Jacob Hays Linville

By Frank Griggs, Jr., Ph.D., P.E., P.L.S.

Linville was born in Pequea, Pennsylvania in 1825, the son of a farmer. No known photograph of him exists. After attending local schools he enrolled in Union College in Schenectady, New York, receiving a BA degree in 1848. He wrote, "The subject of bridges was not embraced in the course of study at Union College. I pursued the regular classical course, and took many optional studies from the scientific course, including analytical geometry and the calculus."

After teaching and studying law in Pennsylvania for a short time, he changed his career goal and became a surveyor under William H. Wilson in the summer of 1852. Between 1854 and 1857 he worked on the Philadelphia, Media & Westchester Railroad. Then he joined Wilson as Assistant Resident Engineer on the middle division of the Pennsylvania Railroad. In this position he began his bridge-building career. The standard Pennsylvania Railroad Bridge (Linville built several) was a Pratt truss with a cast iron supporting arch designed by Herman Haupt, who worked on the line until 1856. Linville married Celeste Rush in 1857, and they had one son.

Linville's first major truss was over the Schuylkill River at Philadelphia. The Arsenal Bridge, built in 1861, consisted of two fixed 192-foot spans flanking a 192-foot center swing span. In 1862, he received his first patent (No. 34,183) for a double intersection truss with cast iron upper chords, wrought iron bars for diagonals and wrought iron links for the lower chord.

Linville's next major effort was at Steubenville, Ohio, over the Ohio River. Linville wrote, "The bridge company desiring the completion of the structure in 1863, without in any manner obstructing the channel, no system of wrought iron construction then in use appeared available. A selection had consequently to be made from the plans of composite structures in use, none of which had been extended to spans of so great extent. The 'Linville and Piper' patent truss was modified to meet the requirement of this particular locality and adopted by the bridge company." He agreed to prepare a design, but only if J. Edgar Thomson, President of the Pennsylvania Railroad, allowed him to build a large testing machine that would make it possible for him to test full-size members. He wrote, "Owing to unavoidable delays in the preparation of this machine it was possible to test only a few of the posts, chords, bars, etc. but the results demonstrated conclusively the accuracy of the data from which the proportions of the tubes had been determined." He described the bridge in an article in the *Journal of the Franklin Institute*. It consisted of four 235-foot deck spans, followed by a main channel span of 320 feet and then three deck spans of 210 feet. Theodore Cooper wrote, "The era of long span truss bridges in America may be considered as dating from the building of the first bridge over the Ohio River at Steubenville…by Mr. J. H. Linville."

Eads Bridge – St. Louis – Mississippi River

Linville's next bridge, built about the same time across the Monongahela River at Pittsburgh, was called the Panhandle Bridge. It had five river spans with four being deck spans, 186 feet long, and one 260-foot-long through truss, all on the double intersection pattern. The through truss was very similar in detail to the Steubenville Bridge. All trusses were for a double track.

