see Plate 6, fig 3, which timber skeleton is intended to tie the whole of the abutment together; and is to be walled up in the masonry of the inside of the said abutment. There are also buttress-ties in the rear of the abutment, as at M, on Plate 1, fig 1, for the like purpose of preventing the weight of the projecting arm, when erected, from lifting partially any distinct part of that abutment. The whole of the abutments of a Bridge may be erected complete, before any part belonging to the timber arms need be inserted—The stone-work of said abutments to be carried up in courses, and each course grouted with cement and gravel. The mortar to be mixed and ground in a wooden mill of simple construction, made for that purpose, whereby a better cement will be furnished at a far less expense.—A level surface near each abutment being procured, a blocking is raised about three feet high from the ground, to afford an opportunity of ascertaining the accuracy or defects of the under side of each rib while framing; this being done, a mould of the exact shape and size of the intended ribs is then fastened on the said blocking, by which each rib is accurately moulded. When the whole of the said ribs are completely fitted, and every appertenance thereto ready for fixing to the abutment, then, the first parts are taken asunder and carried to their respective stations, on rolling skids prepared for that purpose. We shall next explain how the arms of the Bridge are to be built.

GEOMETRICAL ELEVATIONS AND PLAN

OF T. POPE'S LEVER BRIDGE IN BUILDING, PLATES 1, 2, & 5.

These fully demonstrate the simplicity of the construction of a Bridge on this plan; and also of the mode in which it is erected.—The first operation after the abutments are completed, in the commencement of the erection of the arms, is to fix in the abutments the first length of the horizontal levers, E E, on Plate 1, fig 1, in the two middle sockets, made for them at L L, on Plate 4, fig 12, and C C, on Plate 4, fig 11.—The next

Geometrical Elevation of Bridge in building.

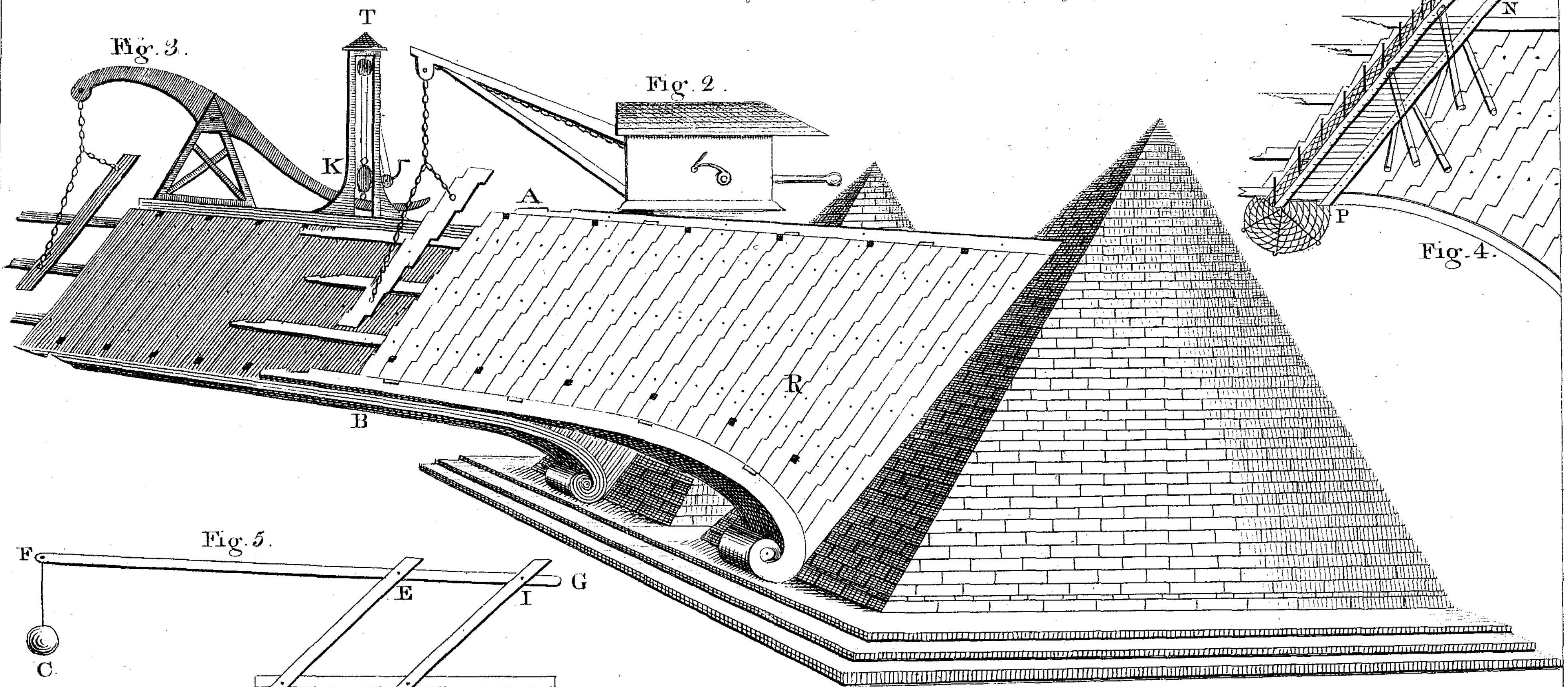


Fig. 1.

T. Pope del.t C. Rollinson sc.t

step in order is, to fix the archivolt or soffit rails F, on Plate 1, fig 1, in the lowest sockets at C C, and L L, on Plate 4, fig 12, and 11, these being secured by the means provided, namely, by certain keys and wedges in the internal parts—The next thing to be done is to commence lowering down the angular or upright levers at G, G, G, on Plate 1 fig 1, and 2, also at R, on Plate 5, fig 1, which form the ribs of the Bridge. When a sufficient number of these voussoirs are lowered down, and secured in their places, either by the iron chain bands and resting plates, as at H and I, on Plate 1, fig 3, or by chain plates and screw bolts, as at K. L, on Plate 1, fig 4, or by locus trunnels and string pieces, or by any other means, so that the whole width of the logs lowered down exceed in distance, from the abutment, the length of the first pieces of the cap-plates D. D. D, on Plates 1, and 2, fig 6 and 1, as at A on plate 5, fig 1, so as not to hinder the succeeding logs from being added, then the said first lengths of the cap-plates may be fixed in their stations in the abutments and the building of the arms may proceed in the same order, till the whole are lowered down, and the arms completed, and united in the centre. The deck or floors to the Bridge are laid and finished as the arms on each side progress; but if a roof is to be added to the Bridge, then that may be erected afterwards. Every fourth, fifth, or sixth pair of angular levers to be distinguished by the term of king-levers, or king-bents, as by their having a tenon formed at each end, which lodges in the cap-plates at the top, and the archivolt rails at the bottom edge of each rib, the intermediate levers, or queen-bents, are wholly defended from any more pressure than is furnished by the action of their own gravity, in their station. We shall now treat on a mode of defence, provided against the pressure on the timber; which some of the theorists, of the present day, who understand the nature of timber best, by the fruit it bears, are so much alarmed about.

A kind of chymical process, or philosophy by fire, may be said to pass on the end-grain rests of the angular levers in each rib, on certain occasions; whereby a vast strength is added to the timber composing the arm of the Bridge.

If, in the erection of a Bridge of vast extent, the timber selected for the purpose should be what is termed green, or unseasoned, then, the iron resting-plates as described at I, on Plate 1, fig 3, for the end-grain rests, or tusks, (or some other single piece of iron made for that purpose), is made red hot, so as to scorch or burn up the sap or vegetable acid, in the said rest, to a certain amount, which will accomplish two valuable purposes; first, it will condense and harden the end-grain of the timber, whereby it will be better able to resist the pressure which the portion of the weight allotted it will furnish. Second, by the sap being dried out of these parts, the iron resting-plates will not be so liable to corrode. And as the author proposes to use sheet-iron, in general, for his resting-plates and linings, particularly for certain parts intended to prevent a compression of the timber, the less vegetable acid or sap the better. But this valuable precaution will only be adopted in Bridges of vast extent. We now proceed to state that the cap-plates and the archivolt-rails are also secured at the top and bottom of the rib to the angular levers, by chain-plates and screw-bolts.

Fig 2, on Plate 5, is a common lifting crane, by which the logs may be lowered down in succession, on the end-grain rests of the angular levers, or inclined plane, from A to B. But fig 3 represents a Lever Jack (as that is the name the author has fixed on this machine, it being one of his own invention.) The arm of this lever is made out of a number of pieces of timber, and is of simple construction and great strength. T. is the frame in which the weight called the regulator traverses. K. the regulator and winch. The mode of hoisting and lowering a log with this machine is far more simple and safe, as also of less expense than any crane heretofore made use of, as the strength of a child of twelve years of age properly applied is sufficient to hoist or lower the heaviest log required in a Bridge, whereas it would take two strong men at least to perform the same task with a crane on the former construction; but as this makes up no essential part in the author's Bridge, we shall pass on to an explanation of the nature and use of the other figures contained on the Plates first mentioned.

Fig 4, on Plate 5, represents one of the ladders, or enclosed stairs, which are placed on each side of each rib while building, for the workmen to ascend and descend upon, to secure the logs as they are lowered down on each rib; and which is the only scaffolding needed in the erection of the arms of a Bridge on this plan. Its construction is like unto a loose flight of stairs, secured to the sides of the rib, by iron lever spanners, which are shifted forward alternately as the logs are lowered down, till the whole of the arms are completed. The treads and risers are let into the sides or string-pieces of the ladder, and an iron hand-rail is fixed from the top to the bottom, to which is fastened a rope-netting on the outside of each ladder, with an extensive netting also at the bottom, lined with canvas, to receive either men or tools, that may by accident fall from the work.

PROP 8.

Fig. 5, on Plate 5. Is a diagram on the same principle as a parallel ruler, belonging to a case of drawing instruments, and which is sufficient to prove the important fact, that the gravity of the angular levers, by their position in the arms of a Bridge, does of necessity furnish (while building) a retrograde pressure towards the abutment.

PRELIMINARIES.

1st. Gravity is that force wherewith a body has a tendency to fall downwards, and, in empty space, is called absolute gravity.

2d. Power and weight, when opposed to each other, signify the body that operates on another, and the other which is operated on. The body which begins and communicates motion is the power; and that which receives the motion is the weight.

3d. Every body by its gravity will descend to the lowest place it can attain.

4th. Whatever sustains a heavy body, bears the weight thereof.

5th. Two equal forces acting against one another, in contrary directions, destroy each other's effects; and unequal forces act only with the difference of them.

We shall now explain the above diagram, not only consistent with these axioms, but also agreeably to the established laws of the inclined plane and of the lever.

And first, we shall ascertain the true state of the gravity of the first log, supposing it to be resting in part on the inclined plane E Q, Plate 5, fig 5, of forty-five degrees, or equal angles; and also sustained in part by the horizontal end-grain rests, or tusks, cut out of the solid timber, as represented at G and R, on Plate 1, and 5, fig 1, on each. And without the said first log being connected in any degree with the beam or lever F G, fig. 5, on Plate 5.

PROP. 9.

If a heavy body be sustained on an inclined plane E Q, fig 5, Plate 5, by a power acting parallel to that plane, and if Q D, be parallel to the horizon, and D E perpendicular to it, then, if the length E Q denotes the weight of the body, the height D E will denote the power which sustains it, and the base Q D the pressure against the plane.

Therefore the weight, power and pressure are as the distance E Q, Q D, D E, and as the distance from Q to D, and from D to E, are equal, the division of the weight of the log is consequently equal on the two planes that sustain it. The state of the gravity of the second log is decided by the first.

SCHOLIUM.

