Historic Structures

significant structures of the past

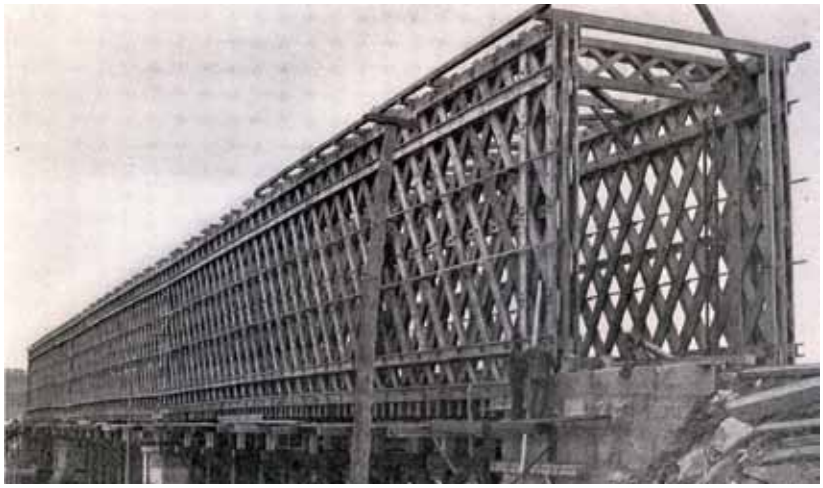

Figure 1: Timber Town Truss under construction. Boston and Maine Railroad. (Merriman & Jacoby, Roofs and Bridges.)

This two part article examines the mid-to-late nineteenth century development of a uniquely American lattice truss railroad bridge configuration.

Part 1 traces the origins of the American lattice truss iron bridge beginning with early European designs. It continues with the morphing of the American wooden lattice girder into an iron truss, documenting the contributions of the engineers of the New York Central Railroad that led to the development of the Hilton riveted wrought-iron lattice truss bridge configuration. Part 2 will examine the engineering logic of a variety of lattice variations, and tell the story of the maturing of the metal lattice and its dissemination across the American landscape.

Lattice Configurations

Development of the American Metal Lattice Truss Bridge and the Hilton Truss

By David Guise

David Guise retired after 40 years of private practice as principal of his architectural firm and is Professor Emeritus at City College of New York. He can be reached at ***davidguise@myfairpoint.net****.*

American architect Ithiel Town's all-timber lattice truss, first patented in 1820, became a successful, commonly used configuration for covered bridges. The timber lattice is composed of two oppositely sloped, dense layers of diagonal planks contained between two parallel chords. Although the Americans called it a truss, Europeans generally referred to it as a lattice or trellis girder (*Figure 1*).

Therefore, it was logical that when iron, and eventually steel, became economically viable that the lattice concept would be built of metal. The iron lattice, developed as a modest span railroad bridge more than three decades later than Town's patent, had much thinner and more widely spaced diagonals *Figure 2*).

The metal lattice truss had an early start in England. The British *Institution of Civil Engineers* credits Sir John MacNeill as, "the engineer who introduced iron lattice bridges into the United Kingdom." In 1845, construction was completed on his 140 foot span lattice bridge over the Royal Canal at Dublin for the Dublin & Drogheda Railway. MacNeill's best known lattice bridge was a dramatic 264-foot clear span Boyne viaduct completed in 1855.

There were several paper proposals prior to MacNeill's bridges, including a patent obtained by George Smart in 1822 for a lattice configuration that was never built. Smart called his lattice a "bridge chain" (*Figure 3*).

The 1884 Supplement to the *Encyclopaedia Britannica* credits John Stuart with obtaining a patent for a lattice truss in 1824; however, a search of the British Patent Office documents could not locate any patent issued to a John Stuart.

Initially, European (*Figure 4*) and American metal lattice trusses were simply iron adaptations of the timber lattice configuration. Early nineteenth century engineers did not have the ability to analyze a lattice configuration. However, the diagonals of the timber Town lattice were wide, and spaced close enough together so that the resulting structure could rationally be calculated as if it were a solid girder.

Just how aware the American engineering community was of early British and European use of metal lattice trusses is a matter of speculation. In 1845, Nathan Rider designed a metal lattice truss that incorporated a series of vertical members. Despite the drawing's title, this often cited configuration was never patented (*Figure 5*). (*Bridge literature often refers to all trusses having sets of*

Figure 2: Typical Metal Lattice Railroad Bridge. Over the Coon River, Lake City, Iowa. (Author's post card collection.)

crossing diagonals as lattice trusses, whether or not there are additional verticals. The author suggests that the term lattice truss might best be reserved for configurations that do not contain vertical web members.)

Patented or not, bridges were built using Rider's combination of a multi-intersecting Town truss lattice pattern with a series of closely spaced verticals (*Figure 6*).

Rider did obtain a patent for a truss; patent 4,287 issued on November 26, 1845. However, it was for a Pratt (compression verticals and tensile diagonals) configuration in which all the panels contained crossed diagonals. It is the only patent Issued to Nathan Rider.

