The National Bridge and Iron Works and the Original Parker Truss

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In Memory of William D. Smith, 1937–97, who appreciated the old bridges and was so generous in sharing his enthusiasm and knowledge

The National Bridge and Iron Works, which existed less than a decade, built two distinctive types of bridges during that brief period. The first, scarcely mentioned in bridge histories, grew from patents for timber bridges and was adapted for iron, demonstrating that "improving" a straight-forward design can change it from useful to complicated and irrational. The second type, the Parker truss, is a strong contrast. Today, the outline of this truss preserves Parker's name, but the connections that were the claims of the patent were used only by the company. Other fabricators used conventional riveted or pinned connections. Five pairs of Parker trusses survive. They have been measured and the connection details inspected. The company's history show how easy it was to become a bridge builder and how short was the lifespan of many such firms.[1]

Introduction

The 1840s saw the introduction of trusses using iron—the Howe and Pratt timber truss with iron tension rods, and Whipple's all-iron bowstring and trapezoidal trusses. The business expansion that began in the middle of the decade provided a market for the new trusses and encouraged others to enter the bridge-building field, some with new and often peculiar designs, but this was ended by the Civil War. Interest resumed after the end of the war as shown by the number of patents issued for bridges: 8 in 1865, 15 in 1866, and 16 in 1867.[2]

In what is probably the first American book on bridges, Thomas Pope traced the cantilever's history and proposed using that structural system for spans of 200 to 2,400 feet.[3] The cantilever offered a means of assembling bridges without falsework, essential in building over deep valleys or fast flowing rivers. National Bridge and its short-lived predecessor, the Solid Lever Bridge Company, started by building bridges that combined cantilevers with common trusses, an idea that seemed to offer advantages. The idea was used briefly until practical difficulties and engineering questions led Charles Parker, engineer for National Bridge, to develop the truss style that bears his name. The five surviving pairs of trusses provide examples of the design and the fabrication methods of 1870. They also show that when engineers are closely associated with the fabrication and erection of their projects, they can make small changes that improve or strengthen the design. Two examples of this are shown.

Company Background and History[4]

The first of the four patents that led to the company's initial contract was issued to Albert Cottrell. He was a builder of timber Howe and lattice bridges, living in Newport, Rhode Island, when he received patent 2,334 on November 10, 1841 (see figure 1). It resembled Pope's 1807 patent for constructing a timber bridge by cantilevering, but Cottrell proposed using a truss and doing all the assembly from one side of the river. When the far side was reached, that end would be weighed down to produce a camber. The increased depth over the piers indicates that Cottrell realized that the counterweights produced a critical load at those points. He is reported to have erected a lattice truss in Maryland by the cantilever method. He also tried to bridge the rapids at Saint John, New Brunswick, but stopped after cantilevering lattice trusses 100 feet from each shore, leaving a 300-foot gap.

Cottrell was still in Newport when he received patent 43,099 on June 14, 1864, which described a "counterbalanced bridge" whose cantilevered timbers met in midspan (see figure 2). There, they would be joined and could be reinforced by adding timbers along the sides which would strengthen the bridge and serve as parapets. The design was weak because each cantilevered timber was interrupted by cross timbers. While the timbers above and below would to

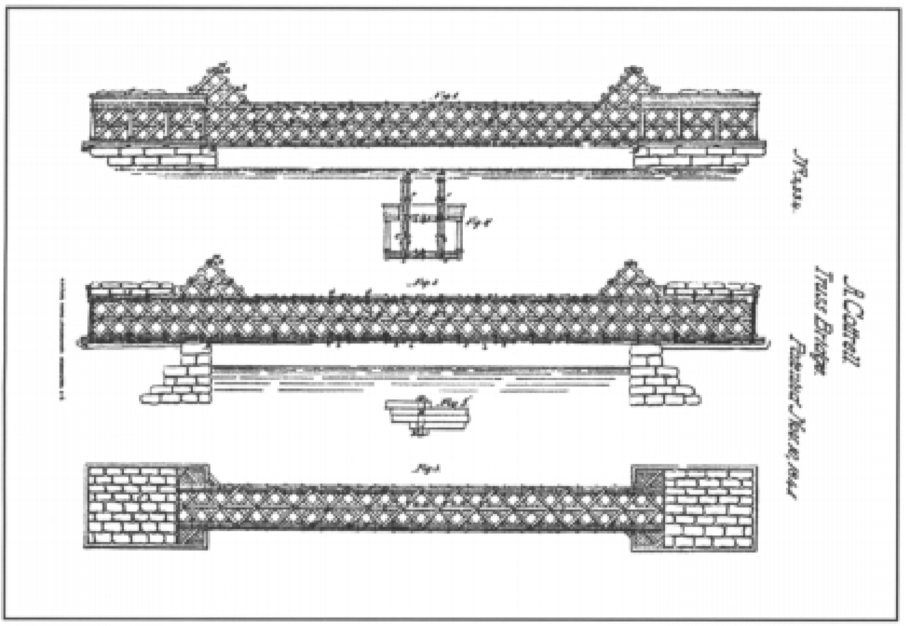


Figure 1. *Patent no. 2,334 awarded to Albert Cottrell in 1841. Supposedly he built such a bridge in Maryland and began one in Saint John, New Brunswick, but stopped with 300 feet of the 500-foot crossing remaining to be erected.* United States Patent Office.

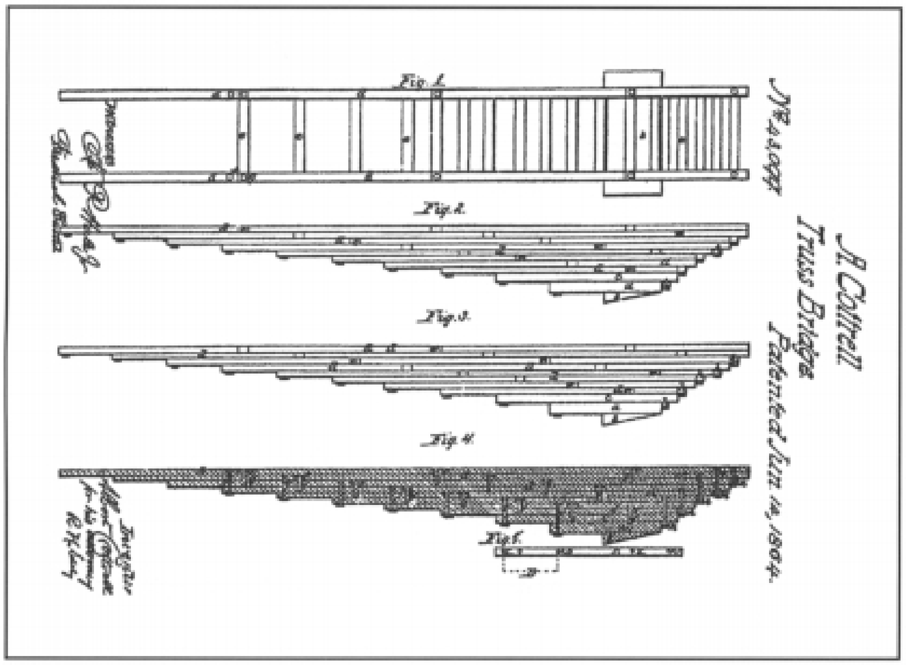


Figure 2. *A later patent, no. 43,099, awarded to Cottrell in 1864. It is not known if any bridges were built to this design.* United States Patent Office.

some extent act as splices, the whole assembly's strength was greatly reduced. The cross ties were important, but a less disruptive method would have been much better.

Cottrell went to Boston about 1867 or 1868 and met Levi Liscom when both were employed at the Chickering Piano factory. Earlier, Liscom had built timber bridges in Vermont and New Hampshire. Probably influenced by Cottrell, for he received no other patent, he applied for a patent and received no. 76,212 on March 31, 1868 (see figure 3). It was more practical than Cottell's second one, for the cross members were attached to the projecting timbers instead of interrupting them. The principal difference was adding a timber bowstring truss to the top of the cantilevers with its bottom chord being the top timber of the cantilever. The truss and cantilevers were tied together by

