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WHITE WATER CREEK BRIDGE
(Dubuque and Dunleith
Railroad Bridge (Approach Span))
Iowa Bridges Recording Project
Spanning White Water Creek,
4 miles S.W. of Bernard
Bernard Vicinity
Dubuque County
Iowa

HAER No. IA-51

BLACK & WHITE PHOTOGRAPHS

REDUCED COPIES OF MEASURED DRAWINGS

WRITTEN HISTORICAL & DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
Department of the Interior
P.O. Box 37127
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(Dubuque-Dunleith Railroad Bridge (Approach Span))

HAER No. IA-51

Location:	Spanning White Water Creek on County Road, 4.0 miles southwest of Bernard; Dubuque County, Iowa UTM: 15.672160.4685470 USGS: Fillmore, Iowa quadrangle (7.5 minute series, 1972)
Date of Construction:	1872
Designers:	John Piper and Jacob H. Linville [designers and patentees]
Builder/Fabricator:	Keystone Bridge Company, Pittsburgh, Pennsylvania
Present Owner:	Dubuque County, Iowa
Present Use:	Roadway bridge
Significance:	This bridge is a remaining span of a seven-span approach bridge built in 1872 to serve a larger seven-span bridge built in 1868 over the Mississippi River at Dubuque. The larger bridge was the first to span the Mississippi at Dubuque, and was one of the earliest of all Mississippi River bridges. The superstructures of both the approach bridge and the river bridge were fabricated and erected by the Keystone Bridge Company, one of the most important and long-lived bridge companies of the nineteenth century. This span is one of the oldest iron trusses still in use in Iowa, and is the only Keystone truss known to be in use in the state.
Historian:	Robert W. Jackson, August 1995
Project Information:	This document was prepared as part of the Iowa Historic Bridges Recording Project performed during the summer of 1995 by the Historic American Engineering Record (HAER). The project was sponsored by the Iowa Department of Transportation (IDOT). Preliminary

research on this bridge was performed by Clayton B. Fraser of Fraserdesign, Loveland, CO.

Early in January 1868, industrialist Andrew Carnegie visited Dubuque, Iowa, with Keystone Bridge Company engineer Walter Katte. Carnegie was vice president and partner in the Keystone company, which he had organized in 1865. The Pittsburgh based firm was basically a renaming and reorganization of the Piper and Shiffler bridge firm which Carnegie had organized in 1862. He felt that his personal attention was crucial to the success of Keystone's efforts to win the contract to build a railroad bridge across the Mississippi River between Dubuque and Dunleith, Illinois. This was a contract which Carnegie desperately wanted, because it played a crucial role in his plans to control certain aspects of the growing railroad business in Iowa.[1]

Building the structure, which Carnegie later characterized as "the most important railway bridge that had been built up to that time,"[2] would establish Keystone as a major builder of bridges across the Mississippi. The company would therefore be in an excellent position to build the other railroad bridges which Carnegie knew must eventually span both that river and the Missouri River. But the construction contracts for these bridges represented only the tip of the financial iceberg which lay underneath the surface of the Keystone operation. Carnegie also expected to profit from sale of the materials which his Union Iron Works would provide to the bridge company, from his share in the railroad companies that would benefit from the existence of the bridges, from the construction companies that built the railroads, and from commissions on the sale of bonds used to finance both the bridge companies and the railroads.

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[1]The account of Carnegie's visit to Dubuque is taken mainly from Andrew Carnegie, Autobiography of Andrew Carnegie (New York: Houghton Mifflin Co., 1920), 123-125. See also Alvin F. Harlow, Andrew Carnegie (New York: Julian Messner, 1959), 89. Information concerning Carnegie's bridge and railroad related business activities is taken mainly from Joseph Frazier Wall, Andrew Carnegie (New York: Oxford University Press, 1970), 269, 278-281. See also Harlow, 78; Harold C. Livesay, Andrew Carnegie and the Rise of Big Business (Boston: Little, Brown & Co., 1975), 54, 70; and John K. Winkler, Incredible Carnegie (New York: Vanguard Press, 1931), 106.

[2]Carnegie, 123.

Carnegie was instrumental in the formation of the Davenport & St. Paul Construction Company which was created to build a rail line north from Davenport, Iowa to St. Paul, Minnesota. The line constructed by this syndicate (which Carnegie served as treasurer) was to carry traffic which crossed the first bridge to span the Mississippi River - the Davenport-Rock Island Bridge (1856). The list of investors for this company was virtually identical to that of the Davenport & St. Paul Railroad Company, which counted Ohio Governor William Dennison among its backers.