The New York Central Railroad was the incubator for the American metal lattice truss, and for the use of wrought-iron for all the members of a truss (rather than a combination of wrought- iron for tensile members and cast-iron for compression members) as well as the birthplace for riveted connections. Howard Carroll, a Graduate of Dublin University, apprenticed under MacNeill in Ireland and is generally credited with introducing the use of riveted connections for truss construction in America, as well as designing the first American all-wrought-iron riveted trusses while a member of the engineering staff of the New York Central Railroad. Carroll's first wrought-iron riveted bridge was a ten span crossing of the Mohawk River built in 1859. As can be seen in the photograph (*Figure 7*), the truss configuration is that of a double intersecting Howe (a Howe has vertical tension members and compression diagonals). Although no documentation has been found to substantiate the claim that all of the truss members are indeed wrought-iron, it is highly likely since all the joints were riveted.

George Thomson provided a sketch of Carroll's "lattice" design for an article in the *ASCE Transactions* of 1897. Although Thomson labeled the sketch a "through lattice," it is a quadruple-intersecting Whipple truss that creates a lattice pattern over the center portion of the span (*Figure 8*). A 126.5-foot long bridge with this configuration was built in 1861 over Tonawanda Creek, in Batavia, New York. All the diagonals are tensile members and all the vertical are compression members. (*Harold Carroll, a Colonel in the Union Army, was killed in action in 1862 at Antietam at the age of 35, sadly shorting his engineering career.*)

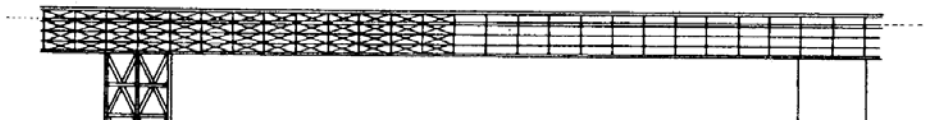

Figure 3: Smart's 1822 Lattice Truss Proposal. (British Patent #4,688.)

*Figure 4: Kew Bridge over the Thames. London and South Western Railway (Courtesy of **lupen.org**.)*

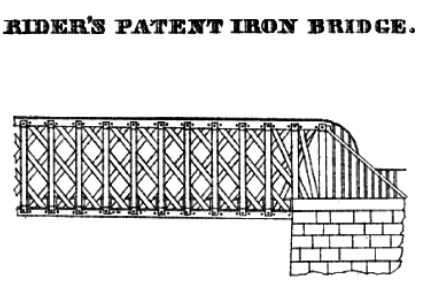

Figure 5: Drawing from Hermann Haupt's. General Theory of Bridge Construction, 1863 plate 8.

Figure 6: Pittsburgh, Fort Wayne & Chicago Railway. Rider's lattice configuration, wrought-iron truss. Built in 1868 over the Allegheny River near Pittsburgh, Pennsylvania. (Courtesy, Pittsburgh History and Landmarks Foundation.)

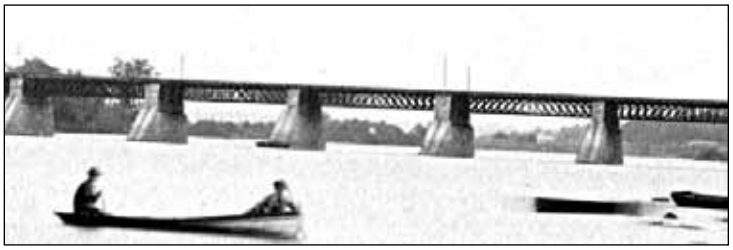

Figure 7: Carroll's 1859 Bridge over the Mohawk River between Schenectady and Scotia, New York. (Courtesy of Schenectady Historical Society. Provided by Katherine Chansky.)

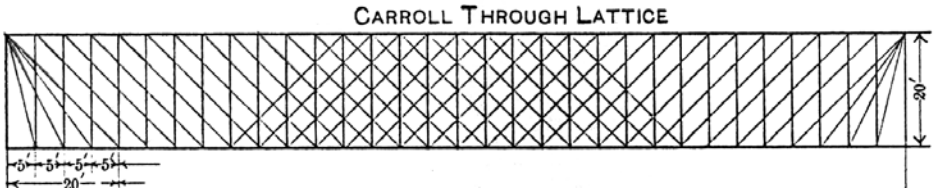

Figure 8: Thomson's drawing of Carroll's Through Lattice Truss. (ASCE Transactions, 1897.)