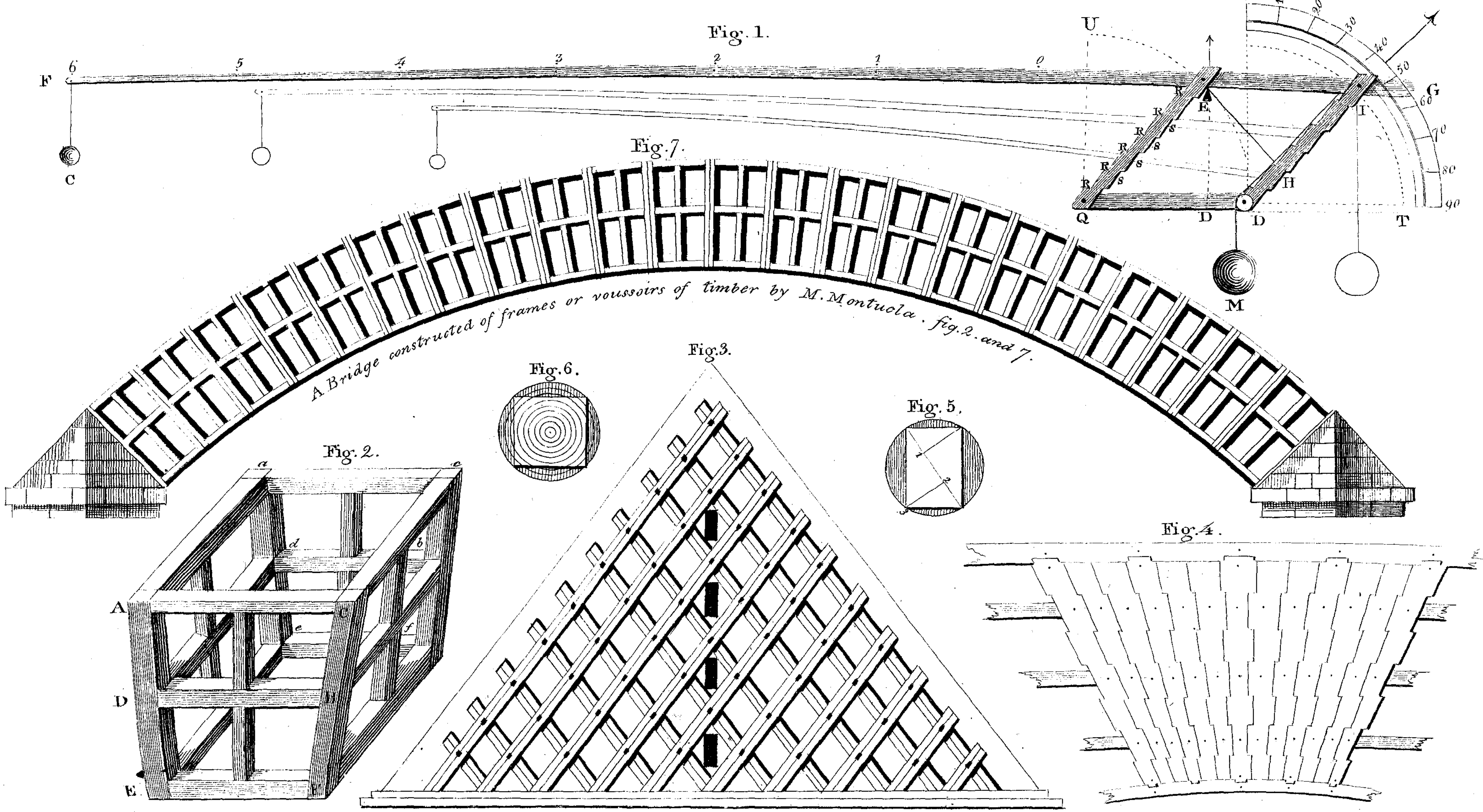
All the angular levers that compose the ribs of a Bridge on this plan are placed at an angle of forty-five or fifty degrees from a horizontal line, but mostly on the former position; that is to say, every two logs are so placed, as the narrow and broad end of every log being put together in a rib alternately, produce a parallel width, by which the same angle is continued within about six feet of the centre, when they move up to a perpendicular. See Plate 6, fig 4.

COR. 1.

The weight of the body, the power that sustains it on the plane, and the pressure against the plane, are respectively as radii, the sine and co-sine of the plane's elevation above the horizon.

For Q E, E D, and Q D, are to one another as radii sine of E Q D, and sine of Q E D.

PLATE. 6.



A Timber skeleton for the abutment of a Bridge.

COR. 2.

The distribution of the gravity of the two angular logs in the diagram being ascertained, by the same rule we prove that the gravity of all the angular levers individually composing the ribs of a Bridge on this plan, and placed at the same angle, independent of the additional force which the horizontal levers will supply, is sure to be distributed in the like proportional manner; that is to say, the one half of the weight of each log forming any rib as at R, on Plate 5, fig 1, will be sustained by the inclined plane first of the pyramid, or the next adjoining log in succession as they are lowered down; the other half is lodged on the horizontal end-grain rests or tusks, cut out of the said inclined planes.

We come next in order to point out the additional force wherewith the angular or falling levers Q E and D I, on diagram, Plate 6, fig 1,* is pressed back towards the abutment by the extra weight and action of the horizontal levers F G, on the said diagram, and E E, on Plate 1, fig 1. We shall now illustrate the foregoing fact by the principles of the compound lever, No 1 and 4.

PROP 10.

First, If the lever F G, on the diagram, be considered distinctly as a lever of the first order, E will be the prop, I the weight, and C the power.

*As there are some omissions in the engraving of the diagram fig 5, Plate 5, we shall refer our reader to the diagram fig 1, on Plate 6, for the illustration of the remainder of this important subject.

Then if the power and weight be in equilibrio, the power C is to the weight I as the distance of the weight from the support E is to the distance of the power from the support.

Secondly, If F G, I D, also be considered a lever of the fourth kind, then,

AXIOM.

If a power be outbalanced by any weight in a given direction, it matters not in what point of that line of direction the weight is applied.

COR. 1.

If the weight M act obliquely against the power C on the lever F G the power and weight will be in equilibrio when the weight M is to the power F as the distance of the power F E is to E H, the perpendicular, drawn from the support E to the line of direction of the weight.

For in this case H E F becomes a bended lever, and the weight M acts perpendicular to E H, at H; and, agreeably to the above axiom, it is all one whether the weight acts at H, or I, in the line of direction I H; and hence,

COR. 2.

If any force be applied to a lever I E F, at I, its power to turn it about the centre of motion E is as the sine of the angle of application E I H.

For if E I be given, E H is as the sine of E I H.

COR. 3.

In a straight lever of these three, the power, the weight, and the pressure upon the support; the middlemost is equal to the sum of the other two.

For the middle one acts against both the others, and supports them.

COR 4.

Then, if agreeably to COR 2, PROP 9, the angular or falling levers Q E, and D I, do distinctly furnish by their own action a pressure backwards on the inclined plane or pyramid, to the full amount, of the half of their neat gravity, independent of any force from the gravity or action of the horizontal levers ; then, it is obvious, from the foregoing facts stated, that if the horizontal levers are allowed to act, they also will, in proportion to the full amount of their respective gravities, be sure to add to the velocity or pressure on the said angular levers.

COR. 5.

Also, as every pair of angular levers, by their decrease of length, and the additional height in which their upper end is placed, through the degrees of altitude which the arms of Bridges will be erected at in general, the weight of every pair of succeeding levers is thrown on the upper part of the rear angular levers, by which the gravity or pressure will be increased towards the abutment.

COR. 6.

Finally on this head, as the angular levers are lowered down, so is the advantage of their retrograde pressure by their gravity towards the abutment secured, by the longitudinal tie of the cap-plates and also of the needles or horizontal levers. But, as before illustrated in another part of this work, when the arms of the Bridge are united in the centre, the action of the levers ceases.

EXTENT. From a recollection of the many absurd opinions lavished on this invention, at its first promulgation, by characters the least to be expected, namely, of those who profess a vast knowledge in science, the author has been ready to conclude that he would suspend for the present any information on this important part of the subject; preferring rather to wait the period, when ocular demonstration should sufficiently punish the gross ignorance of these pretenders to science and enemies to the useful arts.

But the author has also considered, that if a Bridge on this plan be indeed capable of the vast extent he has heretofore asserted, and which, from a multiplied conviction of the excellence of its principles, he still dares to assert; how dishonorable would it be on his part, were he to shrink from the just vindication of its true merits, because a mere quack philosopher and two or three bookful theorists, (who may be looked up to by some as *Gods in science*, but who are in reality of those that are the pests of the arts in every age) because these, in the plenitude of their wisdom may think fit to doubt the existence of the vast powers vested in this invention, without having once investigated even one of its golden properties.

The narrow limits that persons of this description have been disposed to fix for the utmost extent of a Bridge on this plan, have at once evinced to the candid and intelligent part of the public who have chosen to judge for themselves, that these sage persons were certainly under the influence of one of two things; namely, a total ignorance of the invention, or a contemptible opposition to its success.

But, as the sons of science in all ages have ever had such characters to contend with, the author conceives it a waste of time, at the present, further to notice such pusillanimous conduct. He therefore shall pass on to explain to the undissembled friends of science the grand reasons why a Bridge on this superior plan can be erected to a far greater distance with a single arc than any heretofore invented.

PROP. II.

The arms of a Bridge being framed to the shape of an isosceles wedge of the proportion of one to twelve for the increase of the depth of each rib (see plate 3, fig 1) the strength of each arm is sure to be equal in all its parts, for any extent.

SCHOLIUM.

If a beam were in the form of an isosceles wedge, like unto A M Z, Plate 3, fig. 1, fixed at the end M Z, and a weight press uniformly on every part of A M, and the sections in all points as I V, be similar; then A I will be as I V, and Z V A a right line. Hence, on this plan the half of a square beam may be cut away without losing any strength. See Emerson, on the strength of timber.

COR.

In like manner, whether an arm of a Bridge on this plan be erected one hundred feet in length from its abutment, as A B, on diagram fig. 1, plate 3, or twelve hundred feet, as A M, on said diagram, or any of the intermediate distances therein marked, it matters not, as they each will be alike strong in proportion to their extent, to carry their own weight, and also whatever additional gravity the men and materials employed in the erection of the Bridge may furnish. This fact is rendered certain, not only by the above rule, but also by many others equally incontrovertible.

PROP. 12.

The small proportion that the thickness of each rib, for the arm of a Bridge of any dimensions on this plan, bears to the depth thereof, is also a sure mean of strength suited to an arm of extra extent.

SCHOLIUM.

The causes that explain the above fact have been abundantly illustrated in practice, in various instances. Hence we witness a superior strength, possessed in a beam of oblong section, with its greatest breadth placed perpendicular to the horizon, to that of a square beam; though the former should contain less timber than the latter. See Plate 6, fig 5.

COR.

But, as the greatest strength that a beam of timber of any dimensions will furnish, by its lateral grain, is far inferior to that strength or resistance which the end grain of timber supplies; so in a much greater proportion will the timber ribs composing the flying arms of this Bridge be infinitely superior in strength to that of any other formation, by their thickness being so much inferior to their depth.

PROP. 13.

The weight of the arms of this Bridge being supported principally on the end grain of the timber, is also a grand reason why it can be erected to a greater extent than any other Bridge. See geometrical elevations of this Bridge in building, Plate 5, fig. 1, and Plate 1, fig. 1.

SCHOLIUM.

The side-logs, or angular-levers, composing the ribs of this Bridge from the abutment to the centre, all rest in the lap of each other, in succession, on their end grain tusks and joggles.

COR. 1.

Therefore, by the length-grain longitudinal needles, or levers, being wholly enclosed in the end-grain tubes formed in the internal part of the above mentioned angular-levers, a strength is furnished superior to any other formation of timber heretofore witnessed; and which strength is abundantly capable of being multiplied beyond what can be needed for a Bridge, of any extent, the people of any country may wish to erect.

COR. 2.

By the above end-grain rests and longitudinal needles being lined with sheet-iron or tin, a prevention is also secured against the compression or indention of the timber in the internal part of each rib, in an arm of any extent.

PROP. 14.

Though the strength of the whole of the timber in the arms of this Bridge is unitedly in action at one and the same time while building, yet the taking out of any single part to repair, after it is built, cannot in the least degree affect the strength of the Bridge; as the said strength is not in one single instance dependent on any one part or side of the rib; therefore, the whole of the arms of a Bridge, of any extent on this plan, may be repaired at any period, without the smallest risk; which furnishes an advantage not to be equalled in any other Bridge.

SCHOLIUM.

This last proposition has been partly explained under the head of Construction and the Inclined Plane; but, as the whole of this Bridge is capable of being repaired with far more ease and less expense than any other heretofore invented, which is an acquisition of no small importance to a structure of this extra magnitude, we shall further particularize the simple means by which it is accomplished.

First. The thickness of each rib being made up of two parts, (see page 211 and 12) and both of these parts so tabled or indented into each other alternately, as, when the log or logs on one side be withdrawn, those on the opposite side, by their toothings, take the full charge of the whole weight or strain; consequently any part may be taken out of one side of the rib, at one time, and repaired with the greatest ease and facility.