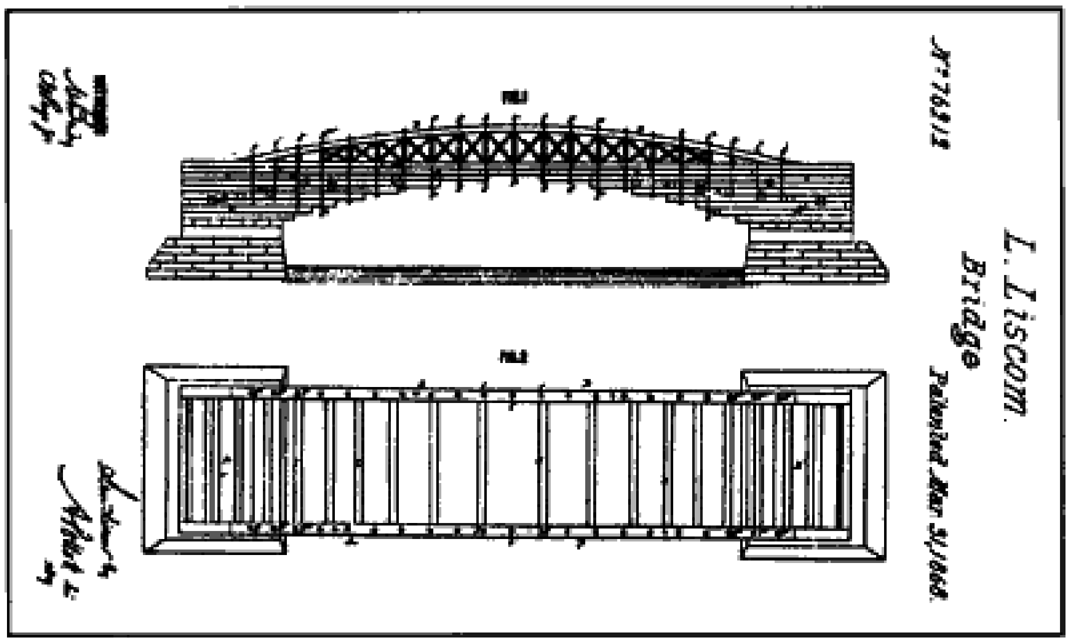


Figure 3. *Levi Liscom's adaptation of Cottrell's second patent received no. 76,212 in 1868. It appears to have been the basis for the design used for the High Street Bridge in Boston.* United States Patent Office.

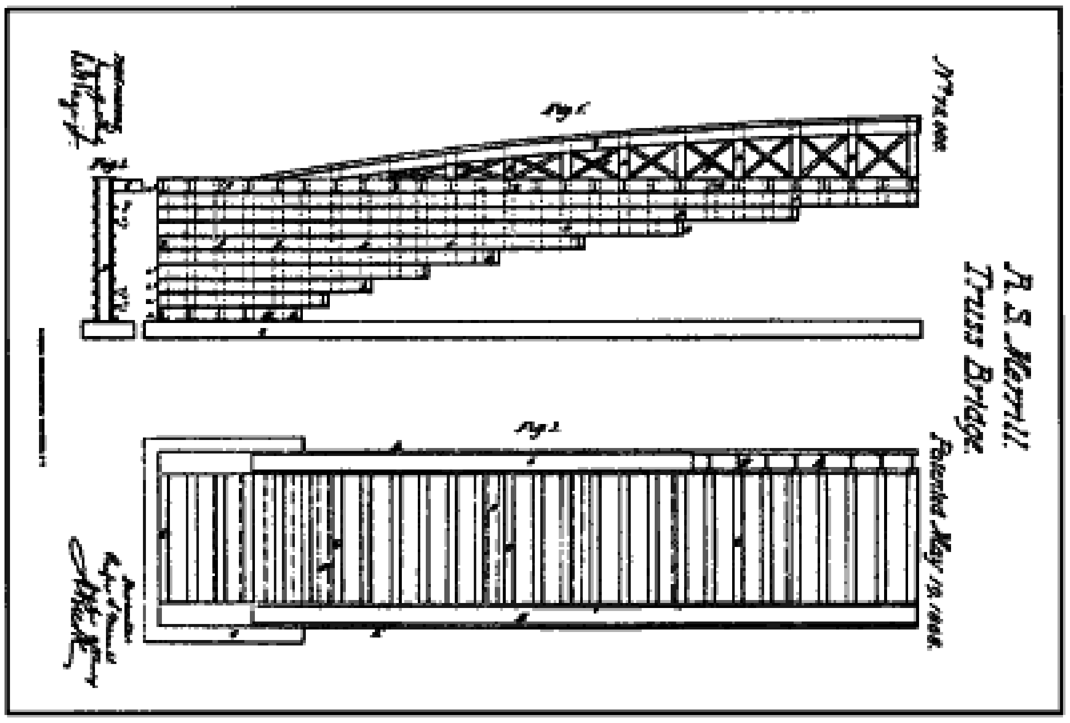


Figure 4. *Rufus S. Merrill's all-iron version of Liscom's design received patent no 78,000 six weeks later.* United States Patent Office.

long vertical iron tie-rods that were located at each truss web vertical web member. The two different structural systems, cantilevers and truss, would act together because of the ties, but Liscom seems to have regarded the truss as assisting the cantilevers and without any independent load-carrying value.

Less than six weeks later, Rufus Spaulding Merrill of Boston received patent no. 78,000 on May 19, 1868, which covered an all-iron version of Liscom's structure (see figure 4). The cantilever timbers on each side were replaced by stacks of channel sections, each made of vertical plate with single angles top and bottom. The stacks were stiffened by vertical beams made of plate and angles, and alternate verticals projected above the topmost cantilever to form the webs of the superimposed iron truss.

Three of the patents, excluding Cottrell's first one, were tied together. Liscom referred to Cottrell's second patent, and then Merrill made reference to both. Another name appeared in the last two patents, William Lincoln of Brookline, Massachusetts, an assignee with Liscom and Merrill.

These paper ideas became realities when the Solid Lever Bridge Company was incorporated in Massachusetts July 6, 1868. Its first contract was received from the Boston

Figure 5. *The first bridge built 1868 by the Solid Lever Bridge Company. It carried High Street over Oliver Street as Fort Hill was being cut down.* Courtesy of the Bostonian Society/Old State House neg. 1434.

Street Department for a bridge to carry High Street over Oliver Street, which had been lowered as part of the cutting down of Fort Hill (see figure 5). Both Merrill and Lincoln were identified with the new company in an 1868 city directory. Sometime before April 1, 1869, the name was changed to the National Bridge and Iron Works with Blodgett and Curry, proprietors. Probably the first company had underestimated the costs or lacked capital for increased business. Merrill was listed with the new company for only that year, but Lincoln had disappeared.[5] Both of the new owners were in the metal trades—William A. Blodgett with Blodgett and White Iron and Steel, and Cadwallader Curry's firm was The Metallic Compression Casting Co., both of Boston. The first office of National Bridge was located at Curry's company.

The company, under one name or the other, built two or three bridges and then received a crucial order for five iron railroad bridges on a railroad between Bangor, Maine, and St. John, New Brunswick.[6] The Merrill patent was used (iron superstructure with the cantilever made of channels) and material was ordered from England, probably because of the railroad's Canadian ownership. Wisely, the company realized that it needed an engineer to design the bridges, which included one span of 154 feet. It hired Charles H. Parker, a mechanical engineer without any experience with bridges, who took Merrill's concept, changed each cantilever portion from a stack of channels to a truss, and produced the required structures.

The company issued a pamphlet in the middle of 1869 (see figure 6) that included drawings of various trusses, including the combined cantilever and common truss, and a list of prices per linear foot of highway and railroad spans up to 150 feet.[7] The design live loads were a moving load of 10 tons for highway spans and one ton per linear foot for those carrying railroads. The company did not limit itself to bridges, for it proposed to fabricate turntables, draw-

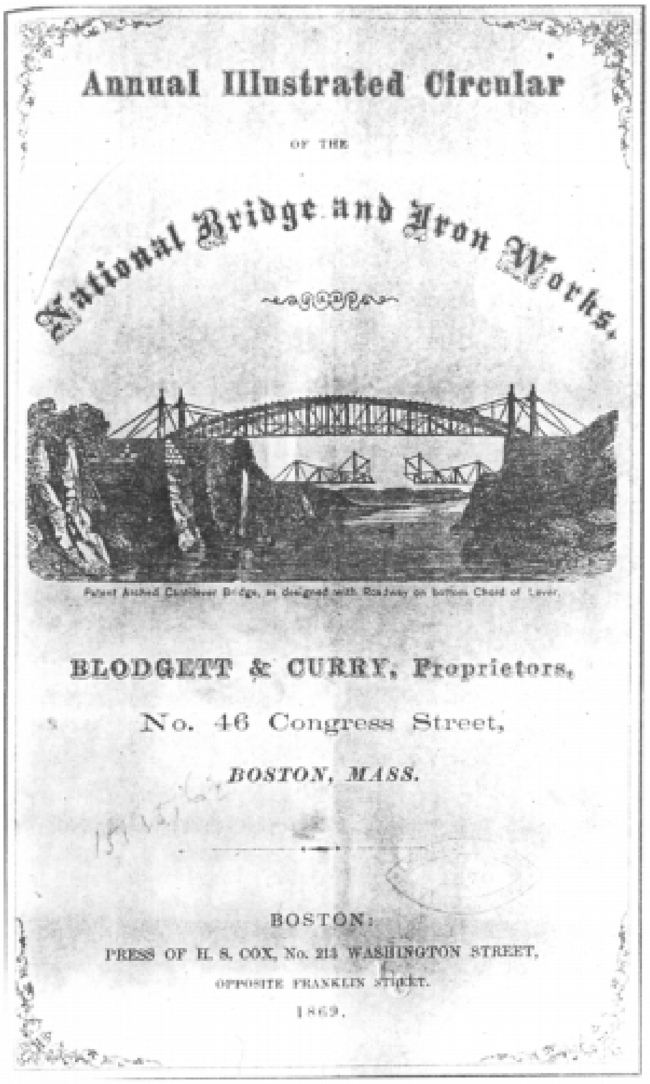


Figure 6. *The cover of the* Annual Illustrated Circular. *Only the bridge over the South Branch of the Oromocto River was built with the cantilevers above the roadway.* Collection Library of Congress by way of Robert M. Vogel.

bridges, roof trusses, and other items for buildings. It claimed the ability to construct foundations under difficult soil conditions, probably based on the cantilever construction—very heady claims for a company less than a year old that had fewer than 10 bridges.

