Baltimore & Ohio Railroad:
Parkersburg Bridge
Parkersburg
Wood County
West Virginia

HAER No. WV-12

HAER
WVA,
54-PARK,
2-

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

PHOTOGRAPHS

HISTORIC AMERICAN ENGINEERING RECORD

BALTIMORE AND OHIO RAILROAD: PARKERSBURG BRIDGE

WV-12

Location:	Parkersburg, West Virginia Parkersburg Quad: 17.451210.4346780
Date of Construction:	1871, 1900, 1905
Present Owner:	The Chessie System
Significance:	Completed in 1871, the Parkersburg Bridge was an important early work of Jacob Linville and incorporated several of his patented innovations. The original channel spans (approximately 348 feet) were of wrought iron and marked the beginnings of an era of long-span trusses. They were fabricated and erected by the Keystone Bridge Company, a firm begun by Andrew Carnegie to provide a market for the output of his famous Lucy Furnace. The remaining spans were principally Bollman trusses of an older type.
Historian:	Dennis M. Zembala

The Civil War did much to establish the railroad as a valuable addition to the nation's transportation network. In particular, the war afforded an opportunity for it to demonstrate its most important advantages over competing systems: its speed and its relative indifference to adverse weather conditions. These advantages were graphically illustrated, of course, in military movements where timing was often of the utmost importance. It also excelled in the movement of materiel (both military and domestic) during the period of heightened economic activity brought on by the conflict. Hence, it was only natural that after the war when the normal economic conflict resumed, the armies of traders and manufacturers would seek to take advantage of the railroad's superiority in speed and reliability. No one realized these advantages more than the railroads themselves. After 1860, they continually sought to improve the service on their lines by improvements in tracking, motive power, repair and handling facilities. The intense competition between railroads for the shipper's dollar meant that such improvements were often the difference between survival and extinction. Hence, the successful expansion of a railroad was intimately linked to its ability to keep pace with the technology of service-connected improvements. The history of the Baltimore and Ohio Railroad bridge at Parkersburg, West Virginia, is an important example of the link between improved service, geographical expansion, and financial success.

Consistent with its intention to build the most direct route from Baltimore to St. Louis, the B & O financed the construction of the Northwestern Virginia Railroad.* Chartered in 1851, this line ran from Grafton to Parkersburg, where it was intended to link up with the Marietta and Cincinnati Railroad and the Ohio and Mississippi Railroad. The Marietta and Cincinnati had been chartered in 1847, but actual construction did not begin until 1851.[1] Similarly, the Ohio & Mississippi had been chartered for 19 years before actual construction began in 1851. All three lines were completed in 1857, giving the B & O the first all-rail link between St. Louis and the eastern seaboard, and on June 1, 1857, several trainloads of luminaries left Camden Station in Baltimore on the inaugural trek to the Mississippi.[2]

As the traffic to the west increased, the ferry connection between Parkersburg and Marietta quickly became an inconvenient bottleneck in operations. The original ferry terminus up the river at Scott's Landing was changed to Belpre to minimize the amount of water carriage. A new rail spur connecting Belpre with the Marietta & Cincinnati cut off a considerable distance from the route. Yet, even though Belpre was just across the river from Parkersburg, the ferry continued to be a source of delay and a bridge across the river became a pressing necessity.[3]

---

* See file on Northwestern Virginia Railroad, Grafton Machine Shop and Foundry, HAER, Washington, D.C.

Construction of a bridge at Parkersburg and one at Benwood (south of Wheeling) were among the first priorities of John W. Garrett's administration. Since Garrett assumed the presidency of the B & O in 1858 and served in that capacity for 28 years, his administration spanned the great period of railroad expansion following the Civil War. As the son of a prominent Baltimore merchant, he brought with him a solid background in business and pronounced managerial abilities. He was largely responsible for diminishing the influence of the public sector (Baltimore City and the State of Maryland) on the operation of the road. Garrett allied himself with the private stockholders on the one issue that would shape the future of the B & O in the 1870's and 1880's: the reinvestment of profits.[4] The public interests had been distrubed by the failure of the company to pay stock dividends and its reinvestment of profits in further expansion. The conflict came to a head in 1856, and Garrett emerged as the major proponent of such expansion. When the victory of the Garrett faction set the stage for continued growth, the two bridges over the Ohio were among its highest priorities for future development.[5]

While actual implementation of plans for the Parkersburg Bridge was held up by the Civil War, there is some indication that survey work was done during this period. On August 30, 1865, the first contract was let to John McConnell to supply masonry for the piers. The next four years were consumed in further studies and the accumulation of sufficient masonry. The construction was further delayed by legal restrictions on the height of the bridge above low water and the length of its channel spans. These restrictions were, in the long run, a great stimulus toward the development of long-span truss engineering.