Second. As every fourth lever or king-bent is tenonted into the cap and archivolt-rails, whereby the queen-bents which fill the intermediate space are protected from the side pressure of any more weight than their own furnishes, it is obvious that there cannot exist more additional pressure on the levers remaining, than that which was produced by the former weight the absent levers bore. And as the end-grain of every single log, in its respective station, will be able to furnish a resistance to more pressure than double the weight of the semi-rib projecting beyond the part where the log or logs are taken out can afford, were it even disunited in the centre, there can be no doubt of those bents that remain bearing the half of that proportion, when united.

Third. Each defective log on the sides of each rib can be taken out of its place by the most simple means, namely, by unscrewing three or four iron bolts, or starting so many trunnels and string-pieces, if of wood. A new log is then moulded to its shape, and placed in its stead, with similar ease. The only scaffolding required for this service being two ladders, of the same kind as those first used in the erection of a Bridge on this plan.

Fourth. Every angular lever is not only surrounded on three sides from the top to the bottom by the adjoining levers, as before noticed, but is also belted on the fourth or outside by the iron chain-bands or chain-plates; by which means each log is so secured, that it has not room to crush, or break. But the relation of this grand and important fact will no doubt make many of our half-taught theorists stare, who profess to know a great deal about the strength of timber.

PROP. 15.

The upper deck of this Bridge, on all occasions, furnishes a vast longitudinal brace and tie, by being cogged down on the beams, as before mentioned; and is a mean of strength abundantly suited to an arm on this plan of extra extent.

SCHOLIUM.

The decks or floors of this Bridge are always to be laid longitudinally, and caulked with oakum in the joints or seams, and afterwards payed over with pitch and chalk; by which means, if faithfully executed, not only a vast strength and firmness is added to the Bridge, whereby it is made capable of withstanding the pressure of wind and tempest, but also a grand preservation of the under part of the structure is secured without the extra and needless expense of a shingled roof.

COR. 1.

Therefore, if a Bridge is required to be built in an exposed situation, the shape of the ribs perpendicular to the horizon on the outer sides thereof will be two concave segments, back to back. See Page 208.

COR. 2.

But the ribs of a Bridge, even of an extensive span, where the situation is not much exposed to wind and tempest, may be built in parallel lines from end to end, provided the overhanging gallery footpaths, which project beyond the ribs on each side, be in a concave circular form. These will furnish a brace of sufficient strength for such a situation, and also supply a grand shelter for the whole of the fabric under the same, as above remarked. See Plate 1, fig. 2.

COR. 3.

In Bridges of small extent, neither of the valuable precautions above mentioned will be needed; therefore, where this is the case, the width of the Bridge on this plan, from out to out, need not exceed from twenty to twenty-six feet, on any occasion.

Having reconnoitred a part of the valuable principles contained in this invention, whereby a Bridge can be erected to a far greater extent than any other, we shall now proceed to furnish the estimate and bills of scantling for the timber and other materials required for the building of the different Bridges described by sections on diagram, Plate 3, fig. 1.

ESTIMATE

Of the expense of Bridges on this plan of invention, from an Arc of 200 feet, to one of 2400 feet span, accurately calculated according to certain fixed prices of materials and labour, with ample allowance for waste and casualties.

The reader will observe, that the author, in these estimates, makes no calculations for building in water; as he wishes never to erect his abutments nearer the river than the highest water-mark, as in all cases those Bridges will be sure to be the cheapest. Also, that every Bridge is built in two halves, one from each shore.

ESTIMATE of a BRIDGE, 200 feet span.

This Bridge would be composed of two arms, and each arm of 2 ribs, and each rib is made up of two thicknesses. The length of each rib is of course 100 feet from the extremity or centre of Bridge A, to the fulcrum or abutment B, See Plate 3, fig. 1. The neat depth of each rib need not ever exceed 6 feet at the centre, by one foot thick; and fourteen feet 4 inches deep at the abutment, by 14 inches thick. The depth regularly increasing one inch to a foot, throughout the arm, till it reaches the abutment, and the thickness of the rib increasing from the centre to the abutment, 2 inches in 100 feet; therefore the author's measurements are easily examined as to these estimates.

The timber composing the angular levers of each rib will measure in their work, agreeably to the above dimen-

sions given, 1100 cubic feet; and as there are 4 semi-ribs to this bridge, the number of cubic feet in them contained, is - - - - - -	C feet. 4,400
The dimensions of the cap-plates and archivolt-rails are as follows; 100 feet long, 12 inches square at the centre, and 14 at the abutment. 4 times	470
The dimensions of the needles or horizontal levers, in this Bridge, are 100 feet long; 4 by 12 inches at the small ends, and 6 by 18 inches at the largest end. - - 4 times	210
The average dimensions of the deck or floor of Bridge, is 28 by 100 feet, and will contain at - 2 times	1,800
The average dimensions of the deck and tie-beams will be 28 feet long. Their shape being somewhat in the form of a prism, in their section will average 6 by 12. - - 60 times	1,680
	8,560
Allowance for working, and waste of timber - - - - - -	1,440

Total number of cubic feet of timber required for the two arms of a Bridge of the above dimensions, 10,000 at 2—2500 (s $)

Labour to do. at per cubic foot, the number of feet used in the arm with-

out the allowance for waste, which will be 8560 - - - - - -	s at 2	$ —2140
Iron work to Bridge - - - - -		1000
Materials and labour for caulking of the deck of Bridge - - - -		1000
To apparatus for building the arms of Bridge - - - - - - - - -		1000
To two abutments built of stone and brick, with a toll-house on each, of timber, with gates, lamps, &c. complete - -		8360
	Total expense	16,000

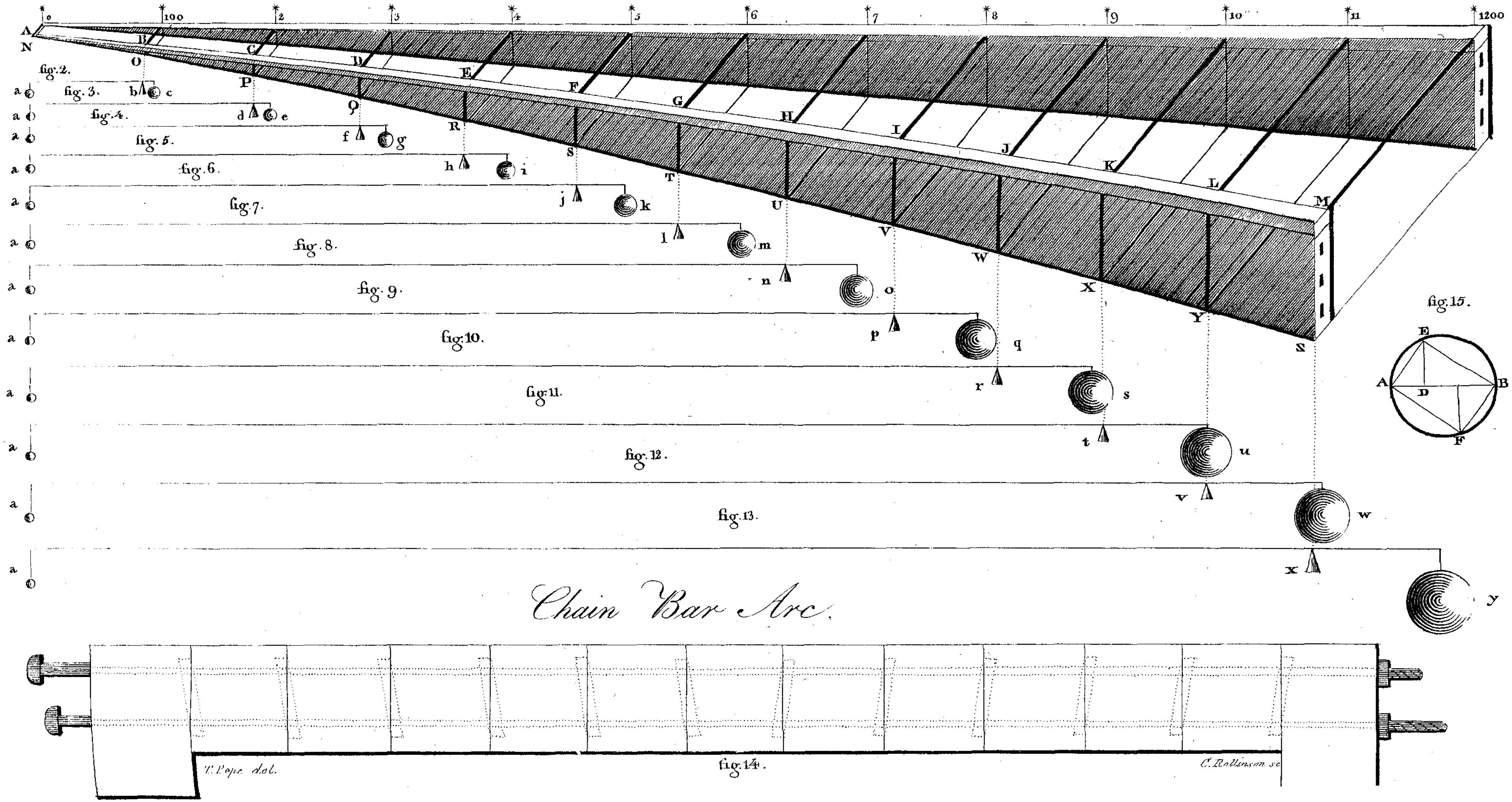
The sum total, as here found, will exceed, in many instances, more than five-and-twenty per cent. over and above what a Bridge of this dimensions could possibly cost in favourable situations. And as the price of materials and labour differ so widely, in the various parts of a country, as also the local advantages and disadvantages, it is not to be expected that estimates can be made to form a standard for all places; as these are more particularly applicable to New-York, and similar situations, but which is never likely to be exceeded in any situation in the United States.

Having given the Estimate of a Bridge of 200 feet span, the arms of which are the proportion of the section of A to B, on fig. 1, Plate 3, we shall proceed by the same rule to give the probable cost of the different Bridges described by the said sections.

PLATE. 3.

Sections of twelve semi arms of Bridge contained between two isosceles triangles.

fig. 1.



	$
The Estimate of a Bridge, of 300 feet span, built on the same proportion as the former, is -	25,000
Do - - of 400 feet span by section A to C	36,000
Do - - of 500 feet span do do	50,000
Do - - of 600 feet span by section A to D	68,000
Do - - of 700 feet span do do	83,000
Do - - of 800 feet span by section A to E	102,000
Do - - of 900 feet span do do	118,000
Do - - of 1000 feet span by section A to F	138,000
Do - - of 1100 feet span do do	155,000
Do - - of 1200 feet span by section A to G	176,000
Do - - of 1300 feet span do do	194,000
Do - - of 1400 feet span by section A to H	216,000
Do - - of 1500 feet span do do	235,000
Do - - of 1600 feet span by section A to I	258,000
Do - - of 1700 feet span do do	278,000
Do - - of 1800 feet span by section A to J	302,000
Do - - of 1900 feet span do do	323,000
Do - - of 2000 feet span by section A to K	348,000
Do - - of 2100 feet span do do	370,000
Do - - of 2200 feet span by section A to L	396,000
Do - - of 2300 feet span do do	419,000
Do - - of 2400 feet span by section A to M	446,000

Bridges built with different materials, and to different shape, will of course vary in their expense.

BILLS of SCANTLING
For Bridges of various Dimensions.

Note 1st.

Whatever be the extent of a Bridge on this plan, the size of the timbers composing the centre, will be the same in all cases, as to thickness and length.

2d.

It matters not what breadth the logs may average that fill up the longitudinal extent of each arm, so as each pair be of one thickness and length; save, that the greater their breadth, the less will be the number of logs required, and also the less will be the labour to each rib.

3d.

The dimensions of the four pair of centre logs or key-voussoirs, to any bridge of this construction, will be in the rough 6 feet long, and 8 inches thick, allowing for tablings, by whatever breadth each pair of logs may average. But to form a scale for the scantling of the timber required for any Bridge, we shall suppose the angular levers to average one with another in breadth, one foot each when finished. Then the dimensions of the timber in the rough, for a Bridge of 200 feet span, will be as follows:

FOR THE ANGULAR LEVERS.