By 1873 Parker had replaced Blodgett as coproprietor. Boston City directories for 1874 showed that Carey B. Dopp of New York City had replaced Curry and the business was listed as C. H. Parker & Co., doing business as National Bridge and Iron Works. By 1874 it had a shop of about 15,000 square feet at McKay's Wharf, Border Street, in East Boston. The shop was probably purpose-built as it did not show on an 1867 insurance map. The rapid growth of the company is shown in an advertisement that appeared shortly before its demise:

> Our experience in this city [includes] the large Iron Depots for the Boston, Lowell and Nashua R.R. and the Boston and Providence R.R.,[8] together with the entire iron work for the roof pavilions and upper stories of the new Post Office and Sub-Treasury Building . . . Numerous Railroad bridges of a great variety of models for the Boston and Albany, Boston and Providence, Eastern, Boston, Barre and Gardner, Nashua, Acton and Boston, Central Vermont, European and North American Railroads, &c., &c., &c.[9]

In 1876 the company failed, probably one of the many dragged down by the long depression that started in 1873. David H. Andrews, employed by National as an engineer from c. 1869 to 1874, purchased the machinery and tools, moved them, and started the company that became the Boston Bridge Works.[10] Parker moved to Pittsburgh where he was general manager for the Fort Pit Bridge and Boiler Works from 1876 to 1884. He returned to the Boston area and to mechanical engineering, then died in 1897.

The Pre-Parker Bridges

The company's first bridge, which carried High Street over Oliver Street in Boston, was based on Liscom's patent, but the vertical iron rods connecting the truss and the cantilevers seem to have been omitted (see figure 5). The cantilevers, built of 12-×-3-inch-spruce deals laid flat and pinned by wooden treenails, met at midspan. Framed cross beams were loaded with stones for counterweights. Although A. W. Parker stated that the arched member was made of the same material as the cantilevers and implied that the balance of the superstructure was wood, those members seem so thin in the photo that they might have been iron. The lattice web sections were separate units as shown by the discontinuity at the verticals. The bridge collapsed when the ground under the counterweights crumbled, but would have been removed in the course of the earth-moving project.[11]

There is no information concerning the bridges at Bristol, Connecticut, and near Worcester, Massachusetts, which were the next contracts. These were followed by the iron bridge over the Assabet River in West Concord, Massachusetts, that had trusses for the cantilevers, Charles Parker's revision to the Liscom design. This span was near a mill and carried heavy wagons, 14 tons according to a letter, but

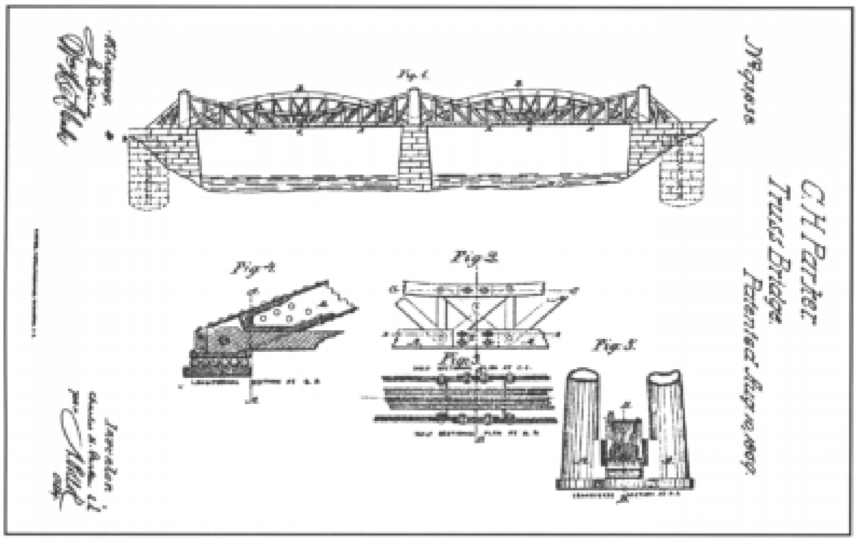


Figure 7. *Patent no. 93,638 awarded to Charles H. Parker, August 10, 1869. The profile is similar to the cover of the circular, and both bridges over the Oromocto may have used some of the patent's features.* United States Patent Office.

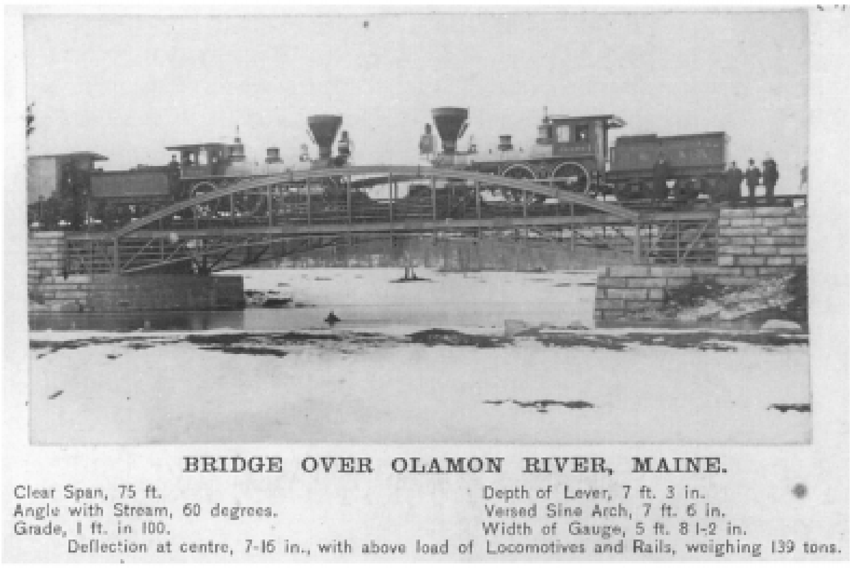


Figure 8. *The Olamon River Bridge, Maine, for the European and North American Railroad, carried trains until replaced in 1886.* Courtesy of HAER Collection Library of Congress, VT3-7, 803128.

the bridge lasted until 1899 when it was replaced so a trolley line could be put through.[12]

Part of the pamphlet described patent no. 93,638 awarded to Parker on August 10, 1869, which went a step beyond Merrill's patent (see figure 7). Once again the bridge consisted of a truss and cantilevers over the roadway. This time they did not work together to carry the entire load. Instead the cantilevers carried all the weight of the structure, including the trusses, and the trusses acting alone carried the live or, as Parker called it, the "useful" load. The patent wording is unclear, and the present writer cannot grasp how the two linked systems can deflect independently as the live load is added. Despite the puzzle, some of the railroad bridges may have followed the design, although the bridges may not have acted in accordance with the design assumptions.

The first of the railway bridges was a 50-foot span over Costigan Brook near Bangor, Maine. It was the only bridge of this contract to have solid cantilevers made of either built-up or rolled channels. Erected in late 1868, the bridge was replaced in 1883. The Olamon, Maine, bridge was 75 feet long and served from 1869 until 1886 when it was replaced instead of modified (see figure 8). In Canada, the cantilevers were above the bridge for the 100-foot span

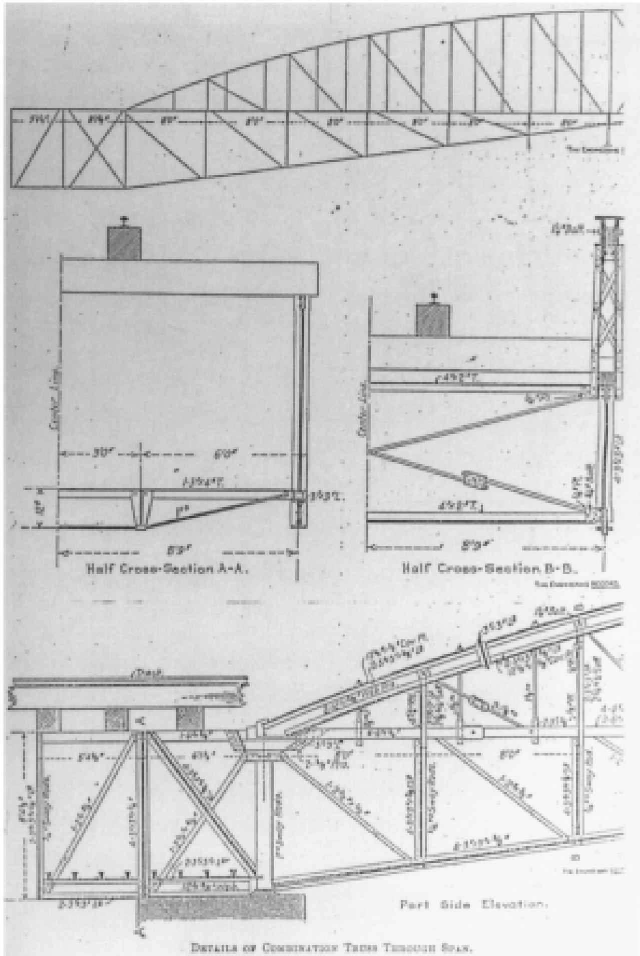


Figure 9. *The bridge over the Magaguadavic from sketches made by Job Abbott and found after his death. He had been chief engineer for the Wrought Iron Bridge Co. and two others in Canada. The member sizes appear in no other place. The arrangement of the bowstring truss's diagonal members makes no sense, but Abbott had long worked with bridges and must have drawn what he observed.* *Engineering Record* 44 (27 July 1901): 79.

