HISTORIC STRUCTURES

significant structures of the past

Isaiah Rogers

Tubular Bridges and Boston's Mechanics' Fairs

By David Guise

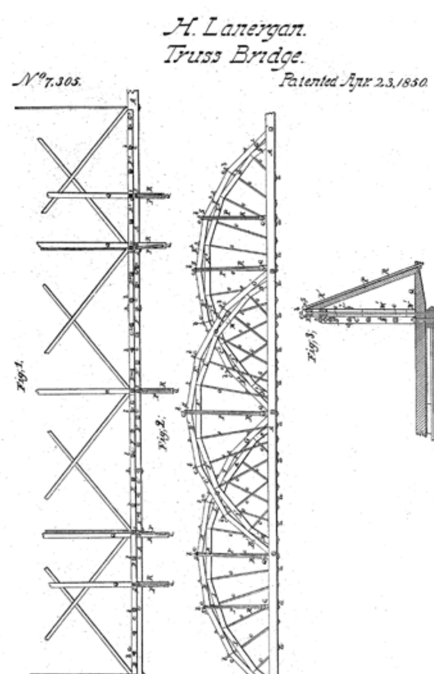
Between September 20th and October 2nd of 1841, an estimated eighty thousand people visited the *Third Charitable Mechanic Association Exhibition* held in Boston's Faneuil Hall and Quincy Market. They crowded the halls, admired the exhibits, and walked through Isaiah Rogers' amazing 70-foot span, ten-foot diameter tubular bridge of intersecting helixes that connected the second floors of the two buildings. The bridge, one of the highlights of the exhibit, was widely acclaimed and awarded a gold medal.

Later that year, Rogers obtained a patent for his unique invention. In 1850, as architect for the Burnet House Hotel in Cincinnati, he used this same configuration to build a bridge across the hotel's open courtyard.

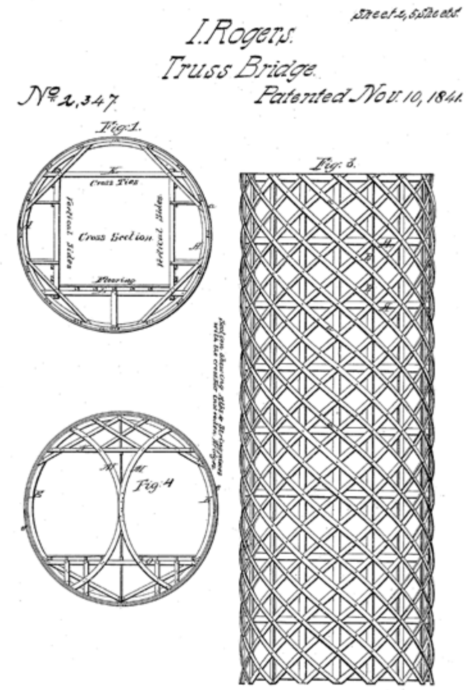
No documentation has come to light that anyone other than Isaiah Rogers ventured to build a bridge of this design. While intriguing to look at, it would be extremely difficult to construct, and its complexity rendered it beyond the capability of any contemporary engineer to calculate the sizes of its various members in relation to a specific span and load.

Rogers' bridge took its place in the Fair's ongoing tradition, started in 1837, of erecting, and then dismantling after the fair closed, a unique temporary bridge to connect the two exhibit buildings.

The Sixth Charitable Mechanic Association Fair, held in 1850, featured a most unusual, irrational, bridge configuration as the connection between



Henry Lanergan's 1850 patent drawing; Library of Congress Patent Office.



Isaiah Roger's 1841 patent drawing; Library of Congress Patent Office.

Faneuil Hall and Quincy Market. It was designed by Henry Lanergan, who had patented his invention earlier that year. No document has come to light indicating that either Lanergan, or anyone else, ever built another bridge to this design.

Given the occasion, Rogers and Lanergan seized the opportunity presented to them, and turned their ideas into realities. Contemporary builders trusted the simpler proven configurations available to them at the time, and saw no advantage in emulating either Rogers' or Lanergan's trusses as both were costly and difficult to construct. Thus, the only known examples of these two designs are the ones their inventors built.

As part of the Fourth Mechanics' Fair, held in 1844, a father and son team introduced their now well-known *Pratt truss* design to bridge the space between the two Fair structures. The engineering logic and simplicity of constructing a Pratt truss was recognized at once, and later, in its more efficient steel form, it became the most commonly used mid-span truss configuration in America.