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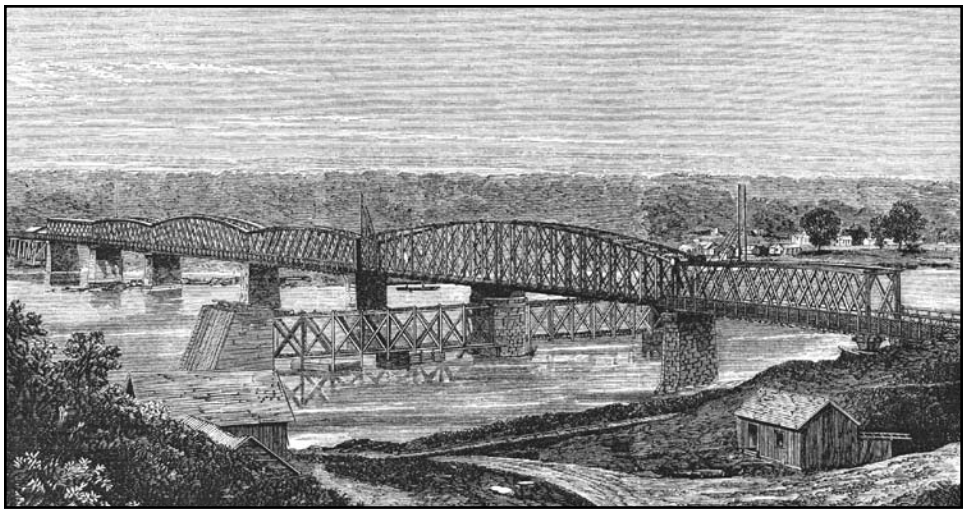
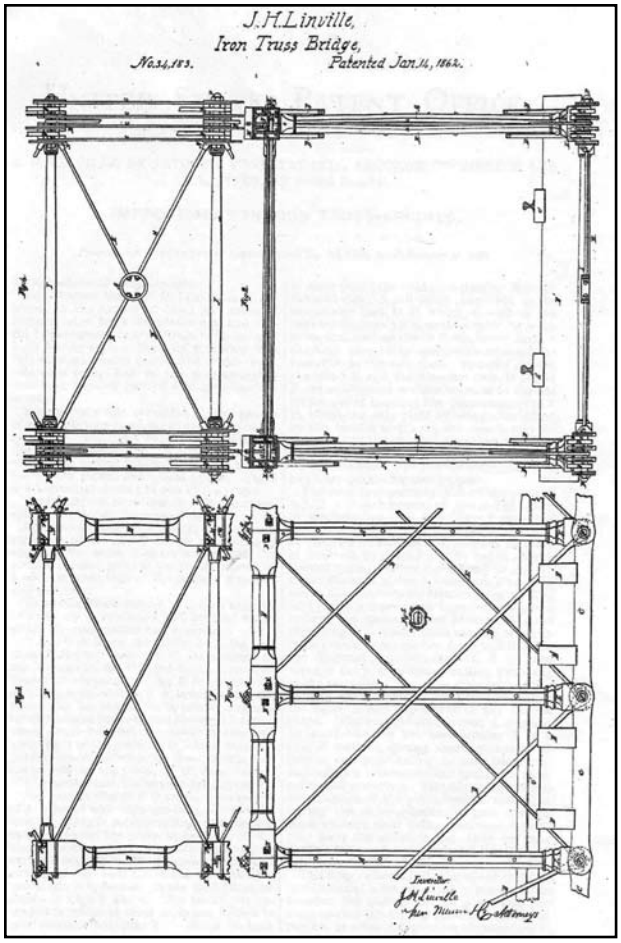


Kansas City Railroad Bridge – Missouri River.



1862 patent drawing.

Linville's next major span, built in 1865, was once again over the Schuylkill River. Based upon this bridge, Linville and Piper obtained patent No. 50,723 for a bridge entirely of wrought iron.

In 1867-68 he designed and built a bridge for the Dubuque and Dunleith Bridge Company over the Mississippi River at Dubuque, Iowa. Starting on the Iowa side, it had four spans of 225 feet, one span of 250 feet, a swing span of 360 feet, and another span of 250 feet.

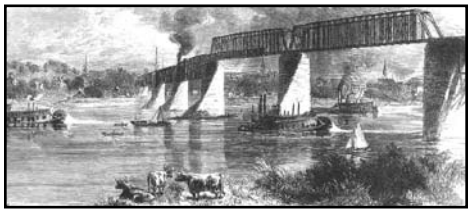
Linville received his third patent (No 84,288) in 1868 for a truss bridge. It was a kind of lattice truss where he preloaded his tension diagonals. There is no evidence that he ever actually built a bridge to this patent.

In a competitive bidding project for a bridge across the Missouri River designed by Octave Chanute, the Keystone Bridge Company received a contract in 1867 to build the superstructure. Chanute indicated in his call for proposals that bidders could submit their own designs for the simply supported and swing spans. Keystone proposed building the fixed spans, combination wood and iron trusses, to Chanute's design, and the 360-foot swing span, iron trusses, to its own design. This was the first bridge across the Missouri River and required Chanute to overcome very difficult pier foundation problems. It opened in 1869. Chanute and his assistant, George Morison, published a report entitled "The Kansas City Bridge" that received a wide distribution.

In 1869, Linville returned to the Schuylkill River to replace Charles Ellet's wire suspension bridge at Callowhill Street at Fairmount Park. It was the first one he designed that was not for railroad traffic. It was a double deck bridge with a single span of 340 feet and a width of 50 feet.