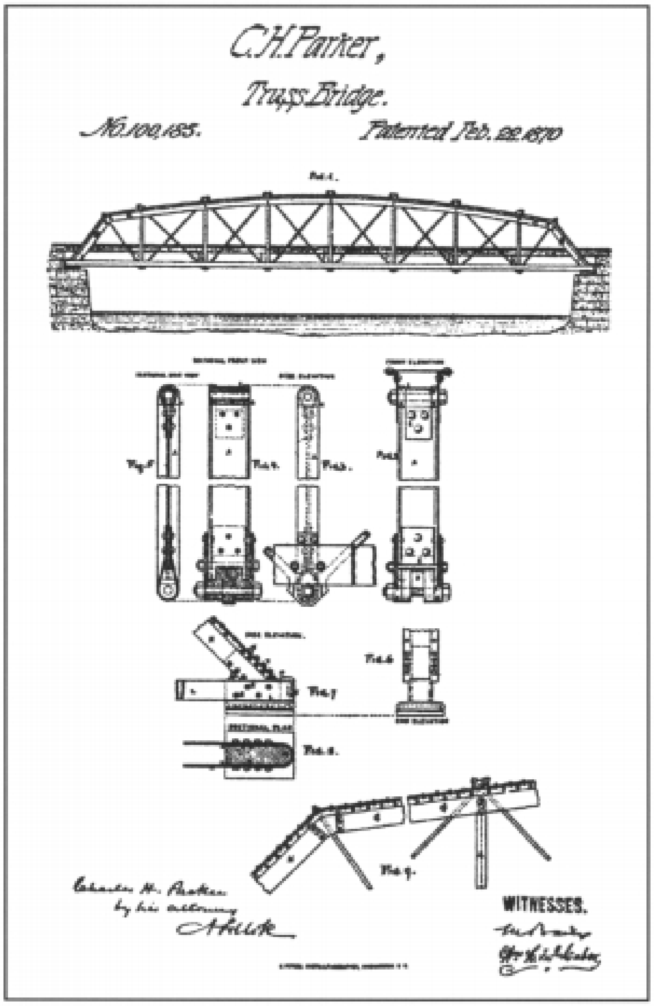


Figure 10. *Patent no. 100,185 granted to Charles H. Parker Feb. 22, 1870, shows the truss profile now linked to his name. The connections to the top chord were used on all the survivors, but the heavy trusses have a different detail at the bottom chord.* United States Patent Office.

over the South Branch of the Oromocto River, while the 154-foot span over the North Branch of that river had them below the roadway. Both failed December 1885 under trains while they were being repaired.[13] Perhaps they were rebuilt, but this is very doubtful. The last bridge was a 104-foot span over the Maguagadavic River (see figure 9). The two over the Oromocto were the only ones to have separate chords for the cantilever and the truss, perhaps an indication that these followed Parker's patent no. 93,638.[14] The use of the cantilever as falsework in erecting a truss is logical if the site is difficult—a deep ravine (such as Oliver Street, Boston), soft ground that could not support falsework, or rapids in the river. Falsework is used only where necessary because it is expensive, and only Oliver Street appears to have been such a site. Falsework for New England bridges was often built during low water in the summer or placed on the ice in the winter.

The Parker Truss

The claims of Parker's second bridge patent, no. 100,185, awarded February 2, 1870, were clearly described and the drawing was well presented (see figure 10). Three improvements were claimed. First, minor changes in bridge lengths could be accommodated by changing the slope of the inclined end post or extending to top chord behind the first

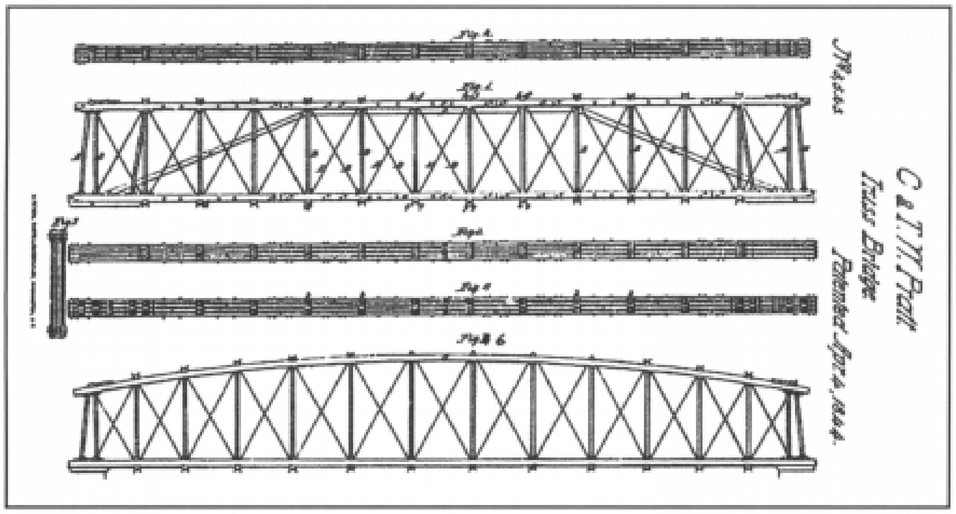


Figure 11. *Patent no. 3,523 awarded to Caleb and Thomas W. Pratt in 1844 shows an earlier use of the curved top chord. The patent's claims related to features for controlling the camber of the truss. The Parker truss did not include any feature described by the Pratts.* United States Patent Office.

vertical web member. Second, the design of the top and bottom connections of the web posts to the chords was new. And third, the casting at the bottom of the end post simplified the connection joining the top and bottom chords. The use of cast iron and the simple connections probably came from Parker's experience as a mechanical engineer.

The truss profile had advantages over both the bowstring and parallel chord patterns. The web system of a bowstring carried little or no load when the load was uniform, but the concentrated loads from heavy vehicles were very punishing as they neared the ends where the web diagonals were the flattest. In parallel chord bridges, the chord load is maximum at the center. If the same material is used for the full length, much of it is wasted near the ends. The curved top chord could not be claimed as a feature, for it was in common use. An early appearance was in patent 3,523 issued April 4, 1844, to Thomas W. and Caleb Pratt, but even they did not claim it as a feature (see figure 11). None of the patented features of the Pratt had any bearing on the Parker truss. The trusses built by Parker to his new design are easily identified, first by the profile and then by the patented connection details that had not been used elsewhere. Only five Parker-patent truss bridges still exist or, more properly, one bridge and four sets of Parker trusses, for the latter are without the original floor systems. Dimensions and relevant data are given Table I.[15]

The Northfield, Vermont, trusses were built for the Vermont Central railroad in 1870.[16] The exact location is not known, but the oft-used photograph was taken by R. M. McIntosh, a Northfield photographer (see figure 12). At some unknown date, but before 1907, it was converted to a roadway bridge and carried Vine Street over the railroad tracks. About 1990, the trusses were overhauled and carried a sidewalk next to the new Vine Street bridge (see figure 13).[17]

The other four bridges were built to carry roadways. The bridge at Woodstock, Vermont, was built early in 1870 to carry Elm Street over the Ottauquechee River. This may be the earliest Parker truss, for the contract was signed about November 1, 1869, before the patent was granted.[18] Double-intersection Warren trusses were later placed under the trusses, and the whole structure was replaced about 1990 with the Parker trusses becoming decorations, mounted on the sides of the new bridge to preserve a village landmark (see figure 14).