Wrought-Iron Tubular Bridges

The underlying concept of building a tubular bridge is inherently rational, although the form proved to be economically unfeasible. More straightforward examples with simpler configurations than intersecting helixes would be built. Suspension bridges had proved to be too flexible to carry trains, and iron tubes seemed to present an answer in that they would deflect less and be more resistant to horizontal wind loads. Their excessive weight and cost ultimately made them

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1850 Britannia wrought-iron tubular bridge over the Menai Straight. Courtesy of Los Angeles County Museum of Art.

Berkeley Wise's 1902 Gobbins Path Bridge.

non-competitive compared to steel trusses. Perhaps the best known tubular iron crossing is the railroad bridge completed in 1850 over the Menai Straits in western England. It was a rectangular wrought-iron tube built by Robert Stephenson, son of the locomotive engineer George Stephenson. Trains traveled inside the tube, as did the pedestrians in Rogers' cylindrical tube.

The two center spans of the Britannia Bridge are each 460 feet long, with the two end spans 230 feet each. The overall length of the crossing, including the entry towers, is 1,511 feet. Although to the naked eye the tubes appear to have a constant cross section, the overall height of the tubes gradually increases from 22 feet 9 inches at the abutments to 30 feet at the mid-river tower. The tube sections are all riveted together forming one continuous hollow girder from abutment to abutment. The maximum bending moment for a continuous beam is at the mid-span support, and is the engineering reason for a deeper tube at that point.

The lack of ventilation in solid tube railroad bridges made the journey through them extremely unpleasant, as the soot from the locomotives had no outlet other than at the ends of the tube. There are stories of gentlemen taking clean shirts with them in order to change after passing through the Menai tubular bridge.

Many articles credit Great Britain as the birthplace of the Tubular Bridge and the 400-foot span Conway Bridge, also built by Stephenson and completed in1848, as the first example. However, Rogers' 1841 tubular bridge preceded it by seven years, and the Menai Bridge by nine.

Neither Stephenson, nor his contemporaries, could accurately calculate the load capacity of their tubes. They initially thought the tube would be excessively deflected by the coal hauling trains and had designed iron suspension chains to help support it. In the process of trial and error testing of the tube for deflection, they realized that the suspension chains were not necessary. However, the towers from which the chains were to be hung had already been built, which explains their strange presence.

Built as part of Canada's Grand Trunk Railroad, the1859 *Victoria Bridge* over the Saint Lawrence River was the most important tubular bridge in the Western Hemisphere, and acclaimed by some at that time as the 8th wonder of the world. The overall bridge length between abutments is 6,600 feet. All of its parts were made in England and riveted together at the construction site. There are twenty four, 242-foot spans, and a main ship channel span of 330 feet. Trusses would ultimately prove to be far more economical than tubes. When the bridge was upgraded in 1897-8 to accommodate vehicle traffic in addition to carrying trains, the tubes were replaced by trusses.

20th and 21st Century Examples of Pedestrian Tubular Bridges

Perhaps the most dramatic tubular bridge is an elliptical one built by Berkeley Wise in 1902 as part of Gobbins Path, a terrifying ocean-edge tourist walk in Ireland. Traversing through it had to be a thrilling experience. Structurally, it has much in common with a Pratt truss; it is a tubular bridge more by shape, than by engineering design.