Number,		Length,		Thick. Breadth.
8 pieces	-	6 feet 1 long,	-	8 by 16
8 do	-	6 feet 2 long,	-	8 by 16
8 do	-	6 feet 3 long,	-	8 by 16
8 do	-	6 feet 4 long,	-	8 by 16
8 do	-	6 feet 5 long,	-	8 by 16
8 do	-	6 feet 6 long,	-	8 by 16
8 do	-	6 feet 7 long,	-	8 by 16
8 do	-	6 feet 8 long,	-	8 by 16
8 do	-	6 feet 9 long,	-	8 by 16
8 do	-	6 feet 10 long,	-	8 by 16
8 do	-	6 feet 11 long,	-	$8\frac{1}{4}$ by 16
8 do	-	7 feet 0 long,	-	$8\frac{1}{4}$ by 16

Number,		Length,		Thick. Breadth.
8 pieces	-	7 feet 1 long,	-	8¼ by 16
8 do	-	7 feet 2 long,	-	8¼ by 16
8 do	-	7 feet 3 long,	-	8¼ by 16
8 do	-	7 feet 4 long,	-	8¼ by 16
8 do	-	7 feet 5 long,	-	8¼ by 16
8 do	-	7 feet 6 long,	-	8¼ by 16
8 do	-	7 feet 7 long,	-	8¼ by 16
8 do	-	7 feet 8 long,	-	8¼ by 16
8 do	-	7 feet 9 long,	-	8½ by 16
8 do	-	7 feet 10 long,	-	8½ by 16
8 do	-	7 feet 11 long,	-	8½ by 16
8 do	-	8 feet 0 long,	-	8½ by 16
8 do	-	8 feet 1 long,	-	8½ by 16
8 do	-	8 feet 2 long,	-	8½ by 16
8 do	-	8 feet 3 long,	-	8½ by 16
8 do	-	8 feet 4 long,	-	8½ by 16
8 do	-	8 feet 5 long,	-	8½ by 16
8 do	-	8 feet 6 long,	-	8½ by 16
8 do	-	8 feet 7 long,	-	8¾ by 16
8 do	-	8 feet 8 long,	-	8¾ by 16
8 do	-	8 feet 9 long,	-	8¾ by 16
8 do	-	8 feet 10 long,	-	8¾ by 16
8 do	-	8 feet 11 long,	-	8¾ by 16
8 do	-	9 feet 0 long,	-	8¾ by 16
8 do	-	9 feet 1 long,	-	8¾ by 16
8 do	-	9 feet 2 long,	-	8¾ by 16
8 do	-	9 feet 3 long,	-	8¾ by 16
8 do	-	9 feet 4 long,	-	8¾ by 16
8 do	-	9 feet 5 long,	-	9 by 16
8 do	-	9 feet 6 long,	-	9 by 16
8 do	-	9 feet 7 long,	-	9 by 16
8 do	-	9 feet 8 long,	-	9 by 16
8 do	-	9 feet 9 long,	-	9 by 16

Number,		Length,		Thick. Breadth.
8 pieces	-	9 feet 10 long,	-	9 by 16
8 do	-	9 feet 11 long,	-	9 by 16
8 do	-	10 feet 0 long,	-	9 by 16
8 do	-	10 feet 1 long,	-	9 by 16
8 do	-	10 feet 2 long,	-	9 by 16
8 do	-	10 feet 3 long,	-	9¼ by 16
8 do	-	10 feet 4 long,	-	9¼ by 16
8 do	-	10 feet 5 long,	-	9¼ by 16
8 do	-	10 feet 6 long,	-	9¼ by 16
8 do	-	10 feet 7 long,	-	9¼ by 16
8 do	-	10 feet 8 long,	-	9¼ by 16
8 do	-	10 feet 9 long,	-	9¼ by 16
8 do	-	10 feet 10 long,	-	9¼ by 16
8 do	-	10 feet 11 long,	-	9¼ by 16
8 do	-	11 feet 0 long,	-	9¼ by 16
8 do	-	11 feet 1 long,	-	9½ by 16
8 do	-	11 feet 2 long,	-	9½ by 16
8 do	-	11 feet 3 long,	-	9½ by 16
8 do	-	11 feet 4 long,	-	9½ by 16
8 do	-	11 feet 5 long,	-	9½ by 16
8 do	-	11 feet 6 long,	-	9½ by 16
8 do	-	11 feet 7 long,	-	9½ by 16
8 do	-	11 feet 8 long,	-	9½ by 16
8 do	-	11 feet 9 long,	-	9½ by 16
8 do	-	11 feet 10 long,	-	9½ by 16
8 do	-	11 feet 11 long,	-	9¾ by 16
8 do	-	12 feet 0 long,	-	9¾ by 16
8 do	-	12 feet 1 long,	-	9¾ by 16
8 do	-	12 feet 2 long,	-	9¾ by 16
8 do	-	12 feet 3 long,	-	9¾ by 16
8 do	-	12 feet 4 long,	-	9¾ by 16
8 do	-	12 feet 5 long,	-	9¾ by 16
8 do	-	12 feet 6 long,	-	9¾ by 16

Number,		Length,		Thick. Breadth.
8 pieces	-	12 feet 7 long,	-	$9\frac{3}{4}$ by 16
8 do	-	12 feet 8 long,	-	$9\frac{3}{4}$ by 16
8 do	-	12 feet 9 long,	-	10 by 16
8 do	-	12 feet 10 long,	-	10 by 16
8 do	-	12 feet 11 long,	-	10 by 16
8 do	-	13 feet 0 long,	-	10 by 16
8 do	-	13 feet 1 long,	-	10 by 16
8 do	-	13 feet 2 long,	-	10 by 16
8 do	-	13 feet 3 long,	-	10 by 16
8 do	-	13 feet 4 long,	-	10 by 16
8 do	-	13 feet 5 long,	-	10 by 16
8 do	-	13 feet 6 long,	-	10 by 16
8 do	-	13 feet 7 long,	-	$10\frac{1}{4}$ by 16
8 do	-	13 feet 8 long,	-	$10\frac{1}{4}$ by 16
8 do	-	13 feet 9 long,	-	$10\frac{1}{4}$ by 16
8 do	-	13 feet 10 long,	-	$10\frac{1}{4}$ by 16
8 do	-	13 feet 11 long,	-	$10\frac{1}{4}$ by 16
8 do	-	14 feet 0 long,	-	$10\frac{1}{4}$ by 16
8 do	-	14 feet 1 long,	-	$10\frac{1}{4}$ by 16
8 do	-	14 feet 2 long,	-	$10\frac{1}{4}$ by 16
8 do	-	14 feet 3 long,	-	$10\frac{1}{4}$ by 16
8 do	-	14 feet 4 long,	-	$10\frac{1}{4}$ by 16

By the above schedule it will be seen, that every eight logs, or single set, of the angular levers, increase in length only one inch to a foot of their breadth when tabled together; also in thickness one quarter of an inch in 10 feet.

The eight cap-plates and archivolt-rails of this Bridge, is each one hundred feet long when scarfed together, beside the length to be lodged in each abutment; the small ends of which are 12 inches square, the larger ends next the abutment are 14 by 22 inches, or as large as any sound log will furnish. Each is made up of two thicknesses.

The eight horizontal levers, or needles, are also 100 feet long when scarfed together, beside the length to be lodged in the abutments; the small ends thereof are 4 inches thick, by 12 inches deep; the part of each next the abutment is 6 inches thick, by 18 inches deep.

The side strings, and carriage skids, are also the same length with the above, and will average 12 inches diameter.

The span of the deck beams to this Bridge is from 25 to 30 feet long; they will average in scantling 6 inches by 12, and are cut to the shape of two isosceles wedges, or a prism.

The deck or floor of Bridge will average five inches thick, and may be of oak or pine.

If any diagonal or perpendicular braces be needed to this Bridge, the size of their scantling will be regulated by their length.

According to the proportional increase of the size of the sections of the isosceles wedge on Plate 3, fig. 1, so will the increase of the quantity of timber be, in the different bills of scantling for the other Bridges.

Therefore agreeably to the rules whereby the different sizes of the timber in the above Bridge are averaged, the bill of scantling for the timber in each Bridge, in the above section, will be regulated according to their various measurements.

GENERAL REMARKS

On the nature and strength of Timber, and other materials.

Having promised, in the table of contents of this small work, some observations on this all-important point, we shall now attend to a brief illustration of the subject, whereby those persons, who have heretofore had nothing to inform their judgment as to science, but the delusive help of untried theory, may be assisted to discover, not only wherein the superior excellence and practicability of the author's invention is contained, but also the gross ignorance manifested in others who have been hardy enough to assume a capability of judging works of art, though they have not possessed one single prerequisite for the purpose. Hence certain *sage* persons, who have taught many to believe that Wisdom was to expire with them, have boldly asserted to their credulous admirers, that the strength of materials was not equal for the support of a Bridge to the extent contemplated by the author; whilst at the same time these vain pretenders were totally ignorant of the strength contained in either a cubic inch or foot of Timber, Stone, or any other material.

We shall proceed to shew, in a few instances, what is the different strength of timber, and the positions in which it is produced: first, we shall cite those authors who have written on the subject; whereby the reader may finally discover that all the experiments and theoretical calculations that have heretofore been made, on the nature and strength of timber, are wholly inadequate to determine the subject; as they are not only contradictory, but also principally confined to the illustration of the strength of the side-grain only, on which the author's invention does not depend.

The celebrated Charles Hutton, L. L. D. and F. R. S. in his Recreations in Mathematics and Natural Philosophy, page 392, on Architecture, proposes the following problem.

PROBLEM 1.

To cut a tree into a Beam capable of the greatest possible resistance.

"This problem belongs properly to mechanics; but, on account of its use in architecture, we thought it might be proper to give it a place here, and to discuss it both geometrically and philosophically. We shall first examine it under the former point of view.

"Galileo,* who first undertook to apply geometry to the resistance of solids, has determined, on a very ingenious train of reasoning, that, when a body is placed horizontally, and fixed by one of its extremities, as is the case with a quadrangular beam projecting from a wall, if a weight be suspended from the other extremity, in order to break it, the resistance which it opposes is in the compound ratio of the horizontal dimension and the square of the vertical dimension. But this would be more correctly true, if the matter of the body were of a homogeneous and inflexible texture.

"It has been shown also, that, if a beam is supported at both extremities, and if a weight, tending to break it, be suspended from the middle, the resistance it opposes is in the ratio of the product of the breadth and square of the depth, divided by half the length.†

"To solve therefore the proposed problem, we must cut from the trunk of the tree a beam of such dimensions, that the product of the square of the one by the other shall be the greatest possible.

§ "Let A B then, Plate 3, fig. 15, be the diameter of the circle, which is the section of the trunk; the question is, to inscribe in this circle a rectangle, as AE BF, of such a nature, that the square of one of its sides AF, multiplied by the other side AE, shall give the greatest product. But it can be proved that, for this purpose, we must first take, in the diameter AB, the part AD equal to a third of it, and raise the perpendicular DE, till it meet the circumference in E: if BE and EA be then drawn, and also AF and FB parallel to them, we shall have the rectangle AE BF, of such a nature, that the product of the square of AF by BF, will be greater than that given by any other rectangle inscribed in the same circle. If a beam of these dimensions, cut from the proposed trunk, be placed in such a manner, that its greatest breadth AF shall be perpendicular to the horizon, it will present more resistance than any other that could be cut from the same trunk; and even than a square beam cut from it, though the latter would contain more matter.

REMARK.

"Such would be the solution of this problem, if the suppositions from which Galileo* deduced his principles, in regard to the resistance of solids, were altogether correct. He, indeed, supposes that the matter of the body to be broken is perfectly homogeneous, or composed of parallel fibres, equally distributed around the axis, and presenting an equal resistance to rupture; but this is not entirely the case with a beam cut from the trunk of a tree which has been squared."

"By examining the manner in which vegetation takes place, it has been found, that the ligneous coats of a tree, formed by its annual growth, are almost concentric; and that they are like so many hollow cylinders, thrust into each other, and united by a kind of medullary substance, which presents little resistance :‡ it is therefore these ligneous cylinders chiefly, and almost wholly, which oppose resistance to the force that tends to break them.