Carnegie also played a crucial role in the formation of the Iowa Contracting Company in 1869, which was organized to build a railroad from Keokuk, Iowa to Nebraska City, Nebraska. This line would carry traffic which crossed the Mississippi on the Keokuk & Hamilton Bridge, which Keystone contracted to build in December of 1868. Carnegie, who took bonds and stocks in the Keokuk & Hamilton Bridge Company as payment for Keystone's contract, eventually became president of the bridge company.

Given the complex web of financial arrangements which Carnegie intended to spin in support of his empire, it is understandable that he would have a keen interest in the outcome of the contract for the Dubuque bridge. Upon arriving in that city, Carnegie found that the Dunleith and Dubuque Bridge Company had already decided to award the contract to the lowest bidder, a firm from Chicago.[3] But Carnegie was not about to give up. He went to work on the company directors, finding them to be "delightfully ignorant of the merits of cast- and wrought-iron. We had always made the upper chord of the bridge of the latter, while our rivals' was made of cast-iron. This furnished my text."[4] Picturing for these men the results of a steamboat striking against a bridge made entirely of cast iron, as opposed to one of cast and wrought iron, he claimed that, "In the case of the wrought-iron chord it would probably only bend; in the case of the cast-iron it would certainly break and down would come the bridge."[5] At this moment, one of the bridge directors enforced Carnegie's argument by stating to the board that on a recent

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[3]Carnegie does not name the competing firm. However, the only Chicago bridge contractor likely to have the capacity to build the type of structure required was the Boomer Bridge Works, run by Lucius B. Boomer. Together with brother-in-law Andros B. Stone, Boomer built the first railroad bridge across the Mississippi River between Davenport, Iowa and Rock Island, Illinois in 1856.

[4]Carnegie, 124.

[5]Ibid.

night he had run his buggy in the dark against a cast-iron lamp-post, which had broken to pieces.

Seizing the moment, Carnegie exclaimed "Ah, gentlemen, there is the point. A little more money and you could have had the indestructible wrought-iron and your bridge would stand against any steamboat. We never have and we never will build a cheap bridge. Ours don't fail."[6] The directors, however, proved to be as shrewd as Carnegie and informed him that his company could have the contract, provided that the bridge be built for the lower price bid by the Chicago firm. Carnegie agreed, and when the bids were opened on January 13, 1868, the Keystone Bridge Company was awarded the contract for the superstructure. The contract for the substructure went to Reynolds, Saulpaugh & Company of Rock Island, Illinois.[7]

The decision of the Dunleith and Dubuque Bridge Company board of directors to chose a cast- and wrought-iron design over one entirely of cast iron, for the same price, was quite sound. Cast iron is a brittle metal that has high compressive strength but low tensile strength (it doesn't stretch well) and a lack of ductility (it doesn't react well to shocks). Wrought iron, on the other hand, is equally strong in compression and tension. Changes in temperature affect cast iron more adversely than wrought iron, and the force required to cause rupture of cast iron is small compared to that for wrought iron. After the Civil War, bridge fabricators increasingly followed the lead of designer Wendell Bollman in using the far more expensive wrought iron for tension members, which were required to stretch, and cast iron for compression members. The combination of the two materials allowed bridge builders to keep costs at a minimum while insuring a certain degree of reliability.[8]

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[6]Ibid.

[7]History of Dubuque County, Iowa (Chicago: Western Historical Co., 1880), 637-638. In his account of this incident, which was written many years after the fact, Carnegie provided little information regarding the particulars of the bidding process. Given the ethics of business practice at this time, however, it is possible that Carnegie learned Keystone was not the low bidder before the bids were opened on January 13, and made his deal with the board of directors in a private meeting before that date.

[8]Eric DeLony, "The Golden Age of the Iron Bridge," American Heritage of Invention & Technology (Fall 1994), 8-22; Mansfield Merriman, Mechanics of Materials (New York: John Wiley & Sons, 1914), 55-59; David Plowden, Bridges: The Spans of North America (New York: Viking Press, 1974), 65.