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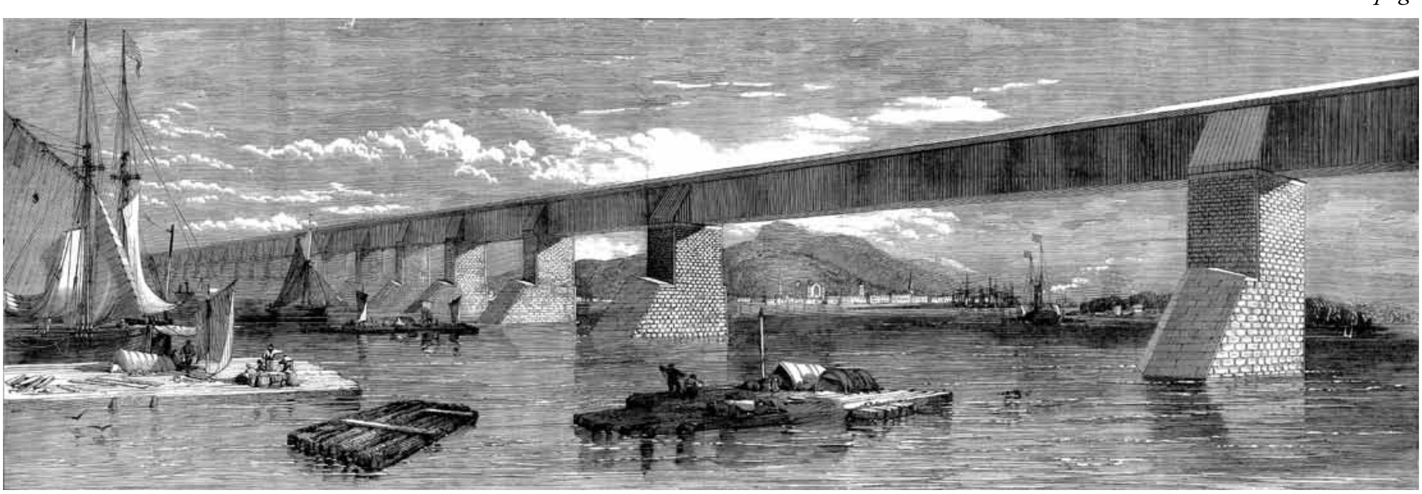

Original Victoria Bridge over the Saint Lawrence River, completed in 1859. Illustrated London News, Feb. 19, 1859.

In 2010, Bernard Tschumi, an architect best known for the "follies" he designed for a Paris park in the 1980s, collaborated with Hugh Dutton to design a cylindrical tubular truss that is visually reminiscent of the timber one Rogers erected 169 years earlier for Boston's Mechanics' Fair. This steel, 115-foot 6-inch clear span bridge solved the problem of providing daylight in a tubular design. It provides pedestrian access over the railroad tracks at the La Roche-sur-Yon train station in France.

Bridges are an indispensable part of our environment. Building them will always be an evolving undertaking. In engineering parlance, the "best" design for a given situation is usually taken to mean the one that can carry the required live load (people, vehicles, trains) across a given distance using the least amount of material. However, engineering knowledge, availability of materials, and the skill levels of workmen are ever changing commodities. Tschumi's bridge was no more "practical" than Rogers'. Lanergan's was almost silly. It is a shame we no longer have those wonderful fairs that permitted inventors to display their ideas. Tschumi's and Wise's examples have taught us that impractical can still be frivolous fun, that there are a few circumstances where "practical" need not always be the highest criteria. Apparently there is an innate fascination with the concept of a bridge one moves through, rather than over.

Tubular bridges constitute a small side-bar in the long history of bridge building. They ultimately turned out to be an inefficient design. The story of their evolution and demise as vehicle and/or railroad bridges provides an example of the engineering community's willingness to try new forms when the current ones fail, to recognize changing requirements, to adopt the use of new materials, and to abandon old ideas.

Tschumi-Dutton's 2010 steel upgrade of Rogers' 1841 timber design. Courtesy of Bernard Tschumi architects, Christian Richters, photographer.

Acknowledgements

If Sara Wermiel had not passed on an inquiry as to whether anyone had ever built a tubular bridge to Isaiah Rogers' patent, this article would never have been written. Henry Scannell at Boston's Public Library located newspaper articles verifying the construction of Rogers' Boston and Cincinnati bridges. James Stewart, Frank Griggs and Sara Wermiel read early drafts and helped to improve the manuscript.▪

References

[1] Report of the Third Exhibition of the Massachusetts Charitable Mechanic Association, September 20, 1841: p.4

[2] Report of the Third Exhibition of the Massachusetts Charitable Mechanic Association, September 20, 1841: p.27

[3] *Daily Ohio Statesman*: October 19, 1850: page 3

[4] Report of the First Exhibition and Fair of the Massachusetts Charitable Mechanic Association, September 13, 1837: p10

[5] The connecting bridge at the Second Exhibition of the Massachusetts Charitable Mechanic Fair held in1839 was designed by William Washburn, who was also the General Superintendent of the fair.

[6] The Town, Burr and Howe truss designs were the most commonly used truss configurations in that time period.

[7] Report of the Fourth Exhibition of the Massachusetts Charitable Mechanic Association, September 18, 1844: p 21. (The Mechanic's Fairs were usually held every three years.)

[8] William Fairbairn and Eaton Hodgkinson provided advice during the conceptual stage.

[9] The importance of this bridge was such that Edward, Prince of Wales, sailed from England to officiate at its opening. Construction took 6 years 1854-1859. James Hodges was the construction engineer.