The intense competition between the railroads and the steamboat industry for western freight had resulted in limitation of the minimum dimensions of bridges over navigable rivers (the debate over the height of bridges over the Ohio had been steaming since the controversy over the Wheeling Suspension Bridge in the late 1840's).[6] By 1862, these restrictions were codified in an Act of Congress requiring bridges over the Ohio, above the mouth of Big Sandy, to have a minimum clearance of 90 feet above low water and a channel span of at least 300 feet. The next adjoining span was to be no less than 220 feet. The first bridge to be completed under these conditions was the Holliday's Cove Railroad's bridge at Steubenville, Ohio (1863-64). Its channel span was a Whipple-Murphy truss 319 feet long and 28 feet deep, with cast iron posts and wrought iron, double-diagonal tension members.[7] The Holliday's Cove line was a subsidiary of the Pennsylvania Railroad, and the Steubenville bridge spans were fabricated in the latter's shops at Altoona, Pennsylvania. The designer of these long-span trusses was Jacob H. Linville, at that time on the staff of that railroad and in charge of its bridge-building program.[8] The Steubenville bridge was followed by Albert Fink's Ohio River bridge at Louisville, also for the Pennsylvania Railroad (1868-70). Its channel spans measured 360 feet and 390 feet, the longest in the country at that time.[9]

The initial impetus given to long-span development was further enhanced by the increase in the size and speed of rolling stock after 1865. It soon became obvious that the increased loads would rapidly outrun the state of bridge design. The most serious weakness of bridges like those at Steubenville and Louisville was their use of cast iron chords and posts. As spans grew in length, their depth increased as well. The result was that chord sections and posts grew in both length and diameter, making them more difficult and expensive to produce and more likely to crack under loading. In addition to loading stress, these large castings were also subject to the greater lateral wind forces in a long span. Although the Whipple truss partially compensated for these forces through the use of closely-spaced verticals and heavier horizontal bracing, the low tensile strength of cast iron posts led to a search for a more suitable material. The resulting development of wrought iron posts and chords was the next step toward the full realization of long-span bridges in the late 1860's. Linville's role in this development helped establish him as a leader in wrought iron design and, consequently, in long-span truss engineering.

In 1865, Linville became president of the newly-organized Keystone Bridge Company, formed by Andrew Carnegie to exploit the capacity of his famous "Lucy" furnace.* (See Photocopies, HAER, WV-12-1.) The new company absorbed the firm of Piper and Shiffler, which had been formed two years earlier by Linville's colleagues on the Pennsylvania. Since Carnegie's ironworks at Pittsburgh (Carnegie, Kloman & Co., the Union Iron Mill) was the country's most advanced complex for the production of large, rolled sections of high-quality iron, the Keystone company was in a particularly advantageous position to pioneer in the development of wrought iron bridges. (WV-12-2, WV-12-3, WV-12-4.) Linville already had some experience with the design of wrought iron members before he came to Keystone. As early as 1861, he had demonstrated his skill with it in his Schuylkill River bridge in Philadelphia. His Steubenville spans used auxiliary rolled beams to carry the floor above the deck trusses.[11] Together, he and Piper had patented several innovations in the design of wrought iron members, most notably the technique of "upsetting" chord heads by forging them in high-pressure molds. This method reduced the weakness in tension members caused by threading iron rods (with the resultant loss of diameter and loss of temper due to the heat of friction). Linville and Piper also patented a technique for rolling flanged sections and using them to build hollow tubes for chords and posts. Their experiments led Linville to advocate all-wrought iron bridges in a circular issued by the bridge company in 1863.[12]

Gradually Linville's abilities and knowledge of wrought iron

* The officers included J. H. Linville, President; J. L. Piper, General Manager; Thomas M. Carnegie, Treasurer; and Andrew Carnegie, Chairman of the Board of Directors.

construction outstripped the company's confidence and led to his departure. The Pennsylvania Railroad was somewhat reluctant to follow Linville's advice and continued to construct chords and posts of cast iron. When he began work for the Keystone company, this limitation was removed. From 1865 to 1875, this company and its principal competitor, the Phoenix Bridge Company, undertook numerous experiments to determine the strengths of typical rolled sections, composite (bolted or riveted) members, and their detail connections. (WV-12-3.) They were among the first to install large testing machines in their shops to determine the strengths and strains of actual members. Aside from its innovations in design and construction, the Keystone company was also a financial success. During this decade, the company built hundreds of bridges of both iron and wood, and fabricated all types of structural ironwork.[13] (See Photocopy of Structural Shapes, HAER, WV-12-14.) In addition, it pioneered in development of steel construction, supplying much of the steel for Eads' bridge over the Mississippi at St. Louis.[14] By 1870, the engineering skill of Linville had combined with Carnegie's knack for organizing the elements of production to make the Keystone Bridge Company the leading firm in the field.*

