White Bowstring Arch Truss Bridge
Spanning Yellow Creek at Cemetery (Riverside) Drive
Poland
Mahoning County
Ohio

HAER No. OH-39

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Historic American Engineering Record
National Park Service
U. S. Department of the Interior
P.O. Box 37127
Washington, D. C. 20013-7127

ADDENDUM TO
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White Bowstring Arch Truss Bridge

HAER No. OH-39

Location: Cemetery Drive/Riverside Drive over Yellow Creek, Poland Township, Mahoning County, Ohio

UTM Coordinates: 17/532860/4541650

Date of Construction: 1877

Present Owner: County of Mahoning (Board of Commissioners)
County Courthouse
Market Street
Youngstown, Ohio

Present Use: Vehicular traffic (bridge closed at time of survey)

Significance: The White Bowstring Arch Truss Bridge is the only known example in Ohio of William Rezner's patented oval wrought-iron tubular arch design. Only two other examples are known to exist in the United States (as of August 1986). Bowstring arch bridges were once common, and many were built between 1850 and 1880, but few have survived. This bridge was built by the Wrought Iron Bridge Company of Canton, Ohio, which was one of America's largest and most important bridge building companies in the late 19th century. The bridge was listed on the National Register of Historic Places in 1983.

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Project Historian
Ohio Historic Bridge Recording Project
Summer 1986

This bridge is a bowstring arch truss which was built in 1877.[1] It is referred to in primary records as the White Bridge, but it is also called the Cemetery Drive, or Riverside Drive Bridge. Many bridges in the second half of the nineteenth century were built with a bowstring design, although few survive today. Most bowstrings had a tubular compression member that was square or round in section, but this particular bridge is unusual because it has an elliptical (ovoid) tubular arch. The bridge was constructed by the Wrought Iron Bridge Company of Canton, Ohio, but it was built to a design patented in 1867, and later improved upon by a patent in 1872, by William Rezner of Cleveland.[2]

The bridge is 127 feet long and eighteen feet wide. The compressive member of the truss is composed of two semi-elliptical sections riveted to a flat plate. The lower chord is in tension. There are fourteen panels, twelve of which are crossed by two diagonal wrought-iron rods. The vertical cruciform columns are in compression, and the diagonal rods are in tension. Lateral bracing in the plane of the bottom chord is attached to the end of the deck beams. There is also overhead bracing at three panel points composed simply of three horizontal bars set across the width of the bridge, and stiffened by diagonal bracing. Builders of bowstring bridges utilized a variety of top lateral bracing often using latticed girders, thus, the use of a bar system on this bridge is unusual. The deck beams rest on top of the bottom chord.

The design of the White Bridge is very similar to Rezner's "Patented Oval Wrought Iron Tubular Arch Bridge". He believed that the oval shape would increase the bridge's vertical stiffness. A hollow tube of wrought iron often was used for the arch in bowstring bridges. Various designs were first produced in an attempt to increase the rigidity of the bridge. A patent for the design was finally developed in 1867 by Rezner working with John Glass, a foundryman, and George Schneider, a railroad machinist, both from Cleveland.

In 1872 Rezner submitted his own patent for an improvement on the first design, which was used on the White bridge. This was for a special bearing shoe that sat on the abutment which connected the arch to the lower chord. The lower chord is of two continuous bars, 6" by 3/4", which taper down to threaded 1/2" diameter rods at their extreme ends. The rods pass through the cast iron shoe and are held by hexagonal or square nuts. The shoe also receives the end of the oval tube, in a manner to allow for the expansion and contraction of the iron in the bridge.

Rezner's first patented design is very similar in many ways to that of the White Bridge. In the latter, however, there are a series of vertical columns with diagonal rods between them, but in the drawing accompanying Rezner's patent the "main stays" appear to radiate along the curve of the bowstring. There are diagonal braces in his original design, but they run, not between the posts, but from the centre of the bottom chord out to the bowstring, across two of the main stays.