The other three are all in Massachusetts. Fitchburg's Lower Rollstone Street was ordered about August 1, 1870, and erected in the fall. It was partially bypassed from 1909 to 1910 in a railroad-grade-crossing removal project and abandoned in 1980 (see figure 15).[19] In Lawrence, the privately owned bridge of unknown date (but probably 1870) crosses the North Canal to the Lower Pacific Mill. The bridge is now carried by steel beams and timbers supported by the canal walls and bents in the canal (see figure 16).[20] At Webster, the 1871 North Village Bridge has been rehabilitated and moved to a park where it carries a walkway. The bridge offered a unique opportunity for study while the trusses were lying on dunnage in a field and while it was partially disassembled in a shop. A feature of this bridge is the difference in length of the trusses, for one is four feet shorter than the other so that the old abutments could be used (see figure 17).[21]

Table I

1	2	3	4	5	6	7	8	9	10
Woodstock	1870	110' *	11' 0"	20' †	210'	9	10' 0"	12/12	6-inch I
Fitchburg	1870	110'	11' 9"	28' 2"	230'	9	9' 6"	12/12	8-inch I
Northfield	1870	103'	10' 0"	--- ‡	230'	9	9' 6"	9/12	9-inch I
Lawrence	?	88' *	11' 2"	22' 2"	185'	8	9' 0"	12/12	6-inch I
Webster	1871	--- §	8' 10"	13' 0"	120'	7	7' 3"	5/12	6-inch I

1. Location
2. Date built
3. Length—overall the bottom chord to end of castings to the nearest foot. Those at Woodstock and Lawrence are approximate because the ends are hidden by the road.
4. Truss depth—center to center of chords at midspan
5. Width—center to center of trusses.
6. Radius of top chord to nearest foot, calculated from depths at center and end of arc.
7. Number of interior panels
8. Length of interior panels
9. Slope of end post (horizontal/vertical)
10. Rolled I-beam used for web post

* Approximate

† Calculated from scaling photograph

‡ The castings for the bottom-chord bracing indicate an original width of 20 feet. This was more than enough for a single track but not enough for a double. Perhaps it carried a gauntlet track. The trusses carrying a single track of the Pennsylvania Railroad over the Little Juniata River were 14 feet on center according to Maw and Dredge, *Modern Road and Railway Bridges* (London: Office of Engineering, 1872), 113.

§ One truss is 69 feet and the other 65 feet. The abutments were not parallel because of the stream bed, and the flare was equal on both sides.

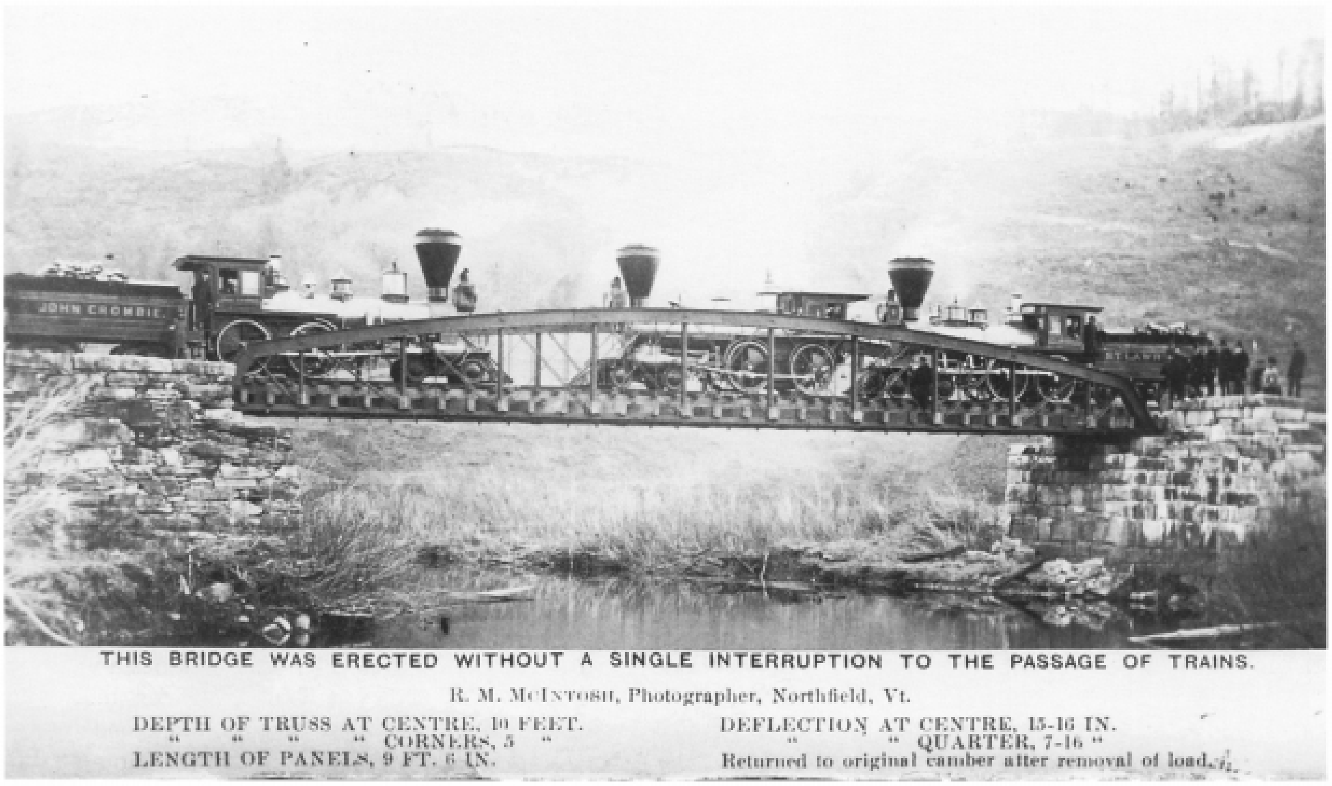


Figure 12. *Testing the Vermont Central Railway Co. bridge December 1870. The dimensions and details match those of the bridge now at Northfield, Vermont, and, in absence of any evidence to the contrary, this bridge was moved to that town.* National Museum of American History, Smithsonian Instiitution, 83-16595.

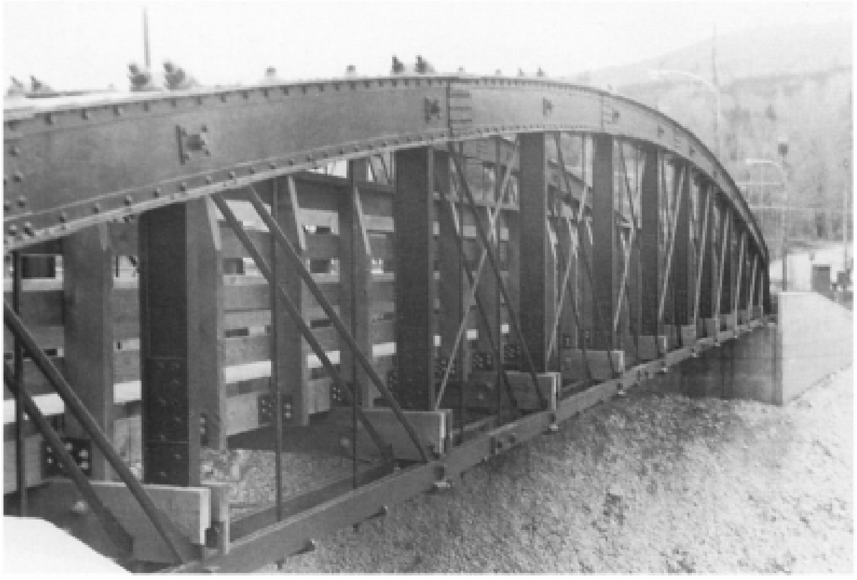


Figure 13. *The Northfield bridge refurbished and carrying the Vine Street sidewalk over the railroad tracks, The vertical hangers between the panel points, the double bottom chords, and their single-bolt splices show clearly.* Photo by author, 1991.

Figure 14. *The trusses of the Elm Street Bridge, Woodstock, Vermont, as they are today—preserved as decorative features on the bridge that replaced them.* Photo by author, 1995.

Figure 15. *Lower Rollstone Street, Fitchburg, Massachusetts. The cast-iron washers for the ends of the web diagonals and the rather short segments of the top chord can be seen as well (bottom right) as the ornamental casting that carried the fabricator's name.* Photo by author, 1995.

Figure 16. *The bridge at Lawrence, Massachusetts, supported by timbers.* Photo by author, 1997.

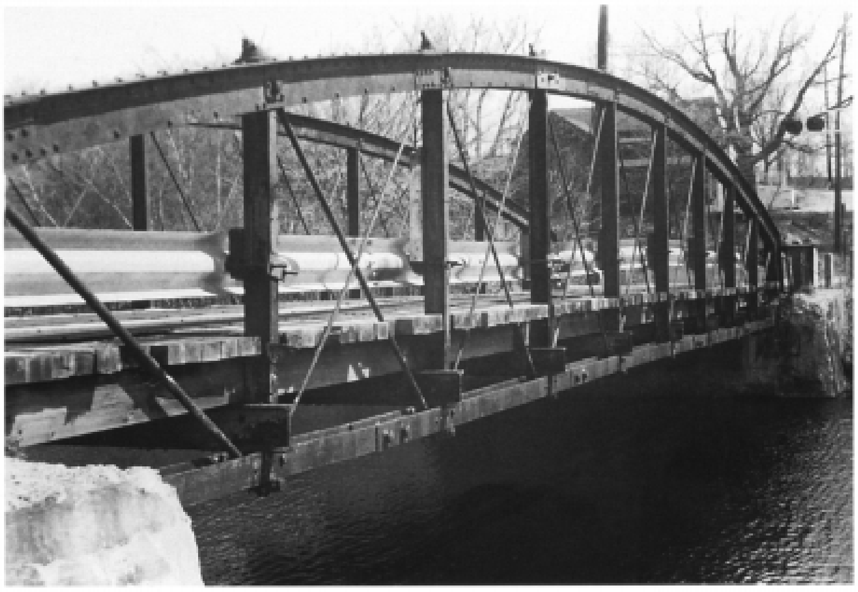


Figure 17. *Webster, Massachusetts, at its original location. The short segments of the top chord, bottom-chord connections, and splices are all evident.* Photo by author, 1997.