One of the largest contracts Linville and the Keystone Bridge Company obtained was for two bridges for the Baltimore & Ohio Railroad to cross the Ohio River. The first bridge was between Benwood, West Virginia and Bellaire, Ohio. The second was downstream, connecting Parkersburg, West Virginia with Belpre, Ohio. Both bridges opened in 1871, and the total cost was exceptionally high, being over $2,237,000.

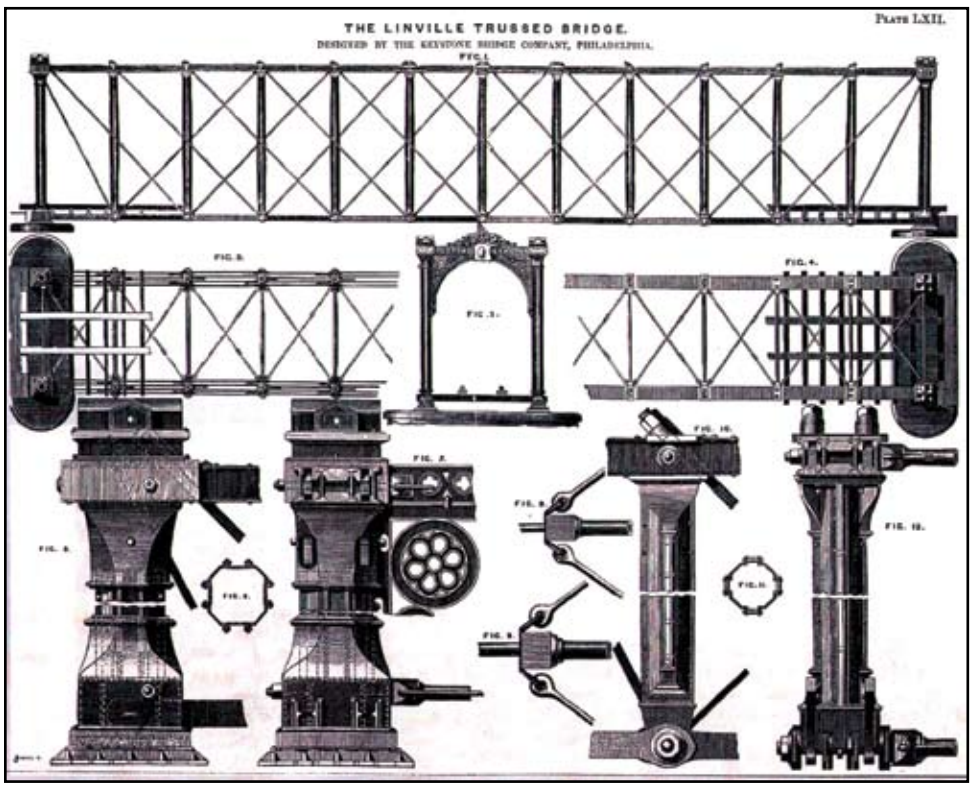
The Benwood Bridge was a high level one, set by law 90 feet above low water, and consisted on the Bellaire side of a long masonry approach of 43 arches followed by two short-span Bollman Trusses and then four main channel spans of 347.9, 207, 235 and 242 feet, plus seven more Bollman Trusses to the Benwood side of the bridge. All trusses were deck trusses with the exception of the two main channel spans, which were through trusses. Overall, the channel length was approximately 1,435 feet.



Parkersburg Bridge – Ohio River

The Parkersburg Bridge had six channel spans. Four were deck spans varying between 209 feet and 315 feet, and the two main river spans were through trusses with lengths of 348 feet 9 inches and 347 feet 9 inches. The Parkersburg approach consisted of 22 Bollman Trusses with spans varying from 50 feet to 100 feet. The Belpre approach consisted of six Bollman Trusses varying in length from 121 feet to 124 feet.