William Rezner was a physician by profession, not an engineer. He had an inventive nature, however, and besides designing bridges he founded the Ohio Bridge Company in 1870. In doing so, Rezner capitalized on the vast resources of the major Cleveland developers of the Marquette, Michigan iron ore deposits. However, the company could not survive the Depression of 1873, and Rezner went back to medicine. Because the company operated for such a short time there are few examples of his distinctive bowstring design. This is the only known example in Ohio, and only two others have been found in other states. One is in Beacon, New York (see HAER No. NY-168), and the other is in Pennsylvania.

The design is very much a reflection of the technology of its period, as the bowstring was extremely popular from 1850 to 1875, but hardly any were built after 1880. Once iron began to be used for bridges in the 1840s, builders searched for the best designs (i.e. designs which were efficient in the use of materials and labor). The bowstring was popular because it had a high carrying capacity, but required a comparatively small amount of material. Although it was popular for about thirty years, some professional engineers felt it had limited use since it could not be properly braced overhead and therefore had a tendency to sway sideways. J.A.L. Waddell, a late 19th century bridge designer and author, said that bowstring bridges "ought to be condemned".[3]

The 1877 construction date was taken from an entry in the Mahoning County, County Commissioners Journal (volume 2, page 265) for 2 July 1877. The entry concerns a contract between the County and the Wrought Iron Bridge Company for building a bridge over Yellow Creek in Poland. The bridge was to be 18 feet wide (which the White Bridge is), and was to have one "5 foot walk". It was to sit on the stonework "as it now stands", and it was to be constructed on the "low truss plan". The White Bridge could have had a sidewalk originally, it being carried on the outside of one of the lines of trussing, on top of extensions of the deck beams. This could explain the fact that some of the external sway bracing appears to have been altered. It is possible that the abutments were from an earlier bridge. The fact that the County Commissioners Journal mentions a "low" bridge, however, suggests that the entry is for a different structure. The road that the White Bridge carries across Yellow Creek was built in the early 1870s, so there should have been a bridge there earlier than 1877. References for an earlier bridge had not been found. In addition, The bridge must have been built after Rezner's second patent. Thus, a date in the mid 1870s seems fairly certain from a stylistic point of view.

The Wrought Iron Bridge Company, Canton, Ohio.

This company was one of the major American bridge building firms in the late nineteenth century. It had agents, and built bridges in New England and the eastern, midwestern, southern and southwestern sections of the United States. It also built bridges in Canada and in Mexico. The company began operations in 1866, expanding into a partnership venture in 1871.[4] At that point it was incorporated under state laws with capital of $106,000, with much ofthat money coming from David Hammond. Hammond was born in Canton, Ohio on 12 September 1830. He worked as a contractor and builder until 1862 when he was given a contract to build a 60 foot iron bridge across the east branch of the Nimishillen Creek in Canton. This was said to be the second iron bridge erected in Stark County. After this experience Hammond concentrated on bridge building, and together with W. R. Reeves he started the firm of 'Hammond and Reeves', bridge builders and contractors based near Fort Wayne, Indiana. Their partnership continued until 1870 when Hammond 'retired', only to invest in the Wrought Iron Bridge Company and become its President. He disposed of his interest in the firm in 1890, and though intending to retire, actually went on to organize the Canton Bridge Company in 1891.[5]

In 1881 it was that the Wrought lron Bridge Company (WIBCo.) had built more highway bridges than any other works in the United States. With a staff of about 150 men [6], they had erected about 3,300 spans, varying in length from six to 120 feet. By that early stage in its history it had worked in 25 different states as well as in Canada, and had constructed truss, arch, swing, and plate bridges as well as iron piers (they built both all-iron, and combination bridges). The material they used was specially manufactured for them to rigid specifications, with regard to tensile strength and quality and was tested on its arrival at the shop. By 1881 they had had no cases of failure or accident - an important boast in a century which had seen a number of bad accidents due to experimentation with bridge design. It was said that:

> Their facilities for accurate and reliable work are unequaled by those of any similar establishment, and enable them to complete contracts with great dispatch. [7]