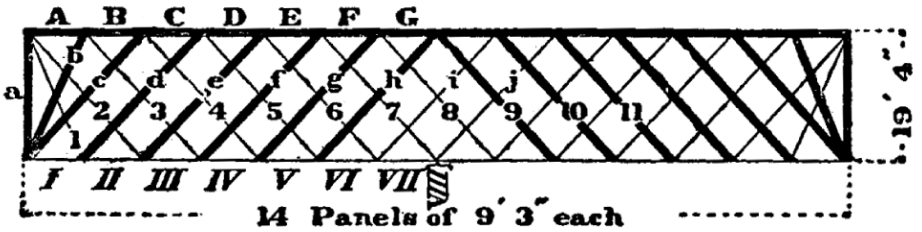

Figure 9: Hilton's Vertical-end Through Truss over the Erie Canal at Canastota, New York in 1864. (Report of the Board of Railroad Commissioners of the State of New York, 1891.)

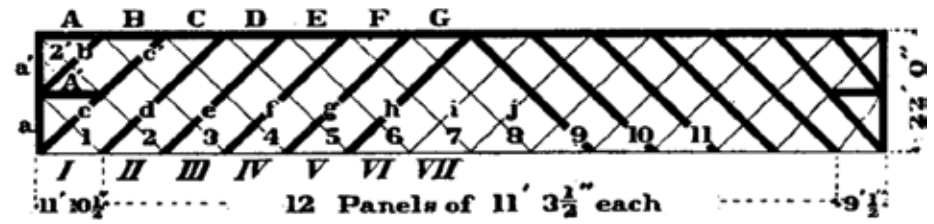

Figure 10: Diagram of a vertical-end lattice through-truss with a horizontal strut at end. Built over the Erie Canal in 1872 at Newark, New York. (Report of the Board of Railroad Commissioners of the State of New York, 1891.)

References

The Institution of Civil Engineers, Selected and Abstracted Papers, Vol LXXIII, p.365. London 1883.

MacNeill's first lattice bridge was an 84-foot span footbridge over the Dublin and Drogheda Railway at Raheny near Dublin. J. G. James, *The Evolution of Iron Bridge Trusses to 1850*, p.17.

The viaduct over the Boyne River estuary was built between 1851 and 1855 by the Dublin and Belfast Railway linking the Dublin and Drogheda Railway with the Ulster Railway. R. Cox and M. Gould, *Ireland*, p.75.

Thomson in *Discussion*, Gray's *Notes on Early Practice in Bridge Building*. Transactions, ASCE, June 1897.

A diagram of Carroll's Mohawk River crossing, along with a table showing the size of all its members, is contained in the *Report of the New York State Railroad Commissioners of the State of New York*, 1891. pp.857-860

George Thomson served as chief engineer for the New York Central Railroad for a period of 21 years. *Memoir of George Thomson*, Syracuse Chapter ASCE, 1910. Thus he had full access to their records.

A diagram of the Tonawanda Creek bridge, along with a table showing the size of all its members, is contained in the *Report of the New York State Railroad Commissioners of the State of New York*, 1891. pp.989-991

Charles Hilton, initially Carroll's assistant in the New York Central's engineering office, developed a solution that eliminated the verticals and provided a lattice texture over the entire span. In the Hilton configuration, one set of diagonals slope downward towards the center of the span and are tension members, and the second set of diagonals are compression members which slop downward towards the abutments. The first bridge believed to be built to Hilton's design is the 129.5-foot long, 1864 crossing of the Erie Canal at Canastota, New York (*Figure 9*).

A slightly later variation of Hilton's vertical-end lattice incorporated a mid-height horizontal member at each end that was capable of handling tension as well as compression stresses (*Figure10*).

Ultimately, the sloped-end through-truss version of the Hilton Lattice became the most commonly built American lattice configuration; as engineers realized that it saved material (*Figure 11*).

Curiously, no American patent appears to have been issued for a metal lattice truss configuration. (*Friedrich Schmemann's 1873 patent (#171,323) application contained an elevation of a metal, triple intersecting lattice truss that had some additional diagonals near its mid-span, however, the patent claim was for a method of constructing the chords of a truss with metal tubes, not for the configuration shown in the patent application. Figure 12*) If an eponymous name is ever bestowed on the American quadruple-intersecting metal lattice truss, Hilton's would be most appropriate.▪

Figure 11: Thomson's schematic drawing of a Typical Hilton Lattice Truss. (ASCE Transactions, 1897.)

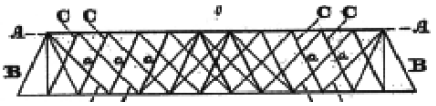

Figure 12.

Acknowledgments

John Hooper at the Boston Public Library provided invaluable help in locating British documents. Cliff McCarthy, historian at the Springfield Museum, located the documentation on the 1877 Springfield, MA lattice truss over the Connecticut River. Katherine Chansky, librarian at the Schenectady County Historical Society located the photograph of, and found information on the 1859 double-intersecting Howe truss crossing of the Mohawk River at Schenectady, NY. James Stewart help track down numerous lattice truss photos to help verify their wide spread use, and along with Dario Gasparini, Saul Brody and James Cooper made constructive suggestions that helped to improve the final manuscript. My thanks to Nikki Alger, Rob Fullmer and Mark Holmberg for their help in guiding the manuscript through the editorial process.