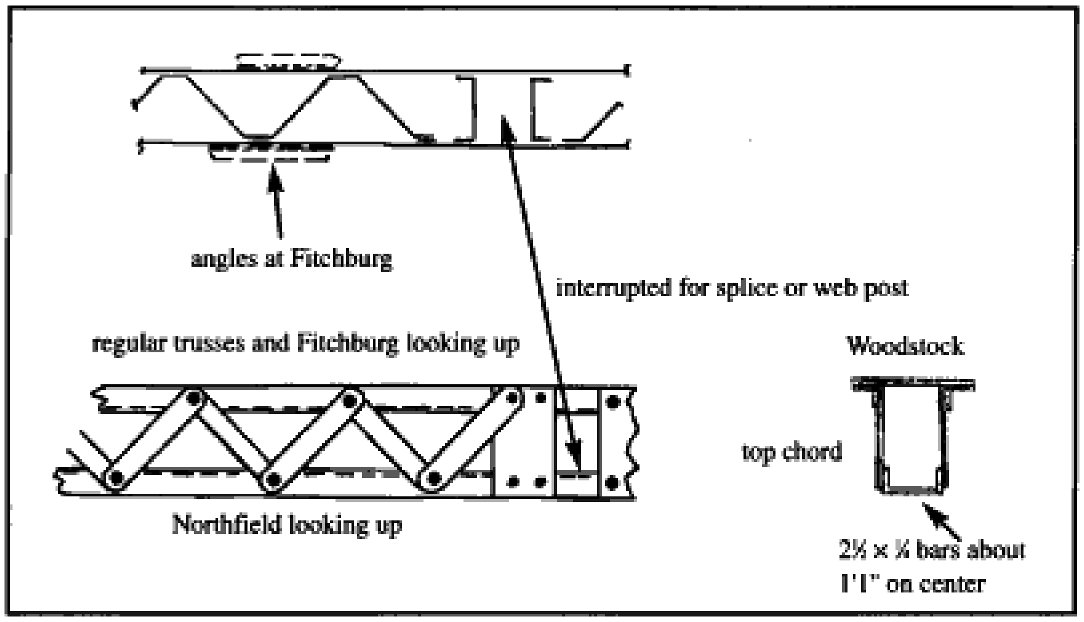


Figure 18. *Shows the three types of battens or lacing used to stiffen the lower part of the top-chord side plates.* Sketch by author.

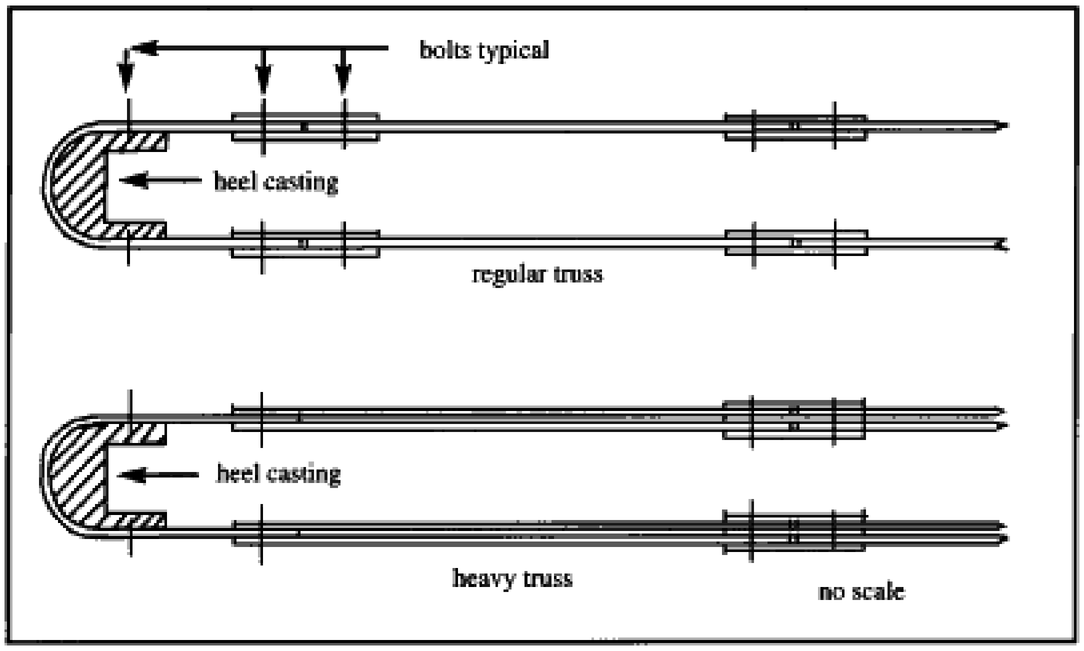


Figure 19. *Bottom chord splices and connections to the hoops that bear on the casting at the bottom of the end posts.* Sketch by author.

The basic structure is the same for all: sloping endposts, curved top chord, I-beam web posts, and the bottom chord forming a loop around the endposts. The main members are wrought iron with cast iron used only for the web-post connections, the heel of the endpost, and beveled washers. Two bridges with significant differences carried greater loads and were referred to as "the heavy trusses": Northfield, a railroad bridge, and Fitchburg, a wide roadway.

In these bridges, the top chord and endposts are inverted troughs made of three plates and two angles. The chord is a circular arc, and the curve of the side plates was probably produced by passing the plate between two rolls whose axes were not parallel.[22] The bottoms of the side plates are connected by lacing bars (battens at Woodstock, the oldest of the survivors) to stiffen them under the compressive loads and lacing each segment of the top chord ends with batten plates (see figure 18). The heavy trusses also have angles at the bottoms of the side plates. Those at Fitchburg are useless for they are not spliced, but those at Northfield are integral parts of the chord. The lacing at Fitchburg could have been riveted to the bottom angles, eliminating the cost of bending the bars and reducing the cost of assembly and riveting. Northfield was fabricated only a few months after Fitchburg. Both splicing the bottom angles and the better lacing arrangement at Northfield show how engineers can improve designs in small ways.

The bottom chords of all trusses are six-inch bars whose thickness varies from one bridge to the next. There are two bars on the regular trusses and two pairs on the heavier ones: the double bars of the heavier trusses are about an