The Keystone Bridge Company, after examining the results of extensive tests conducted on both types of material, concluded that upper chords of cast iron could be safely used in bridge construction if properly fabricated and designed. The preference of the company, however, was to use columns and compression chords entirely of wrought iron. Cast iron was only used in short blocks or flat, solidly-bedded plates, which were subjected to compressive strains, and, in some instances, in bases and capitals of posts, washers, gibs, etc. Should any portion be subjected to tensile strain, the safe limit was assumed at one and a quarter tons per square inch.[9]

The Dubuque-Dunleith Bridge was completed in December 1868, one month ahead of schedule at a cost of $800,000.[10] The 1,760 foot-long bridge, which was officially opened on New Year's Day, 1869, was originally accessible on the west (Dubuque) side by a wood trestle approach of about 2,400 feet which crossed the slough between First Street and the bridge. Over a period of years the City of Dubuque began filling in this slough, thus allowing a shorter trestle. In January 1872 the Keystone Bridge Company completed the erection of seven cast and wrought iron, eight panel pin-connected Pratt through trusses over the slough in

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[9]Keystone Bridge Company, Descriptive Catalogue of Wrought-Iron Bridges (Philadelphia: Allen, Lane & Scott, 1875), 18-21. Shortly after the publication of this catalogue, on the night of December 29, 1876, the cast- and wrought-iron Lake Shore and Michigan Southern Railroad bridge at Ashtabula, Ohio collapsed with great loss of life. Built in 1865, the bridge was the second and last adaptation of a Howe truss in an all iron design. The ensuing investigative report by the American Society of Civil Engineers condemned combination cast- and wrought-iron bridges in favor of all wrought-iron construction. As a result, it could be reported by T. Appleton, C.E., before a meeting of the Boston Society of Civil Engineers on February 6, 1878 that "The use of cast iron is becoming obsolete among builders of iron bridges. It is hardly ever used except for joint boxes at the ends of columns etc., and many builders find they can dispense with it even there, as experience has shown that it is not a reliable material." Engineering News, February 21, 1878, 60. The collapse of the bridge, however, had less to do with the choice of materials than it did with the adaptation of a Howe truss in an iron bridge.

[10]Randolph W. Lyon, Dubuque: The Encyclopedia (Dubuque, IA: First National Bank of Dubuque, 1991), n.p.

place of the wooden trestle. The White Water Creek Bridge is one of these spans.[11]

On Saturday, January 13, 1872 the seven spans were tested according to the common practice of the day. Two locomotives of the Illinois Central Railroad, with tenders fully loaded with coal and water, were placed on each span in succession from east to west, making a stationary load of about one ton per lineal foot of bridge. All spans passed the test. It was also found by observation taken under span number five, that under the load of one ton per lineal foot, moving at the rate of fifteen miles an hour, the deflection of the span was only 1/32" more than with the same load stationary.[12]

At some point between 1874 and 1889, three of these approach spans were removed.[13] In 1887, the same year that the High

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[11]Alex. Simplot, "View of Dubuque In 1872," A lithograph printed in History of Dubuque County, Iowa (Western Historical Company, 1880), frontispiece; 1875 Keystone Bridge Company Catalogue; F.B. Maltby, "The Mississippi River Bridges: Historical and Descriptive Sketch of the Bridges over the Mississippi River," Journal of the Western Society of Engineers 8 (August 1903), 459; John W. Reps, Cities of the Mississippi: Nineteenth-Century Images of Urban Development (Columbia, MO: University of Missouri Press, 1994), 266-267; U.S. Congress, House, Report of the Chief of Engineers: 1878-79, 45th Cong., 3rd Sess., Appendix X, "Reports Upon Bridging Navigable Waters of the United States," Chapter IV, "Description of Bridges on the Mississippi River From Saint Paul, Minn. To Saint Louis, Mo.," 983-987. The catalogue of the Keystone Company reports that eight identical shore spans were constructed at Dubuque for the Dubuque and Dunleith Bridge Company. However, it is clear from lithographs and newspaper accounts that only seven spans were erected in 1872.

[12]Dubuque Daily Times, 17 January 1872; Dubuque Herald, 17 January 1872.

[13]Evidence for the possible date of removal of the first three spans comes from bird's-eye lithographic views of Dubuque. One of these views, Alfred R. Waud, "Bridges on the Mississippi at Dubuque," in William Cullen Bryant, ed., Picturesque America, Or the Land We Live In 2, shows all seven spans in place in 1874. The other view, drawn in 1889, shows only four approach spans. See H[enry] Wellge, "Perspective Map of City of Dubuque, Iowa" (Milwaukee: American Publishing Company, 1889), a lithograph on exhibit at the Dubuque County Historical Society, Dubuque, Iowa. Both of these lithographs are reproduced in Reps, 266-270. The Wellge view, however, is too small in reproduction for the details

Bridge (wagon bridge) was opened immediately adjacent to the railroad bridge, the City of Dubuque and the Illinois Central Railroad spend a great deal of money on civic improvements. These included a new passenger station and filling of the sloughs with land.[14] It is quite possible that the two spans known to have been acquired by Dubuque County were obtained at this time. One of these spans is the White Water Creek Bridge, and the other is the bridge which formerly spanned the Little Maquoketa River. This second bridge was replaced approximately two years ago and is now owned by the Dubuque County Conservation Board. It sits in the weeds next to a heritage trail just off of Highway 52 at Clay Hill Road, approximately six miles northwest of Dubuque. The fate of the third span is unknown. The Iowa Department of Transportation Structure Inventory and Appraisal sheets for the White Water Creek Bridge have long given a construction date of 1890, which provides some indication that the County actually erected the bridge in its present location at about that time.