They prided themselves not just on the quality, but on the speed of their work:

> Our extensive facilities for manufacture are so complete, that we have shipped the iron work for a 60 ft. span within 7 hours after receiving the iron from the mill, and have completed 100 to 140 ft. spans at points from 100 to 300 miles from our works, in 8 to 15 days.[8]

In 1891-2 the firm's original plant became too small and they moved to a larger, specially built plant in the southwestern section of Canton. This was on a 12 acre site, on the line of the Coshocton and Zanesville Branch of the C. C. & S. R. R. The railway tracks entered the site at the northeast corner, and from there other tracks allowed for the distribution of material as it arrived. Material was stored on skids adapted for that purpose, or was conveyed by rail to the stock house. Material for built-up members was conveyed to the shop on the north track and was unloaded on adjacent skids in the shop. It was laid off there and marked for punches and shears. From punches and shears it passed to straightening machines, or curving rolls to the assemblers and from there to the reaming tools, the riveters and riveting machines, the planers, the fitters and the drills. It was then stored ready for loading. The machinery for the various operations was laid out in consecutive lines from east to west. The finished bridge parts were either stored or loaded directly on to the cars for transportation to the appropriate destination.

The Main Building was 256 feet square, part of which was divided into a Superintendent's office, a template and pattern room, a tool room, a machine shop for small tools, and a packing room. The major part of the building was devoted to the Main Shop for the manufacture of built-up members. There was also a Forge Shop, which was connected by tracks to the Yards, the Stock House, and the Main Shop itself. The Main Shop was designed to have only four columns in the whole area, so the floor area was unimproved for the assembly of large bridge parts.

The Engine Room had engines, an electric generator, incandescent and arc light dynamos, an air compressor and receivers, with pressure and heating fans overhead. The electric generator powered 17 dynamos, each one operating one or more machines, as needed. The Boiler Room was outside the Main Building, and next to the Engine Room. It had a boiler and furnace, the feed water being purified before passing to the boiler. The exhaust steam heated the feed water and was used in cold weather to heat the works, by being passed through coils of pipe in aheater box, through which air was forced by a fan for distribution through the building. The plant was completely electrified with each machine having its own electric motor instead of being powered by belting and shafting. The company claimed that it was the first bridge manufacturer to adopt that method of transmission for the whole plant.[9]

WIBC's new site design seems to have been much influenced by up-to-date thinking on plant layouts. The metal industry was the first in the United States to pay attention to the design of works and plants in order to increase productivity. An American engineer, Alexander Lyman Holley, was behind a number of innovative plant layouts in the 1860s and 70s, the primary goal of which, according to Holley was "to assure a very large and regular output". He believed that good plant design was as important for this as technological innovation. He said that:

> It will have been observed that the capacity of these works for a very large and regular output, lies chiefly in an arrangement which provides large and unhampered spaces for all the principal operations of manufacture and maintenance, while it at the same time concentrates these operations.

Holley was very proud of his design for Andrew Carnegie's Edgar Thomson Works in Pittsburg, Pennsylvania. The site was on the Monongahela River at the junction of three railroads. It was selected to make the fullest use of existing railroad transportation. The plant was designed to assure as continuous a flow as possible from suppliers of the raw material, through the processes of production, to the shipment of the finished product to the customer.

> . . . these works were laid out, not with a view of making the buildings artistically parallel with the existing roads or with each other, but of laying down convenient railroads with easy curves; the buildings were made to fit the transportation.

The design of the works allowed it to become the most efficient steel producers in the country, or in the world. Although not in the same league. WIBCo was one of the major bridge building companies in the country at the time, so presumably it was worthwhile for them to invest in a well designed works.[10] A Sanborn Insurance Map of Canton for 1891 shows both the old and the proposed plants. In 1900 the Wrought Iron Bridge Company was bought up by the American Bridge Company, becoming one of its 35 plants.