The Newport and Cincinnati Bridge, Linville's next record-setting bridge, consisted of four spans with all trusses being through trusses – the main span of 420 feet, two at 220 feet and a fourth of unknown length. Keystone and Linville were required by Congress to build a bridge 100 feet longer than the Steubenville Bridge, which a few years earlier was considered impossible by

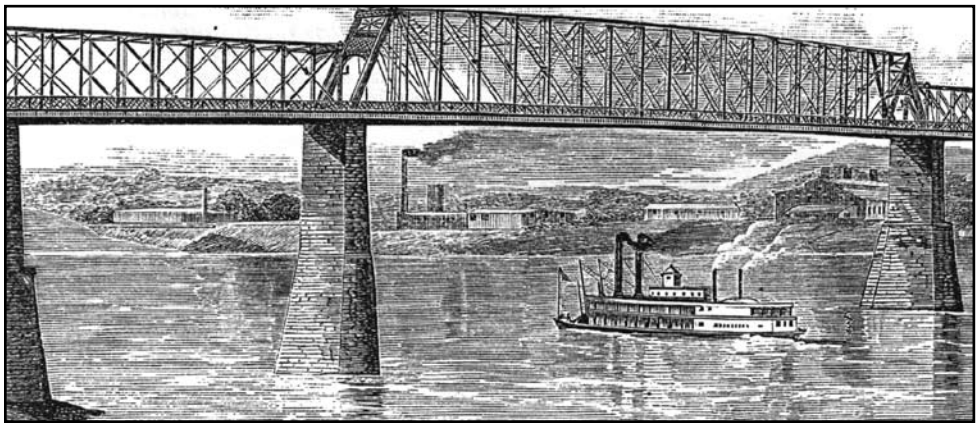


1865 patent drawing.

some. The bridge utilized many Steubenville details, except there were no cast iron parts. It opened in 1872. Due to several changes in the span length and height above the river made by Congress, Linville had to make changes in the design after fabrication began. He never liked the final appearance of the bridge.

In the same year, Linville's Keokuk and Hamilton Bridge over the Mississippi River opened. It was very similar to the Dubuque Bridge, with a swing span of 376 feet 5 inches, two fixed spans of 253 feet 6 inches and eight fixed spans varying in length from 148 feet 4 inches to 161 feet 7 inches.

Linville and the Keystone Bridge Company became involved with the design and construction of a bridge over the Mississippi at St. Louis in 1867. James Eads was selected as Chief Engineer for the bridge, and proposed a three-span arch bridge built with steel. Linville was named consulting engineer for the project. After reviewing the plans, he told Andrew Carnegie, "The bridge if built upon these plans will not stand up; it will not carry its own weight…I cannot consent or imperil my reputation by appearing to encourage or approve of its adoption. I deem it entirely unsafe and impracticable, as well as in fault in the quality of durability." Carnegie responded, "Well Captain Eads will come to see you, in talking over the matter explain this to him gently, get it into proper shape, lead him into the straight path and say nothing to others." Eads sent more detailed plans to Linville for his review and suggestions. Linville, apparently still believing that Eads's plans were faulty, submitted his own plan to build the bridge in three spans over the main channel. For the first time, he proposed to build the spans off site on pontoons and float them down the river and place them on the piers, thus cutting out the necessity of falsework. The Board did not like Linville trying to substitute his design for Eads's, and he was terminated as consulting engineer.



Newport/Cincinnati Bridge

Over time, the Keystone Bridge Company made some concessions to Eads and was awarded the superstructure contract. The all-steel bridge Eads had planned ended up with a large amount of wrought iron and a different grade of steel, chrome steel. Final span lengths were 520 feet over the center of the channel, with two 502-foot side spans. It opened in 1874. It was a double deck structure with the railroad on the lower deck, and carriages and pedestrians on the upper deck. It took three years longer to build than Eads had promised and cost about $6 million more than he had estimated ($5 million).

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Linville received another patent on a variation on his Keystone Column (#132,475) in 1872. In 1873, he was granted another patent, (# 145,114) for Truss Frames for Bridges.

The Cincinnati Southern Railroad Bridge over the Ohio River was Linville's next major structure. In 1873, it was becoming customary to invite "public tenders for both the design and construction of these bridges, furnishing sections of the rivers, with a general specification giving the loads to be provided for, and the maximum strains allowed upon the iron." The length of span was prescribed in the specifications for the bridge, along with a certain quality of iron, and tests that were required on the materials before beginning construction. The Bridge Company's specifications set the span lengths at 525 feet for the main span, two spans of 300 feet, four spans at 110 feet and a swing span of 370 feet. Clearance above the river was 100 feet. With this span, 100 feet longer than the Newport Cincinnati Bridge just upstream, Linville once again accomplished what many had considered impossible.