"But, what takes place when the trunk of a tree is squared, in order that it may be converted into a beam? It is evident, and it will be rendered more sensible by inspecting fig. 6, on Plate 6, that all the ligneous cylinders, greater than the circle inscribed in the square, which is the section of the beam, are cut off on the sides; and therefore the whole resistance almost arises from the cylyndric trunk inscribed in the solid part of the beam. The portions of the cylindric coats, which are towards the angles,‡ add indeed a little strength to that cylinder; for they cannot fail of opposing some resistance to the breaking force; but it is much less than if the ligneous cylinders were all entire. In the state in which they are, they oppose only a moderate effort to flection, and even to rupture. For this reason, there is no comparison between the strength of a joist made of a small tree, and that of another which has been sawn, or cut with several others from the same beam or block.‡ The latter is generally weak, and so liable to break, that joists, and other timber of this kind, ought to be carefully rejected from all wooden work which has to support any considerable weight.‡

"We shall here add, that these ligneous and concentric cylinders are not all of equal strength. The coats nearest the centre, being the oldest, are also the hardest; while, according to theory, the absolute resistance is supposed to be uniform throughout.

"It needs, therefore, excite no surprise that experience should not entirely confirm, and even that is should sometimes oppose, the result of theory. Hence we are under considerable obligations to Duhamel* and Buffon*, for having subjected the resistance of timber to experiments: as it is of great importance in Architecture to know the strength of the beams employed, in order that larger and more timber than is necessary may not be used.

But, notwithstanding what has been said, it is very probable that the beam capable of the greatest resistance, which can be cut from the trunk of a tree, is not the square beam; for the following experiments, made by Duhamel,* seem to prove, the size being the same, that the beam which has more depth in proportion than breadth, when the depth is placed vertically, presents so much more resistance; and even without deviating very much from the law proposed by Galileo,* viz. the compound ratio of the square of the vertical dimension and that of the breadth.

Duhamel,* indeed, caused to be broken twenty square bars of the same volume, to determine what form of dressing would render them capable of the greatest resistance. They all had 100 square lines of base, and four of each sort were employed, of the different dimensions, to compose the same area.

†The first four, which were 10 lines in every direction, sustained a weight of 131 pounds.

† Four others, which were 12 lines in one direction, and $8\frac{1}{3}$ in another, sustained each 154 pounds. The above law would give 157 pounds.

† The next four, which were 14 lines in height and $7\frac{1}{7}$ in breadth, supported each 164 pounds. Calculation would give 183 pounds.

Four more, which were 16 lines in height and $6\frac{1}{4}$ in breadth, sustained each 180 pounds. According to calculation they ought to have supported 209 pounds.

The last four, which were 18 lines in height and $5\frac{1}{2}$ in breadth, sustained each 243 pounds. Calculation would have given only 233 pounds. It is very singular that in this case calculation should give less than experience; while in the other cases the result was contrary.

Buffon* began experiments on a larger scale, in regard to the resistance of timber, an account of which may be seen in the Memoirs of the Academy of Sciences for the year 1741. It is to be regretted that he did not pursue this subject, on which no one could have thrown more light. It appears to result from these experiments, that the resistance increases less than in the square of the vertical dimension, and decreases in a ratio somewhat greater than the inverse of the length."

"In short, the result of the whole is, that to solve the proposed problem, it would be necessary to have physical data of which we are not yet in possession; that the beam capable of the greatest resistance, that can be cut from the trunk of a tree, is not a square beam; and that in general many researches are to be made respecting the lightening of carpenters' work, which often contains forests of timber in a great part useless."

|| On the 428 page of the above work the same author, Mr. Charles Hutton, in describing a Bridge proposed to be constructed of timber frames or voussoirs, designed by M. Montucla, (See Plate 6, fig. 2 and 7, 166 page of this work,) gives the following relation.

* It appears (said he) from the experiments of Muschenbroeck, and the theory of the resistance of bodies, that a piece of oak 12 inches square, and 5 feet in

length, can sustain in an upright position, without breaking, 264,000 pounds; "hence it follows that a cross band, as AC or EF in the voussoirs on Plate 6, fig. 2, 5 feet in length and 12 inches by 10, can support 220,000 pounds, &c. &c."**

** Here we see exhibited one solid proof, among many others, that might be adduced, that men of theory alone (in general) are wholly inadequate to produce invention in mechanism, much less to decide on the invention of the practical artist, for want of a competent knowledge of the true nature, position, and strength of materials in their work, which is alone to be acquired by practical demonstration. The importance of which they in general are very little sensible of.

Hence we find that the celebrated Montucla, in his above calculations on the strength of the timber in the voussoirs of his new-invented Bridge, which is here repeated by the learned Hutton, makes no difference between the resistance which the end grain of timber furnishes, and that which the side grain supplies, though the strength of the one be to that of the other in this instance as one is to seventy, else he would have discovered that the vertical stiles of the voussoirs passing the end-grain of the horizontal extradosses and intradosses must inevitably be crushed with less than one seventy times the weight that the latter would resist. See AC, DB, and EF, ac, db, and ef, on fig. 2, Plate 6, being a diagram of one of the voussoirs belonging to Montucla's arc of one hundred feet span, fig. 7, on same Plate.

From the whole of the above relation, we gather the following remarks :

* First, It appears that this celebrated writer had nothing to offer in his prolix dissertation on timber, but the account of the experiments which others had made.

† Second, That the said experiments, like the generality of those recorded on this subject, only serve imperfectly to prove what is the strength of the lateral or side-grain of timber, which hundreds of practical men have heretofore demonstrated to a far greater amount.

‡ Third, That the learned writer, when he animadverts on Galileo's principles as to the weakness of the medullary substance in timber, appears to have forgotten the old proverb, which says, that the hand cannot say unto the foot, I have no need of thee ; for it seems that he did not consider that the soft fibres in timber were to the hard ones, in the same tree, as so many blood vessels and air-pipes in the grand system of man, which not only constantly communicate strength, but without which the structure must inevitably fall to decay.

§ Fourth, It is evident that the said philosopher had not attended strictly to the spirit of his problem, which went to shew, that a beam of oblong section would carry more weight than the largest square beam that could be cut out of the same log, though a greater number of its ligneous hoops or cylindric fibres were cut off ; and although the beam would contain less matter ; otherwise he would have known by the same laws that a joist made of a small tree (that he mentions on 394 Page, Vol. 3, Recreations) could not carry the same weight, as the same quantity of matter would in an oblong shape, not only by the laws proposed by Galileo, but by the repeated proofs that practical men have given.

‖ Fifth, We can but lament that the professedly wise men of the present day should so much content themselves with the relation of the opinions and experiments which ancient authors have supplied, without producing a single proof of their own researches and practical demonstrations ; as if these sages had already dried up the fountain of discovery, or that nothing more was needed to be known; especially as the natural resources of such men in general (particularly those who have a few unmeaning letters at the end of their names) are so much more compatible with the subject, as to time and wealth, than the practical artificer, who have fewer means or opportunities to explore causes and effects, except it be in the execution which he is daily called to engage in. But perhaps the reply with these persons will be, that the vast labour and expense attendant on all such experiments, on a large scale, which is the only plan likely to be useful, would far exceed the abilities of individuals, who might otherwise be disposed to investigate this useful branch of mechanical knowledge. And this objection, say they, has been the only cause why so little has been done to determine by experiment this all-important subject.

Admitting the whole of this plea, that the scale which is nearest to full size on which any experiments are made, to be indubitably the most conclusive, and also that such experiments are always attended with considerable expense, likewise readily admitting that there are some of the sterling sons of art (and Mathematicians among the rest) who are not very wealthy ; for it has been proved a mournful truth, that

Artists are seldom born with golden lockets ;
Oft those most rich in skill, most poor in pockets.

Yet, if a sufficient number of these can be found; men who cannot easily sneak from the arduous, though eventually pleasing task, of searching the deep mysteries of Nature and Art; a plan may soon be devised, whereby these plausible excuses may be done away, and the grand object finally accomplished. Here is one:

First, Let the learned Mathematicians in every city cheerfully unite, not only their talents of skill, but also of gold or silver, or even copper, according to their several abilities, to bring about the grand object. And let them be incorporated for the self same purpose.

Second, If this be, or not, sufficient strength, let such company of mathematicians deign to invite also the joint efforts of a suitable number of the most intelligent of their elder brethren, namely, the practical artists and mechanics of the said city. Always granting permission to any that may claim kindred to the scientific family, to come forward and prove their relationship.

Third, Should the exploring the rich mines of causes and effects so happily reward and stimulate these veterans in the cause of science to greater exertions, and more help be yet needed, then, *let this* two-fold band of the invincibles of science, petition the government of the state or country, for such pecuniary aid as they may stand in need of; which government would doubtless readily contribute to the supporting and cherishing of all such laudible exertions that finally must tend to dignify and enrich a nation with many invaluable advantages; especially as the said government would have an opportunity of previously witnessing the persevering endeavours of such persons, who had first set their own shoulders to the wheel, before they cried out to Hercules.

We shall now unfold to the reader the labours of a more industrious class than those first mentioned.

Belidor, in his *Science des Ingenieurs*, gives us the following account of his experiments on the strength of the side grain of timber; by placing weights on the middle of their lengths.

1st Experiment. Three oak bars, each one inch square, by 18 inches long, placed horizontally, with their ends loose. The medium weight that broke them was 406 pounds.

2d - do - Three oak bars of the same size as the former, with their ends firmly fixed, were broken by the medium weight of 608 pounds.

3d - do - Three oak bars, 2 inches broad, by one inch deep, by 18 inches long, with their ends loose, were broken by the medium weight of 805 pounds.

4th - do - Three oak bars, one inch broad, by 2 inches deep, by 18 inches long, with their ends loose, were broken by the medium weight of 1580 pounds.

5th - do - Three oak bars, one inch square, 3 feet long, ends loose, were broken by the medium weight of 187 pounds.

6th - do - Three oak bars, one inch square, 3 feet long, ends firmly fixed, were broken by the medium weight of 283 pounds.

7th - do - Three oak bars, 2 inches square, 3 feet long, ends loose, were broken by the medium weight of 1585 pounds.

8th - do - Three oak bars, one inch and $\frac{2}{3}$ broad by $2\frac{1}{3}$ deep, and 3 feet long, ends loose, were broken by the medium weight of 1660 pounds.

If we compare experiment the first with experiment the third, the strength will appear proportional to the breadth, the length and depth of each piece being the same.

If the first with the fourth, the strength appears as the square of the depth nearly, the breadth and length being the same.

If the first with the fifth, the strength will be seen to be nearly as the length, inversely, the breadth and depth of each piece being the same.

If the fifth with the seventh, the strength will appear to be nearly in proportion to the breadth, multiplied by the square of the depth, the length being the same in both.

If the first with the seventh, the strength is as the square of the depth, multiplied by the breadth, and divided by the length.

Experiments 1st and 2d show the increase of the strength, by fastening the ends, to be in the proportion of 2 to 3. Experiments the 5th and 6th show the same thing.

By the whole of the above experiments, it appears that the rule founded on the Galilean hypothesis, for finding the comparative strength of timber, is nearly true.

M. Buffon and M. du Hamel, also men of acknowledged abilities, were directed by the government of France to make experiments on this important subject; and were supplied with ample funds and every suitable apparatus they could need; they also had the choice of the best subjects in all the forests in France.

The reports of M. Buffon may be found in the Memoirs of the French Academy, for the year 1740, '41, '42, and 1768; and those of M. du Hamel, in his work, *Sur l' Exploitation des Arbres, et sur la Conservation et la Transportation de Bois.*

We shall now give a brief account of M. Buffon's experiments on timber.

First, He shewed that a batten cut out of a tree with the hard fibres or cylindric hoops running through the deepest part, and placed perpendicular to the horizon, would be stronger than a batten of the same size with the hard fibres passing through horizontally or in opposite direction, as 8 is to 7, for the same reason that an assemblage of planks, set edgeways, will be stronger than the same number laid flat and piled on each other.

His next experiment was the trial of the strength of ten pieces of sound oak, 4 inches square, the third day after the said timber was cut down.

The first piece was 7 feet long, 4 by 4, weighed 56 pounds, bore for the space of 22 minutes 5275 pounds, bent 4 inches and 5 parts of a hundred before it broke.

The second piece was the same size as the first, and weighed 60 pounds, bore for 29 minutes 5350 pounds, bent 3 inches and 5 parts of a hundred before it broke.

The third piece was 8 feet long, 4 by 4, weighed 63 pounds, bore for 13 minutes 4500 pounds, bent 4 inches and 7 parts of a hundred before it broke.