When the Baltimore and Ohio finally undertook the construction of the superstructures for the bridges at Parkersburg and Benwood, it was only natural for them to obtain the services of Linville and the Keystone company. Albert Fink was the only member of Latrobe's staff with the mathematical ability to design such long-span structures, and he had left the B & O in 1858 to become chief engineer of the Louisville & Nashville. Although Bollman was still with the B & O, the scale of the channel spans at Parkersburg was apparently beyond his range of capability. It is altogether likely that even if Bollman had the ability to design such structures, the fabrication of such large members would have been beyond the capacity of the Mt. Clare foundry. It was altogether much more convenient (and probably cheaper) to contract for them with a firm such as Keystone, which combined technical expertise in both design and fabrication.

As a whole, the superstructure of the Parkersburg bridge looked both backward and forward in the development of bridge engineering. The shorter spans were classic Bollman trusses, built on the lines of Bollman's 1851 patent. Although the usefulness of this design was coming to an end, there is some indication that in this case it may have been extended by the use of wrought iron chords and posts instead of the customary cast iron members. The Parkersburg approach from Market Street to the east bank of the river utilized 22 Bollman deck trusses varying in length from 50 to 100 feet. (WV-12-5.) From the west bank of the river to the Belpre abutment, Bollman used six longer deck spans (121 feet 7 inches; 121 feet 0-1/2 inches; 120 feet 9-12 inches; 120 feet 11 inches; 120 feet 5 inches; and 124 feet 10 inches).[15] The use of Bollman trusses for the shorter approach spans was obviously a

* It served as the nucleus for the merger which produced the American Bridge Company.

concession to a loyal employee. By 1870 their complexity had made them obsolete, and many railroads were already replacing them with wrought iron plate girders. In fact, the Keystone Company supplied a 65-foot plate girder for the span over Market Street (where it had the added advantage of providing extra clearance over Parkersburg's main street).[16] (WV-12-6.) Even if the Bollman truss continued to serve a useful function for spans of intermediate length (say, 75 to 125 feet), it was nevertheless obvious that it would not do for long spans. The six river spans at Parkersburg were all-wrought iron construction designed by Linville and built by the Keystone Company to his specifications. Four of these were deck trusses varying in length from 209 to 315 feet. The two channel spans (#38 and #39) were through trusses of 348 feet 9 inches and 347 feet 9 inches, respectively. All six were the Linville-Piper type, a modification of the double-intersection Pratt truss. At the time of their completion in 1871, they were second in length only to Albert Fink's Louisville bridge (1870), which had channel spans of 400 and 370 feet.[17] (See Photocopy, Prints and Photographs Division, Library of Congress, Washington, D.C.) These two channel spans at Parkersburg were Linville's largest early attempts at all-wrought iron construction and incorporated many of the improvements which he and Piper had pioneered. The most important of these was the use of their patented wrought iron "trussed" column for end posts and verticals. This was a composite of eight rolled sections riveted together along their length. (See photocopy of "Double Intersection through Bridges," Keystone Bridge Co., Album, Plate 4, figs. 5-6, WV-12-3.) The sections were not flush along their length but instead were separated by short tie rods which ran through the columns. The purpose of these rods was twofold: they kept the sections apart so they could be painted, and they offset the tendency of the columns to bulge in the center under compressive forces.[18] Through experiment, Linville discovered that the composite columns were unsuitable for inclined or horizontal members since their weight (especially in long spans) made them subject to flexure and thus to distortion.[19] Consequently, the top chord was a square or rectangular tubular girder built up of wrought iron plates--continuous along the entire length of the span. The bottom chord consisted of a series of parallel eyebars bolted or pinned at the foot of each post. A suspender hung from each of these pins and supported a pair of transverse eye beams which carried the deck and the stringers for the rails. The horizontal, double-diagonal stiffening trusses in each panel were adjusted by turnbuckles. One of the major innovations evident in this bridge was the use of footings and other connecting pieces of wrought iron, instead of the standard cast iron. While these pieces retained their original shape (WV-12-3, figs. 6, 8, 10), the use of the new material meant that they were less likely to fracture.[20]