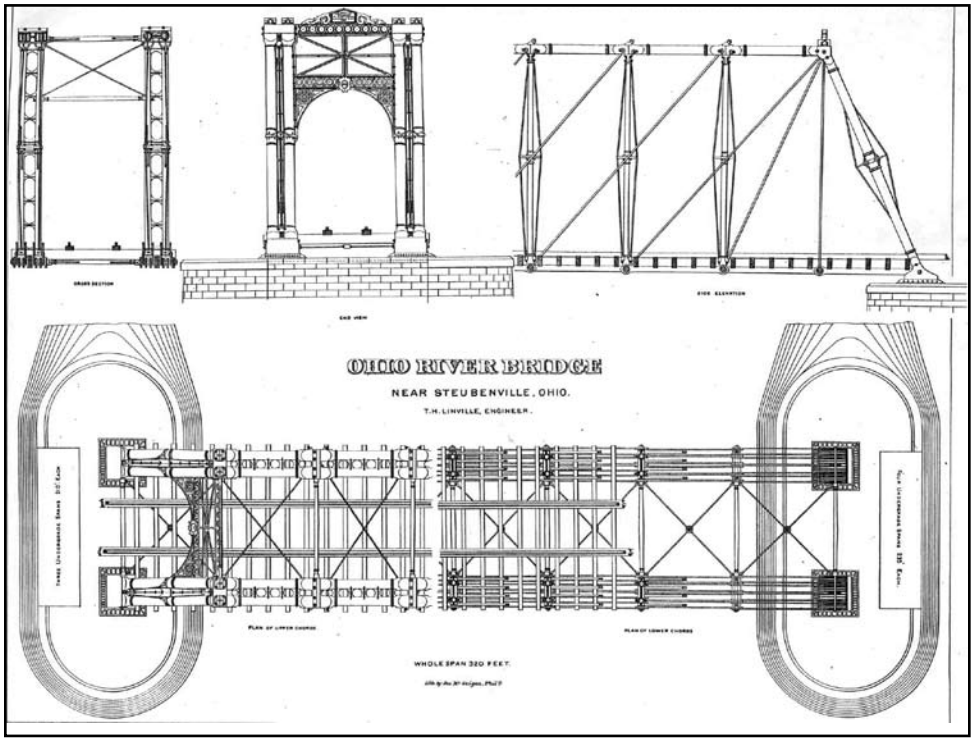
Cincinnati Southern Bridge – Ohio River.

In 1876, Linville was selected to design the structure for the Metropolitan Elevated Railroad Company along Sixth Avenue between Canal Street and 59th Street in New York City. In the late 1870s, he also built long-span pivot swing bridges for the Central Railroad of New Jersey at Amboy and Newark.

Linville was one of the most prolific bridge builders from 1860 to 1880, when railroads began to cross major rivers of the country. He set the record for railroad truss bridge spans on three occasions. He was by all measures one of the giants of 19th century bridge building. He, however, did not seem to agree with this assessment. He summarized his career in the following words:

I became engineer of bridges and buildings, when the designing of the bridges and building for the mainline and dependencies was entrusted to me. In the Keystone Bridge Company the case was similar. The executive work was done by me and the designs were mainly made under my direction. There was no time to fully mature anything, no leisure for study or calm reflection. My energies were exhausted and health broken down by the incessant demand for estimates and plans; and in traveling involved in making proposals, visiting work in progress, and in settlement of questions growing out of work under construction…I care not for fame, and only fear that your generosity and friendly feeling may lead you to give me greater credit and praise than I merit. As I utterly despise all that I ever constructed, and with the present light cannot comprehend why I did not accomplish something better. I presume every tyro from the schools now wonders why mistakes, now so apparent were made, but no one can realize and understand these things who has not groped in untrodden paths as did the early builders of American bridges.

Linville's memorialist noted: "Personally, his disposition was singularly loving and sympathetic, and all with whom he came in contact were greatly attracted to him." He died in 1906 a month short of his 81st birthday, and is buried in Philadelphia, his home for over 30 years.▪



Steubenville Bridge – Ohio River.

Dr. Griggs specializes in the restoration of historic bridges, having restored many 19th Century cast and wrought iron bridges. He was formerly Director of Historic Bridge Programs for Clough, Harbour & Associates LLP in Albany NY, and is now an independent Consulting Engineer. Dr. Griggs can be reached by email at ***fgriggs@nycap.rr.com****.*