The fourth piece was the same size as the third, and weighed 68 pounds, bore for 15 minutes 4600 pounds, bent 3 inches and 75 parts of a hundred before it broke.

The fifth piece was 9 feet long, 4 by 4, weighed 71 pounds, bore for 12 minutes 3950 pounds, bent 5 inches and 5 parts of a hundred before it broke.

The sixth piece was the same size as the fifth, and weighed 77 pounds, bore for 14 minutes 4100 pounds, bent 4 inches and 85 parts of a hundred before it broke.

The seventh piece was 10 feet long, 4 by 4, weighed 82 pounds, bore for 15 minutes 3600 pounds, bent 6 inches and 5 parts of a hundred before it broke.

The eighth piece was the same size as the seventh, weighed 84 pounds, bore for 15 minutes 3625 pounds, bent 5 inches and 83 parts of a hundred before it broke.

The ninth piece was 12 feet long, 4 by 4, weighed 98 pounds, bore 2925 pounds, bent 8 inches before it broke.

The tenth piece was the same size as the ninth, and weighed 100 pounds, bore 3050 pounds, bent 7 inches before it broke.

Each of the first three pairs consisted of two cuts of the same tree; the one found next to the root was always found to be the heaviest, stiffest and strongest; from which M. Buffon recommends a certain and sure rule for estimating the goodness of timber by its weight.

Other experiments were also made by M. Buffon on several pieces of sound oak timber in a green state, of different scantlings, which were as follows:

		Inches.	Practice.	Theory.
The	1st piece	7 ft. long, 5 by 5, bore	11,525 lbs.	11,525
	2d piece	8 ft. long, 5 by 5, bore	9787 lbs.	10,085
	3d piece	9 ft. long, 5 by 5, bore	8308 lbs.	8964
	4th piece	10 ft. long, 5 by 5, bore	7125 lbs.	8068
	5th piece	12 ft. long, 5 by 5, bore	6075 lbs.	6723
	6th piece	14 ft. long, 5 by 5, bore	5300 lbs.	5763
	7th piece	16 ft. long, 5 by 5, bore	4350 lbs.	5042
	8th piece	18 ft. long, 5 by 5, bore	3700 lbs.	4482
	9th piece	20 ft. long, 5 by 5, bore	3225 lbs.	4034
	10th piece	22 ft. long, 5 by 5, bore	2975 lbs.	3667
	12th piece	24 ft. long, 5 by 5, bore	2162 lbs.	3362
	14th piece	28 ft. long, 5 by 5, bore	1775 lbs.	2881
	15th piece	7 ft. long, 6 by 6, bore	18950 lbs.	weight
	16th piece	8 ft. long, 6 by 6, bore	15525 lbs.	weight
	17th piece	9 ft. long, 6 by 6, bore	13150 lbs.	weight
	18th piece	10 ft. long, 6 by 6, bore	11250 lbs.	weight
	19th piece	12 ft. long, 6 by 6, bore	9100 lbs.	weight

			Inches.		Practice.	Theory.
The	20th	piece	14 ft. long,	6 by 6, bore	7475 lbs.	weight
	21st	piece	16 ft. long,	6 by 6, bore	6362 lbs.	weight
	22d	piece	18 ft. long,	6 by 6, bore	5562 lbs.	weight
	23d	piece	20 ft. long,	6 by 6, bore	4950 lbs.	weight
	24th	piece	7 ft. long,	7 by 7, bore	32200 lbs.	weight
	25th	piece	8 ft. long,	7 by 7, bore	26050 lbs.	weight
	26th	piece	9 ft. long,	7 by 7, bore	22350 lbs.	weight
	27th	piece	10 ft. long,	7 by 7, bore	19475 lbs.	weight
	28th	piece	12 ft. long,	7 by 7, bore	16175 lbs.	weight
	29th	piece	14 ft. long,	7 by 7, bore	13225 lbs.	weight
	30th	piece	16 ft. long,	7 by 7, bore	11000 lbs.	weight
	31st	piece	18 ft. long,	7 by 7, bore	9245 lbs.	weight
	32d	piece	20 ft. long,	7 by 7, bore	8375 lbs.	weight
	33d	piece	7 ft. long,	8 by 8, bore	47649 lbs.	weight
	34th	piece	8 ft. long,	8 by 8, bore	39750 lbs.	weight
	35th	piece	9 ft. long,	8 by 8, bore	32800 lbs.	weight
	36th	piece	10 ft. long,	8 by 8, bore	27750 lbs.	weight
	37th	piece	12 ft. long,	8 by 8, bore	23450 lbs.	weight
	38th	piece	14 ft. long,	8 by 8, bore	19775 lbs.	weight
	39th	piece	16 ft. long,	8 by 8, bore	16375 lbs.	weight
	40th	piece	18 ft. long,	8 by 8, bore	13200 lbs.	weight
	41st	piece	20 ft. long,	8 by 8, bore	11487 lbs.	weight.

M. Buffon observes that he found, by numerous experiments, that oak timber lost much of its strength by drying, or seasoning; and therefore, in order to secure uniformity, his trees were all felled in the same season of the year, were squared the day after, and tried on the third day, in their green state.

M. Buffon considers the experiments on the five inch bars as the standard of comparison, having both extended these to a greater length, and having tried more pieces of each length.

From the above experiments some conclusions respecting the laws of the strength of oak timber may be deduced; from which it will be seen that the theory established is by no means accurate.

EXPERIMENTS MADE BY M. DU HAMEL.

He took 16 bars of willow, two feet long and half an inch square, and supported them by props under the ends: he broke them by weights hung on their middle, four of them by weights of 40, 41, 47, and 52 pounds; the mean is 45.

He then cut four of them $\frac{1}{3}$ through, from the upper side, and filled up the cut with a thin piece of harder wood, stuck in very tight: these were broken by weights of 48, 54, 50, and 52, the mean of which is 51.

He cut other four half through from the top; they were broken by 47, 49, 50, and 46, the mean of which is 48.

The remaining four were cut $\frac{2}{3}$ through from the top edge, and their mean strength was 42.

☞ Another set of experiments, still more remarkable, by the same author.

Six bars of willow, 36 inches long, and $1\frac{1}{2}$ square, were broken by 525 pounds, at a medium.

Six bars were cut $\frac{1}{3}$ through, and the cut filled with a wedge of hard wood, struck in with little force; those broke with 551 pounds.

Six bars were cut $\frac{1}{2}$ through, and the cut was filled up in the same manner; they broke with 542 pounds.

Six bars were cut $\frac{3}{4}$ through, and loaded till nearly broken: were unloaded, and the wedge taken out of the cut; a thicker wedge was put in tight, so as to make the bar straight again, by filling up the space left by the compression of the wood: this bar broke with 577 pounds.

ON THE ABSOLUTE STRENGTH OF TIMBER.

The strain which arises by pulling timber in the direction of its length is called TENSION.

The absolute strength of a fibre, or small thread of timber, is the force by which every part of a fibre is held together, which is equal to the force that would be required to pull it asunder; and the force that would be required to tear any number of threads asunder, is proportional to all of them; but the areas of the sections of two pieces of timber composed of fibres of the same kinds are as the number of fibres in each; and therefore the strength of the timber is as the area of the sections.

Hence all prismatic bodies are equally strong; that is, they will not break in one part more than another.

Bodies which have unequal sections will break at their smallest part, if it be between the ends; and therefore, if the absolute strength which would be required to tear a square inch of each kind of timber be ascertained, we may easily determine the strength of any other quantity whatever.

The following table is taken from Muschenbrook's experiments. He has described his method of trial minutely. The woods were all formed into slips fit for his apparatus, and part of the slip was cut away to a parallelopiped form, $\frac{1}{5}$ of an inch square, and therefore the 25th part of a square inch in section; the absolute strength of a square inch was as follows:

	lbs.		lbs.
Locust tree,	20,100	Pomegranate,	9,750
Jujeb, - -	18,500	Lemon, - -	9,250
Oak and Beech,	17,300	Tamarind, -	8,750
Orange, - -	15,500	Fir, - - -	8,330
Alder, - -	13,900	Walnut,* -	8,130
Elm, - -	13,200	Pitch Pine,	7,650
Mulberry, -	12,500	Quince, -	6,750
Willow, - -	12,500	Cypress, -	6,600
Ash,* - -	12,000	Poplar, - -	5,500
Plum, - -	11,800	Cedar, - -	4,880
Elder, - -	10,000	Sycamore, -	4,500

* M. Muschenbroek has given a very minute detail of the experiments on the two timbers Ash and Walnut, stating the weight which will be required to tear asunder slips taken from the four sides of the tree, and on each side in a regular progression, from the centre to the circumference. The numbers of this table corresponding to the two timbers, may therefore be considered as the average of more than fifty trials made on each; and he says, that all the others were made with the same care; therefore there is no reason for not confiding in the results.

PRACTICAL OBSERVATIONS.

The following observations on Woods will be of great use to the practical carpenter, in making a proper choice of timber, according to the purposes he may want to employ it for.

1st, The wood immediately surrounding the pith or heart is the weakest, and its inferiority is so much more remarkable as the tree is older. Muschenbroek's detail of experiments is decidedly in the affirmative.

M. BUFFON, on the other hand, says that his experience has taught him that the heart of a sound tree is the strongest, but he gives no instances; it is certain, from other experiments on large oaks and firs, that the heart is much weaker than the exterior parts.

2d, The wood immediately next to the bark, commonly called white or blea, is also weaker than the rest, and the wood gradually increases in strength as we recede from the heart to the blae.

3d, The wood is stronger in the middle of the height of the trunk than at the springing of the branches, or at the root, and the wood of branches is much weaker than that of the trunk.

4th, The wood on the north side of all trees, which grow in the European climate, is the weakest, and that of the south side is the strongest; and the difference is most remarkable in hedge-row trees, and such as grow singly.

5th, The heart of a tree is never in its centre, but always nearer to the north side, and the annual coats of wood are thinner on that side. In conformity to this it is a general opinion of carpenters, that timber is stronger whose annual plates are thicker. The tracheæ, or air vessels, are weaker than the simple ligneous fibres. These air vessels are the same in diameter and number of rows, in trees of the same species, and they make the visible separation between the annual plates. Therefore, when these are thicker, they contain a greater proportion of the simple ligneous fibres.

6th, All woods are more tenacious while green, and lose very considerably by drying after the tree is felled.

ON THE COMPRESSION OF TIMBER.

In considering strains of this kind, it is absolutely impossible to conceive how a piece of timber, that is perfectly straight, can be bent, crippled, or broken, by any force whatever acting at the extremes. But suppose the smallest force whatever, acting in the middle, or on the side, in a direction perpendicular to the length; this force will be sufficient to give it a small degree of curvature, and if a strong force be supposed to act at the ends at the same time, each pressing the timber in the direction of its length, these forces will greatly contribute towards breaking it.

It is therefore admitted, that if a piece of timber be bent, or if the fibres of that timber are not quite straight, there is a certain force which, if acting at the ends, will break it.

But it is also insisted, that a piece of sound oak timber, of small dimension, placed upright, and steadied on its sides, as in a wall, with a piece of sheet iron on each end, to prevent the perforation of any uneven bodies that may come upon it to divide the fibre, would bear a greater weight than could possibly be piled or built upon it.

The first author who has considered the compression of columns with attention is the celebrated *Euler,* who published, in the Berlin Memoirs for 1757, his Theory on the Strength of Columns. The general proposition established by his theory is, that the strength of prismatic columns is in the direct quadruplicate ratio of their diameters, and the inverse ratio of their lengths. He prosecuted this subject in the Petersburgh Commentaries for 1778, confirming his former theory. *Muschenbroek* has compared the theory with experiment, but the comparison has been very unsatisfactory; the difference from the theory being so enormous as to afford no argument for its justness, neither do they contradict it; for they are so very anomalous as to afford no conclusion or general rule whatever.

EMERSON'S EXPERIMENTS ON TIMBER.

The proportion of the strength of several sorts of wood, that he had proved, will appear in the following table.

Oak, Box, Yew, and Plum,	11	Beech, - - - -	$6\frac{2}{3}$
Ash, Elm, - - - - - -	$8\frac{1}{2}$	Cherry tree, - -	$6\frac{1}{2}$
Walnut, Thorn, - - -	$7\frac{1}{2}$	Willow, - - - -	$6\frac{1}{3}$
Red Fir, Holly, Plane, -	7	Alder, Asp, Birch,	6
Crab tree, Elder, - -	7	Hazle and White Fir.	6

A cylindric rod of good clear Fir of $\frac{1}{4}$ and $\frac{1}{16}$ of an inch square or an inch circumference, drawn in length, will bear at extremity 400lbs.