The main river span of the Dubuque-Dunleith Bridge was designed for the use of small steam engines and was never intended to support the heavier locomotives in use towards the end of the century. Therefore the bridge required repair and renovation in 1893, with the draw span being rebuilt. In 1899 there was a more substantial rebuilding of the entire bridge, which included filling of the sloughs and reconstruction of the western approach. The first river span on the Dubuque side was replaced by a solid earth embankment, which shortened the bridge by 225 feet.[15] At this time the remaining four approach spans were removed. Because the work was done by the railroad, it is probable that it maintained ownership of these spans. The eventual fate of these trusses is unknown, but given that they were made of iron they were probably not of any further use to the railroad. Therefore, it is assumed that they were scrapped.

The seven approach spans were identical Linville and Piper patent trusses, each a 93′ long, eight-panel, pin-connected Pratt through truss with inclined end post and riveted, wrought-iron Keystone columns. The upper chord has two channels with cover plate and lacing while the lower chord has two looped square eyebars on the outer panels and four looped square eyebars on the middle four panels. The verticals are riveted Keystone columns with two looped square eyebars at the hip. The diagonals are

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to be made out.

[14]Frank T. Oldt, ed. History of Dubuque County, Iowa (Chicago: Goodspeed Historical Assoc.: 1911), 189.

[15]Dubuque Herald, 7 November 1899; Maltby, 457.

looped square eyebars and the lateral bracing features round eyerods with turnbuckles. The struts are slotted cast-iron I-beams, and the floor beams are I-beams, U-bolted to the verticals. Because the approach bridge was not designed for, and posted against, pedestrian traffic, there were originally no guardrails. At some point the White Water Creek Bridge acquired lattice guardrails (probably of steel), and the span over the Little Maquoketa River acquired steel plate guardrails (now removed). Each span has cast-iron hip blocks, bearing shoes, portal knee braces and vertical connectors.

These spans featured the characteristic "Keystone" wrought-iron cylindrical hollow column, which was patterned after a design first used in 1861 by Linville on the 192-foot span over the Schuylkill River near Philadelphia, Pennsylvania. Following the construction of that bridge, Linville was granted patents for columns made of sections, united by transversely intersecting tie-bolts. This design is perhaps the most striking feature of the White Water Creek Bridge. It was claimed by Linville that the swelling of the column towards the center, along with separation of the sections, would provide greater resistance to flexure and allow for the interior of the columns to be inspected for corrosion and repainted.

According to the 1875 Keystone Catalogue, "the cylindrical form of strut or column is the best adapted, theoretically, to resist compressive force, applied vertically, in the direction of its axis. A hollow cylinder, of uniform thickness, is the only form of strut offering uniform resistance to flexure, transversely, in every direction, and affording the highest resistance with the least expenditure of material."[16] Despite this claim, the lateral struts of the White Water Creek Bridge are slotted I-beams.

Several Piper and Linville design innovations, in addition to the use of hollow cylindrical columns, are claimed in the 1875 Keystone catalogue for their single intersection through trusses. These include wrought-iron upper chords, weldless chord links, pin connections, adjustable counters, suspended cross-girders, and improved safety floors. Although not all of these design features can said to be unique to the Keystone company, it is clear that the association of Piper and Linville was most productive.

John Piper, the lesser known of the two patent holders of this truss design, first met Andrew Carnegie in 1856 when Piper was chief mechanic for the Pennsylvania Railroad Company shops in

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[16]Keystone Bridge Company, 25.

Altoona. Carnegie, who was then assistant to railroad general superintendent Thomas Scott, found himself immediately impressed with Piper and the two men struck up a close friendship. They worked together in 1861 on rebuilding the Long Bridge across the Potomac River, and in 1862 Carnegie suggested to Piper that he and general bridge supervisor Aaron Shiffler should form an independent company for the erection of railroad bridges. This action was taken in February 1862 with Carnegie, Scott, Piper, Shiffler, and company chief engineer for bridges and buildings Jacob H. Linville as partners. Each partner received a one-fifth interest for $1,250.[17]