All tension members in the bridge incorporated Linville and Piper's patented technique of upsetting bars to increase their surface area at pinned and bolted connections. Bars were pressure-forged into molds to increase their width or thickness at each end before the eyes were punched or the ends threaded. On square bars, the eyes were formed by bending the end around to form a loop. The end was then united to the body of the bar by scarfing.[21] These techniques decreased the possibility of failure due to the weakening of bars caused by earlier methods. In addition to the Bollman and the Linville spans, the bridge also incorporated a number of the so-called "shad-belly" girders for 11 short spans of the east approach. Seven of these were 25 feet long and four were 29 feet 6 inches. These were wrought iron also, and their depth increased toward the middle, making them resemble the belly of a fish. They carried the track over the city's streets, and their graceful curves must have been rather attractive from below. The total length of the openwork was 4,397 feet. Together with the 2,676' of embankment approach on the Ohio side and a shorter one on the West Virginia side, the total length of the bridge was (and remains) 7,140 feet. The entire structure, with its 39,000 cu. yds. of masonry, cost over one million dollars.[22]

The Parkersburg bridge was the best bridge that money and the state of bridge engineering could provide. Its technology was a combination of the tried and tested methods of the pre-Civil War period and the most advanced techniques of the new era of long-span structures. Both the Bollman spans and Linville's were built with the advantage of the latest knowledge of scientific analysis. Both were calculated to withstand the maximum loads anticipated at the time. Neither foresaw the large increases in the weight and speed of rolling wtock which would eventually make them obsolete. The Bollman trusses were the first to go. Between 1898 and 1900, they were replaced by steel modified Warren trusses of riveted construction. (WV-12-7, WV-12-8.) The six river spans built by the Keystone Company were replaced by more modern steel structures in 1904 and 1905. With one exception these spans continue in service with minor alterations.[23] (WV-12-10.)

Both the Parkersburg and Benwood bridges were opened to traffic in 1871. Each cost over a million dollars to build, and together they constituted a huge investment for that day. Once the river had been crossed, the B & O was committed to further expansion to justify the outlay. Garrett undertook the task with apparent relish, and by the mid-1880's the B & O was one of the three or four major railroads to the West. Once the bottleneck of river ferrying had been removed, Garrett increased his control over the Marietta and Cincinnati and the Ohio and Mississippi. In the 1880's, he established Cincinnati as one of the chief operating centers of the B & O system. New track was laid into the city and its terminal facilities vastly improved. As the Great Plains developed into a source of agricultural products and a market for manufactures, the value of an all-rail transportation network increased. Garrett's investment in the Parkersburg bridge yielded handsome dividends, not only to the railroad, but to those it served.[24]

FOOTNOTES

1. Edward Hungerford, The Story of the Baltimore and Ohio Railroad, 1828-1928, Vol. I (New York, 1928), pp. 299-300.

2. Hungerford, pp. 305-315; William Prescott Smith, Great Railway Celebrations of 1857 (New York, 1858).

3. Manuscript history of Parkersburg bridge (An.), HAER File.

4. Baltimore and Ohio Railroad, Report of the Majority and Minority of a Special Committee of the B & O Railroad to Investigate Its Financial Condition, General Line of Policy Heretofore Pursued (Baltimore, 1858).

5. Hungerford, pp. 109-112.

6. Clifford Lewis, S. J., "The Wheeling Suspension Bridge," West Virginia History, Vol.   (Nov., 1971).

7. Carl Condit, American Building Art: the 19th Century (New York, 1960), p. 141; Theodore Cooper, "American Railroad Bridges," Trans. A.S.C.E., Vol. XXI (July, 1889), p. 17; Keystone Bridge Company, Album (n.p., 1874), p. 34.

8. J. E. Greiner, "The American Railroad Viaduct," Trans. A.S.C.E., Vol. XXIV (Oct., 1891), p. 365.

9. Keystone Bridge Co., pp. 34-35.

10. Condit, p. 114.

11. Greiner, p. 367.

12. It is unclear as to which company this was, Piper and Shiffler or Keystone. See Greiner, p. 367. For biographical information on Linville, see Trans. A.S.C.E., Vol. XXXIII (1907), p. 744.

13. Keystone Bridge Co., pp. 34-42.

14. Ibid., p. 15.

15. Baltimore & Ohio Railroad, 45th Annual Report (Baltimore, 1871).

16. Ibid.

17. Condit, p. 146.

18. Keystone Bridge Co., p. 25.

19. Ibid.

20. Ibid., pp. 17-18.

21. Ibid., p. 24.

22. Hungerford, p. 110.

23. Huntington, West Virginia, The Chessie System, Engineering Department. Drawing of Parkersburg bridge, February 16, 1950, 2 sheets.

24. Hungerford, pp. 109-111.