David Hammond had a major role in the expansion of the Wrought Iron Bridge Company but he was not the only significant figure. Job Abbott was vice president in the 1870s, and although he left in 1878, he was still a director at the time of his death in August 1896. Abbott went to Harvard and graduated from its scientific department in 1864. He worked for several railroad companies, eventually moving to Canton, Ohio, where he hecame interested in patent law, and then in construction work. During the 1860s he advertised himself as an architect, civil and mining engineer and "solicitor of patents." Ironically as a patent attorney he sometimes represented other Ohio bridge builders who later directed rival companies. He took a major part in the huilding up ofthe Wrought Iron Bridge Company, and received numerous patents for bridges jointly with Hammond in the 1870s. His designs included several bowstring bridges that were used by the company.[11]

Abbott went on to organize the Toronto Bridge Company in 1878, and the Dominion Bridge Company, Montreal in 1882, which built some of the heaviest bridges in Canada (the Lachine Bridge for the Canadian Pacific Railroad over the St. Lawrence River for example). During Abbott's career he established business relations with the great European rolling mills and with foreign engineers, especially those in Scotland and Belgium.[12]

Another key figure in the development and management of WIBCo was Edward Landor (born in Norwich, England in May 1855) who worked for the company from 1877 to 1900. He was assistant Engineer, Chief Engineer and then President and Manager. In 1900, Landor went to work for the American Bridge Company at the time when the latter brought out Wrought Iron Bridge Company. In that year, however, he was working at Zanesville, Ohio, as resident engineer on the construction of the 'Y' bridge, the design for which he said he had prepared with the Wrought Iron Bridge Company.[13]

WIBCo was one of the bridge companies heavily involved in "bridge pools" in Ohio in the late 19th century. Bridge pools were alliances between participating companies which helped to regulate prices paid to companies for their work. The companies would decide which of them would put in the lowest bid before submitting their supposedly secret bids for a bridge contract. Information on "bridge pools" are in the report on the Forder Pratt Through Truss Bridge (HAER No. OH-42).

NOTES

1 National Register Nomination.

2 The firm patented an arch bridge design ("The Hammond and Abbott Arch Bridge", named after two of the founders). The design is not that used for this bridge, however. as apart from any other differences the bowstring does not have the distinctive cross-section of the White Bridge.

3 Bridge Files Ohio Historical Society (compiled by David A. Simmons, OHS)

4 C. E. Church, Wrought Iron Bridges Built by the Wrought Iron Bridge Co., Canton, Ohio. (Fitchburg, Mass: 1885). Illustrated pamphlet.

5 "Bridge Building" American Pictorial Monthly (Midsummer 1902): 25.

The article gives further details of Hammond's career. He began the Canton Bridge Company in 1891 with his son Vinton H. Hammond, and son-in-law John R. Reed. He was elected vice-president in 1898. His sons Geo. I., Vinton H., and Harry were general agents for the Canton Bridge Company. They were known as the 'Hammond Brothers'.

6 Wm. H. Perrin, ed., History of Stark County, Ohio (Chicago: Baskin and Batley, 1881).

7 Ibid.

8 Church, Wrought Iron Bridges by the Wrought Iron Bridge Co.

9 Wrought Iron Bridge Company, Canton, Ohio (1892?). Booklet published at the time of the Company's move in c. 1892.

10 All the information on Alexander Holley is from Alfred D. Chandler, Jr., The Visible Hand: The Managerial Revolution in American Business (Cambridge, Massachusetts: The Belknap Press of Harvard University Press, 1977) pp. 259-66.

11 See note 2 above.

12 Obituary. Engineering Record 34, (5 September 1896): 253.

13 Bridge Files, Ohio Historical Society (compiled by David A. Simmmons, OHS). Landor was a Life Member of the American Society of Civil Engineers. The information is taken from a copy of the "Permanent Biographical and Professional Record of All Members of the American Society of Civil Engineers" for Landor.

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Bridge Files, Ohio Historical Society (compiled by David A. Simmons, OHS).

** denotes material taken from the Bridge Files at the Ohio Historical Society.