Much of Piper's work for the railroad involved the rebuilding of wooden bridges that had been destroyed by fire, a common occurrence in the days preceding the introduction of metal railroad bridges. Piper had often discussed with Linville designs for iron bridges that would have the flexibility of wood, and several patents were taken out by the two men prior to construction of the first iron bridge in the Altoona shop. It was the success of this small bridge, which replaced an earlier wooden bridge on the line, that encouraged Carnegie to suggest the formation of the Piper & Shiffler bridge company.[18]

Linville was still on the staff of the Pennsylvania Railroad Company in 1862 when Congress granted the right to a subsidiary of that line, the Pittsburgh, Cincinnati, Chicago & St. Louis Railroad, to build a bridge across the Ohio River at Steubenville. The 320-foot iron span, the first long-span truss in the country, was completed in 1864. Its erection required the provision of special tools, machinery, testing apparatus, and appliances of erection due to its unusual dimensions, length, and proportions. This included a 500-ton-capacity machine designed by William Sellers of Philadelphia in 1863 that allowed the testing of full-sized structural members to the point of failure.[19]

The experience of erecting this bridge no doubt convinced the partners of the Piper and Shiffler company that a significant expansion of the firm's capabilities would be necessary to build the huge spans needed to cross the Ohio, Mississippi, and Missouri. Therefore, the company was reorganized with an initial

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[17]Wall, 188-189; Carnegie, 116.

[18]Carnegie, 115-116; Livesay, 53; Harlow, 76; Hendrick, 128; Wall, 228. The 1875 Keystone Catalogue suggests that this bridge may have been built on the Junction Railway. See page 25.

[19]Delony, 18; Plowden, 69; Keystone Bridge Company, 12.

capital of $300,000 in 1865 with Linville as president, Piper as general manager, Shiffler as assistant general manager, and Walter Katte as engineer. Scott served as a silent partner, subscribing to half of Carnegie's $80,000 stock investment. The original bridge works of the Piper & Shiffler company were enlarged and improved, and the company immediately began making a profit.[20]

On January 20, 1868, shortly after Carnegie had successfully wrapped up the contract for the bridge at Dubuque, he wrote a letter to the directors of the Keystone company urging them to expand the plant facilities of the firm by building a new blacksmith shop, purchasing additional machinery, and acquiring land across the Allegheny River for a new foundry so that the company would have the necessary capacity to win further contracts for the really "big bridges at St. Louis and Omaha."[21]

In 1872, the year the Dubuque approach spans were erected, the Legislature of Pennsylvania authorized the Keystone company to increase its capital stock to $1,500,000, at which time it erected new works of enlarged capacity, including machine-shops, smith-shops, riveting-sheds, bolt-cutting and testing houses, pattern-shops, a large iron building for a foundry, offices, stables, and "all the accessories of a first-class establishment".[22]

The Keystone Bridge Company was certainly a first-class establishment in 1872, and until its absorption along with twenty-four other firms by the American Bridge Company in 1900, could be counted as one of the most important manufacturing enterprises in American industrial history. The White Water Creek Bridge is the only product of this company known to still be in use in the state of Iowa. It is therefore important not only for its association with an early Mississippi River bridge, but also as a rare extant example of the work of the Keystone company.

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[20]Keystone Bridge Company, 7; Wall, 228-229.

[21]Wall, 270-271.

[22]Keystone Bridge Company, 7.

APPENDIX
IMPLICATIONS FOR FURTHER RESEARCH

Several questions concerning the White Water Creek Bridge arose during the research and writing of this report. Some of these questions, due to limitations in the scope of the Iowa Historic Bridges Recording Project, have remained unanswered. It is suggested that scholars interested in this bridge consider pursuing the following:

1. Which firm was the original low bidder for the Dubuque-Dunleith Bridge superstructure construction contract?
2. What was the contract amount for the river bridge, and for the approach spans?
3. When were the first three spans of the approach bridge moved from their original location?
3. Where did the third, "missing" span taken down between 1874 and 1889 end up?
4. Why does the 1875 Keystone Catalogue indicate that the Dunleith and Dubuque Bridge Company bought eight 93' spans, instead of the seven that were erected?

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ADDENDUM TO
WHITE WATER CREEK BRIDGE
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Spanning White Water Creek on County Road
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This appendix is an addendum to a 13-page report previously transmitted to the Library of Congress.

APPENDIX: ADDITIONAL REFERENCES

Interested readers may consult the Historical Overview of Iowa Bridges, HAER No. IA-88: "This historical overview of bridges in Iowa was prepared as part of Iowa Historic Bridges Recording Project - I and II, conducted during the summers of 1995 and 1996 by the Historic American Engineering Record (HAER). The purpose of the overview was to provide a unified historical context for the bridges involved in the recording projects."