A Spear of Fir, 2 inches diameter, will bear 7 ton, but not more.

A good hempen rope, of an inch circumference, will bear 1000lbs. weight at extremity.

A piece of sound oak, one inch square, and one yard long, supported at both ends, will bear in the middle 330lbs.

A piece of sound oak, one inch square, and one foot long, supported at both ends, will bear in the middle 1100lbs.

A piece of elm, 1 foot long, and one inch square, will bear 930 pounds.

A piece of Fir, 1 foot long, and one inch square, will bear 770 pounds.

The weight of sound live oak is from 80 to 112 pounds per cubic foot.

The weight of sound white oak is from 52 to 66 pounds the cubic foot.

The weight of pitch pine is from 42 to 54 pounds the cubic foot.

The weight of white pine is from 40 to 48 pounds the cubic foot.

REMARKS ON STONE AND BRICK.

The weight of this first material is as diverse as that of timber, and the strength thereof is to be ascertained thereby, to as great an amount as any other material.

The weight of Marble is from 250 pounds the cubic foot, or 9 feet to the ton; to 140 pounds, or 16 feet to the ton. But the average weight of the best Italian Marble is 12 cubic feet to the ton.

A column of Marble of this specific gravity last mentioned, six feet diameter, would sustain more weight than can be placed upon it.

The weight of mountain Granite, is from 224 pounds the cubic foot, or 10 feet to the ton; to 140 pounds, or 16 feet to the ton. But the average weight of the best Granite is 13 cubic feet to the ton.

A column of Granite of this last specific gravity, 5 feet diameter, would sustain more weight than can be placed upon it.

The weight of Portland, Purbec, and Hannam stone, is found to be from 160 pounds the cubic foot, or 14 feet to the ton, to 112, or 20 feet to the ton. But the average weight of the best sort of these stones is found to be 15 feet to the ton.

A column of Portland, or Hannam stone, of the said specific gravity, 7 feet diameter, would sustain more weight than can be placed upon it.

The best brown Second River Jersey stone (North America) for majestic appearance, (especially in large public buildings) soundness of texture, and consistency of strength, is not to be exceeded by the stone in any other country of the world. Its average weight is from 100 to 140 pounds the cubic foot.

A column of this stone, 7 feet diameter, would carry more weight than can possibly be built upon it.

There are many other sorts of stone which are doubtless not inferior to those we have cited, not only to be found in other countries, but also in the rich mines of the United States, which in years to come, when the professed sons of art are better acquainted with their valuable quality and use, will be disposed of to greater advantage than is witnessed in the present day.

The weight of hard well-burnt brick will be found to be from 114 to 130 pounds the cubic foot.

A column of brick, of the last mentioned weight, well laid in good cement, 9 feet diameter, would sustain more weight than can be built upon it.

REMARKS ON IRON, &c.

GOLD is unalterable by art, and the heaviest of all known bodies; will so expand that a grain may be beaten into a leaf of fifty square inches; and a Gold Wire, one tenth of an inch in diameter, will suspend or support 500 pounds weight, without breaking.

Next to this valuable metal for strength is IRON. This is the hardest, the most elastic, and, except Tin, the lightest of all metals.

An Iron wire, one tenth of an inch in diameter, will carry or support 450 pounds weight, without breaking.

An Iron rod, one quarter and one sixteenth of an inch square, will carry 3 ton, without breaking.

An Iron bar, one inch square, will require a force of 4500 pounds weight to break it, by the arm of a lever of 6 inches.

An Iron bar, 4 inches square, will require a force of 288,000 pounds weight to break it, by the above means.

An inch square bar of the best Swedes iron, 12 inches long, will weigh 3 pounds, 1½ ounces.

An inch round bar of the best Swedes iron, 12 inches long, will weigh 3 pounds.

SILVER is nearly as ductile as gold. A wire of it, one tenth of an inch diameter, will sustain 270 pounds.

COPPER, though an imperfect metal, comes near to silver in point of ductility. A wire as above will support 299 pounds.

TIN is the lightest, least elastic, or sonorous of any metal. A wire as above will support 50 pounds.

LEAD is still softer than tin; a wire as above will only support 29 pounds. But those four last articles have little to do with the materials that are most generally used in building. We shall now pass on to a recapitulation of the experiments here recited, and offer some remarks thereon.

RECAPITULATION.

First, We admit that timber of the same species widely differs in various countries in its growth, strength, texture, and durability, from obvious causes: namely, soil, situation, seasons, and climate. Hence the lighter the soil, the warmer the clime, and the less exposed the situation, the quicker will be the growth of the tree, the softer and more weak the substance, the lighter and less durable the timber. While, on the contrary, the tougher the soil, the cooler the clime, and the more open and exposed the situation, the slower will be the growth of the tree, the more firm and compressed its texture, and the more weighty, strong, and durable, the timber.

Hence the Roman Oracle VITRUVIUS, and his successor PALLADIO, and other practical men in those days, who were well acquainted with these facts, confirmed this opinion, by estimating the Oak's growth, perfection, and decay, in those parts, to be an hundred years for each article. Ah! say some (to whom the words of Alexander Pope will justly apply), we know better than the ancients; for

> We think our fathers fools, so wise we grow;
> Our wiser sons, no doubt, will think us so.

But the author has, in the course of his short experience of thirty-three years in the science of Architecture, abundantly witnessed the timber in many antique buildings corroborating the above estimates to their fullest extent.

Therefore, if we wish to reconcile the great difference existing between the experiments of the celebrated characters first mentioned, the author knows of no other method than to conclude, that when *Duhamel* informs us that an inch bar of oak 3 feet long would carry no more than 131 pounds without breaking, that it must have been of such timber as grew in a very light sandy soil, and, being half smothered with the branches of other trees, it was impossible that the strength thereof could be equal to those in a more open situation.

And as to *Belidor's* experiments on pieces of oak of the same size which bore 56 pounds more each, we must naturally suppose that his timber grew in a more favourable situation to the former.

But when we come to the experiments of an *Emerson*, where he tells us, that a bar of oak 3 feet long, by one inch square, the size of the former, bore 330 pounds, being 201 pounds more than those of *Duhamel* we must indeed believe that his timber grew in a different clime and soil, and was of a far superior texture to either of the former.

But, however, these strange differences, (and many more, the reader may notice) in the ascertaining of the product of the strength of different pieces of timber by the foregoing experiments may be accounted for, the great diversity of opinion that exists between these wise men as to the part of a tree wherein the strongest timber is to be found, as also the clime, appears more irreconcileable than the former, and is not so easily palliated; for there can exist but one conclusion with the man of information and practical experience, which is, that from a small distance from the face of the ground, every foot in the length of the shaft, upwards, decreases in its firmness, strength, and weight; likewise, as one of the authors referred to admits, the branches are inferior to the whole, also, if the tree divides as a fork, both the prongs, or stems thereof, are inferior in strength to what a single shaft would be. But, as to the real strength of timber, much depends on the age of the tree when cut down, the season of the year, and the mode of treatment it receives after it is cut down, in seasoning.

But the first or best plan to preserve the vital strength of the timber is, first, to girdle the tree nearly level with the ground, cut off its head, lop off its branches, strip off its bark, and let it stand, two, four, or six months before it is cut down, and the timber thereof will endure beyond that of the adjoining tree of equal goodness cut down and seasoned any other way. But this last article is somewhat a digression from our main object, though valuable to be known.

It has been asserted by some that the wood immediately surrounding the pith or heart of a tree is the weakest, and there is no doubt of its correctness, but that the timber on the north side of a tree is weaker than that on the south, never was correct, for the most obvious reasons; first, the same number of ligneous fibres, or cylindric hoops, which surround the heart, is to be found on the north side of a tree, as on the south, and as the heart of a tree is never to be found in the centre, but always nearer to the north side, the annual coats of wood must of course be thinner on that side, and as it is a well known axiom, that whether timber or iron, the finer the grain, the stronger and heavier the material; especially in timber, inasmuch as the medullary substance or the marrow between the grain is of less strength than the hard fibres. Second, as it is also an axiom that the quicker the growth of a tree, the sooner will it decay, so also that side of a tree which grows the fastest will be more infirm, and of less durability, as it is alone by the cold blast of wind and tempest that the grain of the knotty oak is compressed and made strong.

THE COMPRESSION OF TIMBER.

This is a subject that has been very little explored by any to the present day, consequently as little understood. The author has abundantly proved to the satisfaction of himself and many others who have witnessed his repeated experiments, that the larger the cube of timber, the greater in proportion will be the extra strength or resistance gained by the tenacity of its end-grain; hence he has found, that if one cubic inch of timber would bear but one ton, four cubic inches united has borne five tons. Other sizes between these have also corroborated the same increase of strength in proportion; and according to the above experiments he has a right to conclude, that a single cubic foot of sound oak will, by the same rule, support on its end-grain 180 tons at the least, though *Muschenbroek* in his experiments gives us only 118 and 147 tons to a log 12 inches square; but his experiments, he informs us, was with logs from 5 to 10 feet long, unsteadied or unsupported on the sides, by which the reader will see the cause of the deficiency.*

THE TENSION OF TIMBER.

By the extensive and minute detail of the experiments of *Muschenbroek*, the reader will discover that timber, as to its tension, and also compression, is not that weak and watery substance, so easily affected, as the blind theorists of our time would have them believe. Hence we find, that it will take a force of 20,100 pounds to tear asunder a bar of locust one inch square, and 17,300 pounds weight to accomplish the same operation on an inch bar of oak.

Therefore, by these two grand objects being ascertained, namely, the extent of the Tension and Compression of timber, the reader is put into the possession of the most simple and true means, whereby he may proceed to ascertain for himself the practicability of a tim-

* All the timber in the author's bridge, which is called to bear weight is not only steadied but wholly surrounded and supported on every side, which is an incontrovertible reason why it should carry triple the weight that Muschenbroek's experiments proved.

ber Bridge on the author's plan, to any extent; without the assistance of any of the *Sir Isaac Newtons* of the present day.

Only a few questions will be needed to decide the fact. First, What is the absolute weight of the arm of a half Bridge, 100 feet in length, on this plan of invention?

Answer. 476 thousand 700 pounds, reckoning the oak timber to weigh 60 pounds the cubic foot, and the pine 44.

Second, What is the amount of pressure produced on the fulcrum by the above gravity, when multiplied by its own proportional distance therefrom?

Answer. 14 millions, 885 thousand, 996 pounds.

Third, What number of end-grain superficial feet of timber will be required in each rib, at the fulcrum, to support the last-mentioned weight, according to the laws that *Muschenbroek's* experiments establish?

Answer. The smallest weight that *Muschenbroek's* experiments furnish for a log of 12 inches square to support on its end-grain is 264,000 pounds. According to this calculation, the whole of the above weight of the two ribs would be supported on the superficies of $56\frac{1}{2}$ feet; consequently, each rib, at the part next the fulcrum, must possess $28\frac{1}{4}$ feet, which is not above half what each rib will furnish.

Fourth, What does the inherent strength or force of the arm of this Bridge consist of, whereby it is rendered capable of supporting its own gravity and effectually resisting the strain thereof?

Answer, A sufficient quantity of the absolute strength of the length-grain of timber, to resist its strain or tension, and also a sufficient superficies of end-grain, to support its weight, and resist compression.

Fifth, How is this furnished?

Answer, The deck or floor of Bridge, with the cap-plates, and string-pieces, will furnish alone, at the least, at the abutment, 1944 square inches of timber. We shall, therefore, by the same author as before referred to (as his experiments are doubtless the most conclusive,) be guided in our calculations.

Muschenbroek informs us that a single bar of oak, one inch square, will take 17 thousand 300 pounds weight to tear it asunder by Tension. Then of course we conclude that it will also require 33 million, 631 thousand, 200 pounds, to tear asunder 1944 inches by the same rule; which is more than double the whole amount of the multiplied weight of the projecting arm of the half Bridge from the fulcrum, or the power of this lever of a hundred feet.

Also the superficies of the end-grain timber of the archivolt-rails, and the lower needles, are more than triple the quantity required to resist the compression of the under or lower part of the said arm, by the laws of the strength of timber thus ascertained.