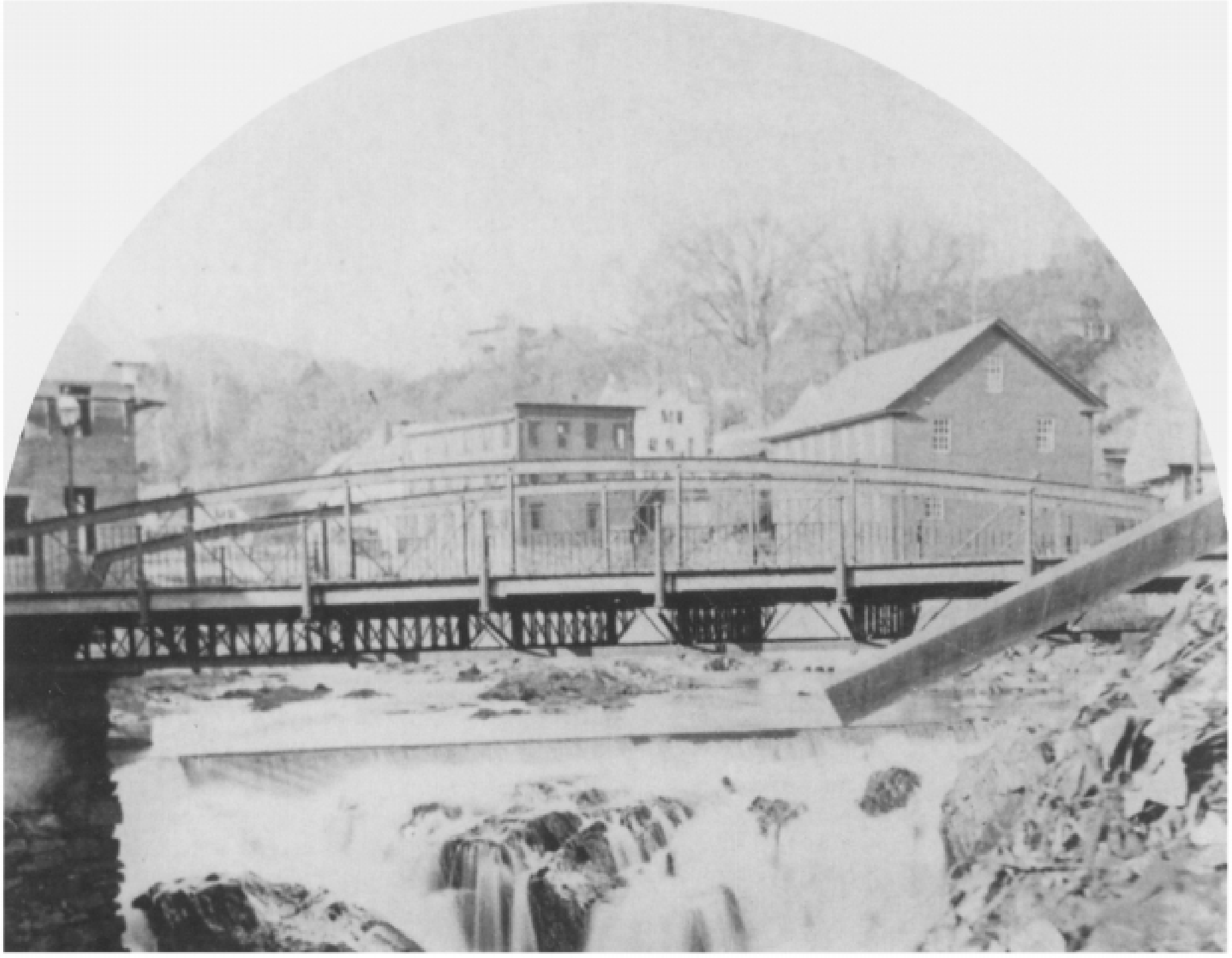


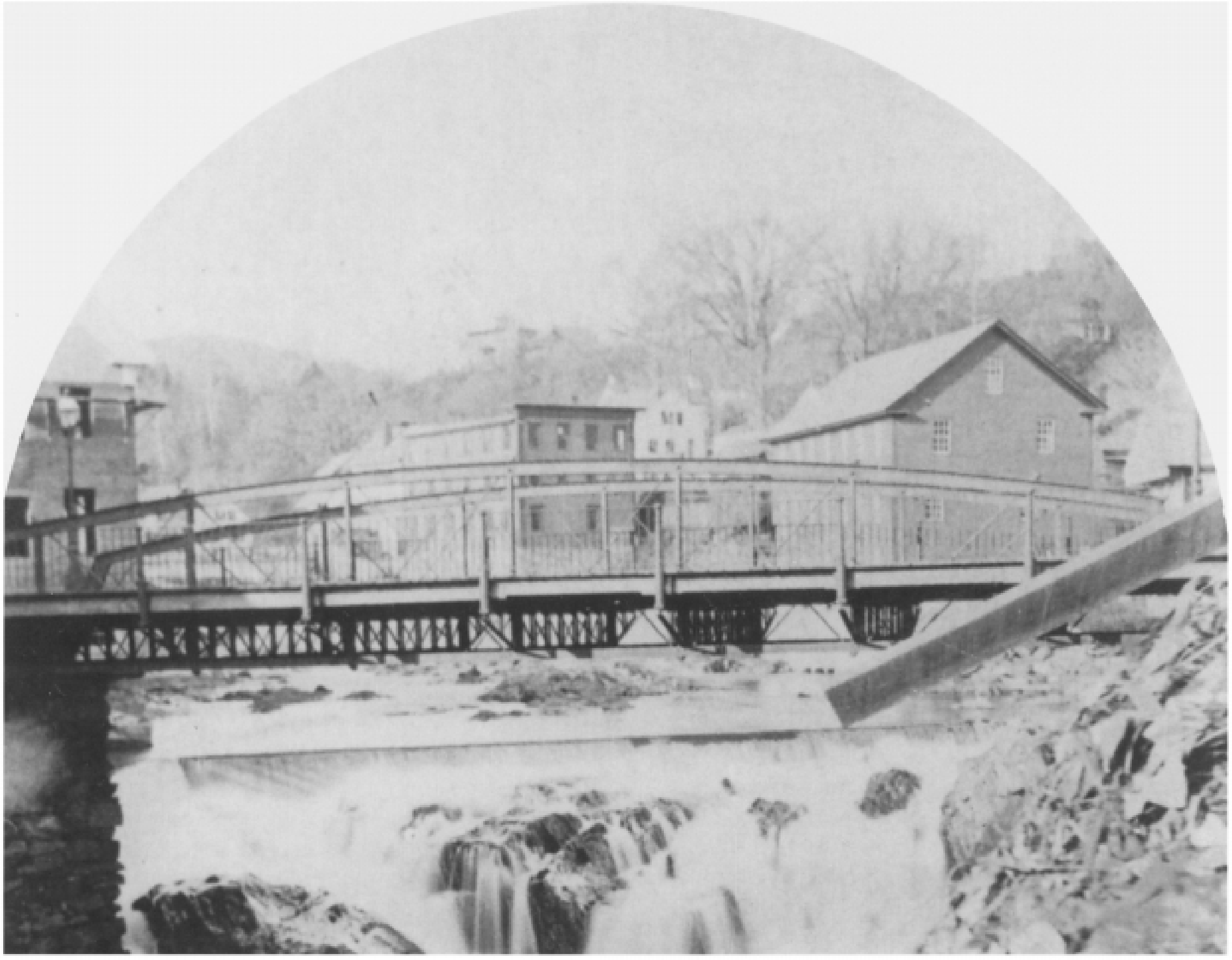
Figure 21. *The bridge formerly at Springfield, Vermont. A rare view that shows the transverse trusses that carried the floor in wider trusses. These rested on the bottom chords next to the web posts and cantilever to carry sidewalks outside the roadway.*
From a stereograph in the collection of Robert M. Vogel.

bridge rested on rollers, but this provision for temperature changes had long been ineffective as the rollers were rusted solidly to the base.

The floor system of the wider roadway bridges was carried by shallow transverse trusses that rested on the bottom chord next to a web post (see figure 21). Joseph R. Worcester stated that the chords and posts of these Pratt trusses were double angles with flat-bar diagonals with single rivets at all joints.[24] These were used at Fitchburg and probably Lawrence because of the widths, but they were replaced long ago. Webster is an example of a narrow bridge with 9-inch I-beams that rest on the bottom chord next to the web posts to which they are bolted.

Another floor system was used at both Vermont bridges. Cross timbers rested on the bottom chord between the panel points with a hanger rod at each timber carrying the load to the top chord. These are threaded at both ends. The upper end is supported by a cast-iron washer bearing on the horizontal plate of the top chord. An iron cross member is tight under the bottom chord bars. Woodstock has three hangers in each panel and Northfield two. Cross timbers were also located next to each web post.

An old photograph of Woodstock shows two inverted U-shaped iron members about 15 feet either side of the bridge's midpoint. These might have been an ornamental feature but, more probably, were meant to provide lateral



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bridge rested on rollers, but this provision for temperature changes had long been ineffective as the rollers were rusted solidly to the base.

The floor system of the wider roadway bridges was carried by shallow transverse trusses that rested on the bottom chord next to a web post (see figure 21). Joseph R. Worcester stated that the chords and posts of these Pratt trusses were double angles with flat-bar diagonals with single rivets at all joints.[24] These were used at Fitchburg and probably Lawrence because of the widths, but they were replaced long ago. Webster is an example of a narrow bridge with 9-inch I-beams that rest on the bottom chord next to the web posts to which they are bolted.

Another floor system was used at both Vermont bridges. Cross timbers rested on the bottom chord between the panel points with a hanger rod at each timber carrying the load to the top chord. These are threaded at both ends. The upper end is supported by a cast-iron washer bearing on the horizontal plate of the top chord. An iron cross member is tight under the bottom chord bars. Woodstock has three hangers in each panel and Northfield two. Cross timbers were also located next to each web post.

An old photograph of Woodstock shows two inverted U-shaped iron members about 15 feet either side of the bridge's midpoint. These might have been an ornamental feature but, more probably, were meant to provide lateral

Figure 22. *The ornamental casting, obviously an extra, that National Bridge and Iron Works installed on a few bridges. It also protects the end post from vehicles. Woodstock, pictured here, and Fitchburg have them.* Courtesy of HAER Collection, Library of Congress, VT3-21, 803128.

bracing to the top chords. None have appeared on photographs of other bridges.

The Northfield bridge, built to carry a railroad, is the only one with lateral bracing at the bottom chord. The rod X-bracing is below the chord bars and fastens to iron castings at each panel point. The castings have vertical projections that fit against the inside of the bottom chords. Only a little of these castings and those connecting the webs can be seen, but it is probable that the latter are similar to those at Fitchburg.