There are also many other means of strength existing in the construction of the author's Bridge, the whole of which are multiplied at pleasure, to the requirements of an arm of any magnitude.

Finally, As to the unerring principles on which this invention is founded, whilst on the one hand they have attracted the respectful attention and admiration of men of liberal science and sound judgment; on the other hand they have by their simplicity and importance confounded the skill and excited the rage of many a book-theorist of high rank amongst us, who could not suppose that this invention was true, otherwise they alone, by their wisdom, must have found it out; from which the author is led to conclude, that

Some are bewildered in the maze of schools,
And some made Doctors Nature meant but fools;
In search of wit these lose their common sense,
And then turn critics in their own defence.

Alexander Pope.

TESTIMONY

Of the Shipwrights of New-York, on the Examination of the Grand Model* of T. Pope's Patent Bridge.

TO THE PUBLIC.

We whose names are hereunto affixed, having maturely examined the Grand Model of Mr. Thomas Pope's Patent Bridge with a single arc, on the principles of the lever, pursuant to a meeting called for that purpose, deem it a duty we owe, not only to the skill of the inventor, but the Public at large, to bear the following impartial testimony of its true merits.

First, We are convinced that a formation of Timber according to the inventor's plan, furnishes more strength for its intended purpose than any other we heretofore have known.

Second, We have no hesitation in asserting, as our joint opinion, that the strength thus furnished is more than equal to all that can be needed.

Third, We are satisfied that by this invention a Bridge may be built to any rational extent.

Fourth, It is our opinion that such Bridges are in every sense of the word preferable to all others of tim-

* The above Model was built to illustrate a Bridge suitable to span the East River at New-York, with a single arc, the chord of which would be 1800 feet, the Altitude or versed sine 223 feet, the abutments were built in the form of so many warehouses, and the whole was erected by a scale of 3-8 of an inch to one foot; the length of Model of half Bridge, in real measure, is nearly fifty feet. The weight that the unsupported arm of this diminutive Model bore at one time, since finished, has been ten tons; and which has astonished the mind of every beholder.

ber heretofore invented, on account of their superior strength, durability, and chaste preservation of navigation.

SIGNED,

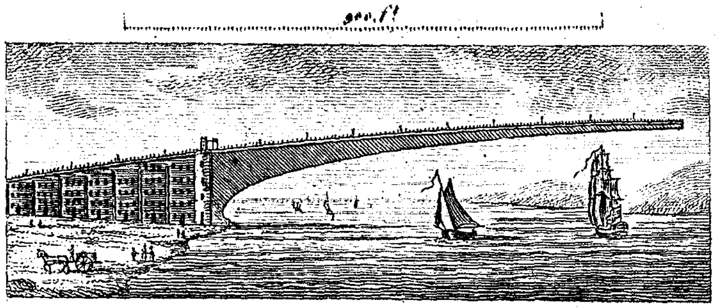
Forman Cheesman,	Jonathan Gorham,
Christian Bergh,	Francis Gantz,
Henry Eckford,	Jacob Weaver,
Adam Brown,	John Aikman,
Noah Brown,	William Millen,
Geo. James,	Joseph Webb,
Joseph White,	Amos Cheney,
William Ball,	Elisha Blossom,

Samuel Thorne.

The above Testimony was published three times in each of the following public papers of New-York, viz. the Evening Post, the Citizen, and the Mercantile Advertiser.

CHAIN BAR ARC.

The author's patent chain bar arc is of important, though simple construction. The various modes of placing the iron links in the internal part, whereby the perpendicular weight is sustained without producing the least lateral pressure, will be found to be of curious invention. Fig. 14, Plate 3, describes an arc of this kind 11 feet wide, and one of the modes adopted in placing the chain and the bars by which the arc is held together. The internal bands which are let into each stone, that not only carries the weight but also prevents the stone from bursting by pressure, are of various forms. This arc will be of great importance, where spacious porticoes, and openings, are required to heavy buildings.



Like half a Rainbow rising on yon shore
While its twin partner spans the semi o'er
And makes a perfect whole that need not part
Till time has furnish'd us a nobler art.

CONCLUSION.

LET the broad arc the spacious HUDSON stride,
And span COLUMBIA'S rivers far more wide;
Convince the world AMERICA begins
To foster Arts, the ancient work of kings.
Stupendous plan! which none before e'er found,
That half an arc should stand upon the ground,
Without support while building, or a rest;
This caus'd the theorist's rage and sceptic's jest.
Like half a rainbow rising on one shore,
While its twin partner spans the semi o'er,
And makes a perfect whole, that need not part,
Till time has furnish'd us a nobler art.
  The muse with humble flight will now unfold
The myst'ries of a work that ne'er was told;
Delineate the plan by simple rules,
That those who can't believe may prove they're fools.
One single arc, whate'er the span may be,
Of river, lake, or swamp, or arm of sea,
Is all it needs, so wond'rous is it plann'd,
To form a spacious Bridge from land to land.
The towering poles of navies in full sail
May pass this arc in e'er so brisk a gale,
And ships at anchor ride beneath the arm,
Or moor to shelter'd wharf, secure from harm.
Thus navigation chastely is preserved,
And sons of commerce lose not their reward.

The butment's built of stone, where stone is found,
For nought can last so long or keep so sound;
But if the place should timber only grant,
Then stone and iron the builder will not want.
The length of butment's not, as men have told,
So long to cut a city in two-fold;
For rivers North and East may have a Bridge,
And streets call'd South and West may bound their ridge.
If half the arc a thousand feet demand,
One hundred is enough upon the land,
To form the butment and the steelyard's prop,
Which balances the power, lest it should drop.
This butment must more gravity possess
Than flying arm by weight can furnish stress;
Consolidation of a mass of stone,
Or towers erect, like those which China own;
But best when butments form a group of stores,
To house the treasure brought from distant shores:
The rent they furnish pays the building's cost,
Which in all other Bridges must be lost.
The stones that first compose the fulcrum's base
Are large and massy, but of even face,
Well bonded by their square and equal form,
So closely plac'd to leave no room for worm,
Or spurious matter of a worthless kind,
That oft is fill'd, in walls, in hopes to bind
The unconnected parts, which ne'er did rest;
These make but cobweb-structures at the best.

The mortar all is ground within a mill;
The only labour is the hods to fill;
One horse and boy for twenty men provide
With cement better made, more cheap beside.
The arms of Bridge are built of stone or wood,
But iron, cast, would furnish twice the good;
Its extra beauty and its lesser weight
Confound the pride and ignorance of the *great*.
Combining levers stretch from shore to shore,
And span the foaming flood ne'er span'd before;
By logs of timber plac'd at angles right
The bold formation is made strong and tight;
Each semi arc is built from off the top,
Without the help of scaffold, pier, or prop;
By skids and cranes each part is lower'd down,
And on the timber's end-grain rests so sound,
That all the force of weight can ne'er divide
Each tabled timber from its partner's side:
And, lest the end-grain should not stand the test,
A sheet of iron 's plac'd between each rest,
That no compression or indention can
Make an impression to defeat the plan.
  The usual mode of building house or ships,
Of framing Bridges, tables, purlins, hips,
'Tis end to side-grain by the ancients plann'd,
On which their ponderous loads were made to stand;
And all the Bridges that were ever built
Repos'd their weight on ceintre, pier, or stilt.

Not so the Bridge the author has to boast ;
His plan is sure to save such needless cost ;
A ladder on each side is lower'd down,
And shifted from the fulcrum to the crown ;
Two men on each descend to drive the bolts,
Wedge fast the trunnels or set taught the nuts,
Or line with boards the parabolic form,
Expos'd to weather and the furious storm.
The lateral shape of Bridge resists the wind,
By concave circle throws its force behind ;
The butment on each shore receives the charge,
Repels with weight the pressure by, and large.
If shores supply with rock to build upon,
The builder then hath an advantage won,
By which he saves the cost that oft ensues
In sinking coffers, caissons, or mud pews.
But should some softer strata heave in sight,
The consequences will be truly light,
As nothing is more easy to provide
Than concave circle on the under side,
By which the pressure will combine to force
The neighbouring infirm strata much more close ;
Its watery particles must soon escape,
And force the solid grains into a heap,
By which the massy butment rests secure,
And through its firm foundation must endure.
Not so the tottering piles of ancient day ;
When prest by weight they quickly slide away,

Wreck, from the centre to the structure's base,
And all its bond and beauty soon deface.
When Time, with hungry teeth, has wrought decay,
Then what will sceptics be dispos'd to say ?
Why, " down the Bridge must fall, without repair,
" And all the author's pleadings will be air."
Not so, he's better arm'd than you expect,
For nought can bring to ruin but neglect ;
A mean 's provided, which can never fail,
To keep up strength whate'er the Bridge may ail :
Each log of wood, where'er its station be,
Is safely shifted for a sounder tree,
With greater ease remov'd than heretofore
A piece could be repair'd in an old floor.
For lasting age this Bridge will far exceed
All others ever built ; they rot with speed.
' But how to reconcile these novel truths
' With what the *Doctors* teach their college youths
' Is hard for us (say some) to understand,
' How timber Bridges can fly off the land,
' Without a prop or scaffold from the strand,
' And meet to join in centre hand in hand,
' Is truly strange and marvellous to me,
' And, till I see it, never can it be !"
Yes, teachers many have their pupils taught
That nothing strange or new can e'er be brought,
But what in ancient times were known or wrought,
So narrow and so mean their scanty thought.

But, base that works of art should judged be
By fools in skill, who have no eyes to see;
Who ne'er by arduous thought, or stretch of mind,
Trac'd causes old, some new effects to find;
Whose stupid life to man was ne'er of good,
Except it were to eat another's food;
And numerous is this tribe, that gain a name,
But not by works of skill, deserving Fame.
Yet, science has her sons in every age,
Her babes of skill, her striplings, and the sage,
And daughters too, on which her hand bestows
Sublime discernments, that no stranger knows;
Though bastards oft intrude and steal the bread
With which the sons of merit should be fed,
Array themselves in ep'lettes, swords and gowns,
And strut about like showmen's drest-up hounds;
And if you ask them a new work to view,
'Oh, sir! say they, it never can be true;
'Besides, I have no time to spare, to look
'At schemes like these; they 're not within my book.
But science owns not such a gaudy train,
Who can on sons of genius pour disdain,
Nor *quack philosophers*, who durst decide
On works of merit they have never tried,
Nor half-taught theorists, of whatever name,
Who seek by others' skill to gather fame;
Nor wanton sceptics, who can dare condemn
More worthy works than ever fell to them.

Methinks the sons of art would be too blest
Were there not men like these to prove their pest.
What! though this Bridge surpass all else before,
Should it be disbelieved e'er the more,
What finite man, to whom all skill was given,
That none beside should read the starry heav'n,
Or find a plan by which to pass the deep,
While blockheads and their follies rest in sleep;
Descry a continent, find out a land,
Mark out a shoal, make known where lies quicksand,
Or trace the magnet which to poles directs,
And, with the quadrant, all mistake corrects;
Or cast great guns, whose thunders loudly roar,
Or make silk cars, philosophers to soar,
Or Drake's dread fireships, that no quarters give,
But blast in sunder all, that none survive
To tell the dismal tale of dire despair,
That ship, and guns, and men, are blown in air;
Or excavate the earth, to float a bark,
To carry goods through rocks and mountains dark,
Propel a boat by steam, 'gainst wind and tides,
That in a calm by others swiftly slides;
That travels night and day, like a stage coach,
Which at the usual time make its approach:
Or make sweet sounds to soothe some savage breast,
Or link such words as poets deem the best,
Or carve some marble that shall stamp renown,
Or paint some golden scene that fame shall crown,

Or build this flying Bridge, the author's boast,
Or thousand other schemes now gone and past,
Or thousand things to come, that none e'er knew,
As time rolls on, invention shall prove true :
If these were all design'd for one man's work,
The other sons of art in caves might lurk,
And mourn their useless state, as lost to fame,
Compell'd to live and die without a name.
ARCHIMEDES foretold the lever's power,
How he could with a pole upset a tower,
Or raise the globe, if fulcrum were but strong,
Sufficient for to rest his lever on.
The author's Bridge shall surely rise to fame,
In spite of envy's efforts, power, or claim,
And men of liberal science own its worth,
Respect his name and cultivate its growth.

T. POPE.