Comments

The Parker truss is a good design for the period, better than many used by competitors. Material was used efficiently as shown by the cast-iron connections and sloping end post. The proportions of truss depth to span and the panel lengths are similar to those chosen for many years after Parker's design. The weakness of the design is in the connections. Only a single bolt was used to connect the web members to the cords and to splice the bottom chord segments, with the latter being severely overloaded. No failures of the Parker truss are known, but the patented features limited the truss to moderate spans, probably about 150 feet. Several improvements were made during the brief period when the five survivors were fabricated. The bottom chord splices at Woodstock, the first built, were not coordinated with the truss connections, and several appear to have required alterations. This problem was avoided in later trusses, and at Webster (the last of the survivors) the splice locations appear carefully planned. All four angles of Northfield's top chord carried load. Also the lacing used less material and was much less expensive to fabricate than at Fitchburg. Little changes like these reduced the labor cost and are evidence of close attention to business.

The design attracted no attention in the 19th century. It was ignored in contemporary textbooks and reference volumes such as those by Boller, Shreve, Waddell, and Vose. No entries appear in the General Index volumes from 1878 to 1899 of *Engineering News.* The omission by Vose is striking because he taught at Bowdoin College, not far away at Brunswick, Maine. On page 208 he wrote, "an examination of the Bowstring Girder suggests a modification of the truss with parallel chords; viz, the arching of the top chord." Parker had already done this! Parker's name did not appear 25 years later, and the earliest mention found by the author is in 1916.[25]

What is today called the Parker truss uses the inclined endpost, which Parker claimed and appears to have introduced in addition to the curved top chord. The truss profile has been used for trusses up to 200 feet and the version with sub-divided panels, called the Pennsylvania truss, for major spans up to 500 feet. or more. Probably no other early design has five surviving examples so that comparison can be made and improvements in details studied. But survivors also raise a question: why are the trusses all from the early, introductory period (four built 1870 and one the next year) when the company was active until 1876? Was the design not as good as we think? Were the purchasers afraid to try something new? Were the other styles more economical? Whatever the reason, bridge students are fortunate that the bridges still exist. Charles Parker deserves to have his name preserved in association with the truss profile that he initiated.

Notes

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1. See Victor C. Darnell, *Directory of American Bridge-Building Companies, 1840–1900* (Society for Industrial Archeology Occasional Publication no. 4: Washington, 1984) for other examples. Among the few histories of early bridge-building companies are David A. Simmons, "Bridge Building on a National Scale: The King Iron Bridge and Manufacturing Company," IA: *The Journal of the Society for Industrial Archeology* 15, no. 2 (1989): 23–39, and, for the Rider Iron Bridge Company and its successor New York Iron Bridge Company, c. 1845 to c. 1853, Victor C, Darnell "The Pioneering Iron Trusses of Nathaniel Rider," *Construction History: Journal of the Construction History Society* 7 (1991): 69–81.
2. Henry Gratin Tyrol, *History of Bridge Engineering* (Chicago: the author, 1911); Llewellyn Nathaniel Edwards, *A Record of History and Evolution of Early American Bridges* (Orono, Maine: Univ. Press, 1959); Eric DeLony, *Landmark American Bridges* (New York: American Society of Civil Engineers, 1992); and David A. Simmons, "Bridges and Boilers: Americans Discover the Wrought-Iron Tubular Bowstring Bridge," *IA: The Journal of the Society for Industrial Archeology* 19, no. 2 (1993): 63–76.
3. Thomas Pope, *A Treatise on Bridge Architecture in Which the Superior Advantages of the Flying Pendent Lever Bridge Are Fully Proved* (New York: the author, 1811).
4. Alfred W. Parker (paper read before the Boston Society of Civil Engineers 18 March 1903) "Early and Curious Types of the Cantilever Bridge in New England and New Brunswick," *Journal of the Association of Engineering Societies* 31 (1903): 34–41. The printed discussions included comments by J. R. Worcester and J. Parker Snow, both well-respected engineers. A. W. Parker was superintendent of National Bridge and a bother of Charles Parker, This paper is the primary source of information about the early bridges. Additional information is found in Lola Bennett, *(Lower) Rollstone Street Bridge*, HAER no. MA-102 (1990) and John Healey, *North Village Bridge (North Main Street Bridge)*, HAER no. MA-99 (1990). The first is in Fitchburg, and the second in Webster, both Massachusetts. Information on Cottrell, Liscom, Charles Parker, and the companies is taken from Parker's paper. Description of the patents is by the author.
5. The author's thanks to the late William D. Smith for tracking the participants' names through the Boston *City Directories*.
6. Those in New Brunswick were ordered by The Western Extension Railway, part of the European and North American Railway System, a Canadian company. The two in Maine were probably included in the contract although the track was nominally owned by the Maine Central Railroad. The name of the American company varies from one reference work to another, but the track from Bangor to Vanceboro eventually became part of that company.
7. *Annual Illustrated Circular of the National Bridge and Iron Works/Blodgett & Curry, Proprietors* (Boston: Press of H. S. Con, 1869). Although it is titled an "annual," only this issue in the Library of Congress is known. Robert M. Vogel provided a photocopy. The latest testimonial letter was dated May 17, and there was no mention of the three Canadian railroad bridges that were completed during the summer. Parker probably joined the company in fall 1868. The West Concord bridge used trusses for the cantilevers. Also, a letter in the circular praising the work stated that it was erected "early in the winter."
8. The Boston and Lowell train shed, built 1873 with a clear span of 120 feet and a length of 700 feet, survived until 1928. The Boston and Providence station opened 4 January 1875, and the train shed was 600 feet long and 130 feet wide. Richard C. Barrett, *Boston's Depots and Terminals* (Rochester: Railroad Research Publication, 1996), 33–4 for the former and p. 90 with illustration on p. 99 for the latter.
9. Tearsheet in the National Museum of American History, Smithsonian Institution, probably from *Poor's Manual of Railroads of the United States* for 1875 or 1876.
10. Gregory Jay Galer, *The Boston Bridge Works and the Evolution of Truss Building Technology* (honors thesis, Brown Univ., 1989), 22–3.
11. Parker, "Early and Curious" (see n. 4).
12. *Annual Illustrated Circular* (see n. 7); Parker, "Early and Curious" (see n. 4).
13. *Engineering News and American Contract Journal* 14 (26 December 1885): 415.
14. *The Engineering Record* 44 (27 July 1901): 79.
15. The descriptions and measurements of the survivors come from the author's repeated inspections. The bottom chords and their connections were hidden or difficult to see—except for those at Northfield, which were out-of-reach but visible from below, and at Webster, where they could be seen, but the details were concealed by many layers of scaling paint and rust.
16. Robert C. Jones, *The Vermont Central Railway*, Vol. 1 (Silverton, Colo.: Sundance Books, 1981), 68, which erroneously states that it was built in 1867. The reverse of the mounted photograph says that it was tested in December 1870, and this was often done as part of the acceptance by the customer.
17. Donald C. Jackson and Jean P. Yearby, *Northfield Parker Truss Bridge*, HAER no. VT-13 (1985) contains 10 photographs taken in 1984 when it was carrying Vine Street. The cover sheet erroneously calls it a product of the Boston Bridge Works.
18. Dennis M. Zembala, *Elm Street Bridge* [Woodstock], HAER no. VT-3 (1983).
19. Bennett, *Rollstone Street Bridge* (see n. 4).
20. Peter M. Molloy, ed, *The Lower Merrimack Valley: An Inventory of Historic Engineering and Industrial Sites* (Washington: 1976), 39.
21. Healey, *North Village Bridge* (see n. 4). The report was made before the bridge was disassembled and moved.
22. A 12-inch deep plate rolled to a 200-foot radius would have one edge about $\frac{5}{100}$ of an inch thinner than the other, an amount which could not be found in field measurements.
23. All field connections must be checked to see if they were really riveted because the use of threaded rivets continued into this century. The erectors was instructed to place the rivets so that the thread and nuts would not show.
24. Parker, "Early and Curious," 40 (see n. 4).
25. Alfred P. Boller, *Practical Treatise on the Construction of Highway Bridges...* (New York: John Wiley and Sons, 1876); Samuel H. Shreve, *A Treatise on the Strength of Bridges and Roofs...* (New York: D. Van Nostrand, 1873); J. A. L. Waddle, *The Designing of Ordinary Iron Highway Bridges* (New York: John Wiley and Sons, 1884); George L. Vose, *Manual for Railroad Engineers and Engineering Students...* (Boston: Lee and Shepard, 1881); J. B. Johnson, C. W. Bryan, and F. E. Turneaure, *The Theory and Practice of Modern Framed Structures...* (New York: John Wiley and Sons, 1893); Mansfield Merriman and Henry S. Jacoby, *A Text-Book on Roofs and Bridges*, 4 vol. (New York: John Wiley and Sons, 1896); A. Jay DuBois, *The Stresses in Framed Structures...* (New York: John Wiley and Sons, 1896); J. A. L. Waddell, *Bridge Engineering*, 2 vol. (New York: John Wiley and Sons, 1916) I: 24.