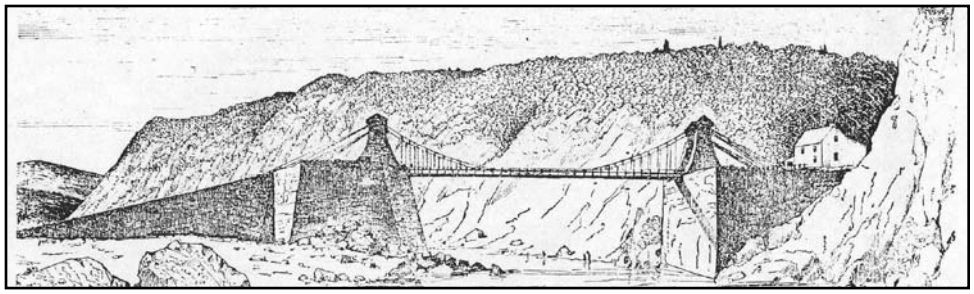
James Finley

By Donald Sayenga



Potomac Chain Bridge.

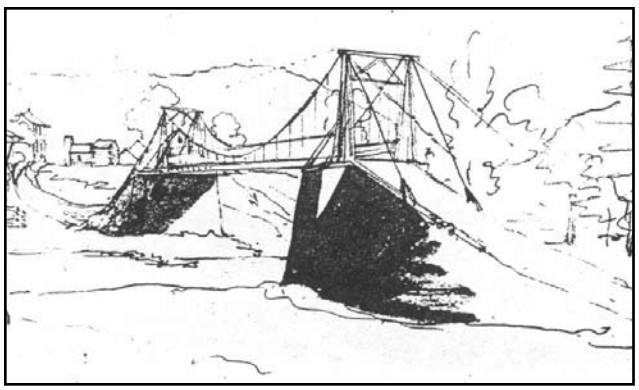
In the pre-natal period of American civil engineering theory and practice, the achievements of James Finley (1756-1828) of Uniontown, Pennsylvania, often have been overlooked, partly because so little is known about his personal life. In 1808 he was granted U.S. Patent X883, the first American patent for suspension bridges. Unfortunately, his original papers have disappeared and the patent file itself was destroyed by fire in 1836. We do know Finley was born in Ireland. He immigrated to the United States prior to 1769 and settled in what is now Fayette County, a region then claimed by both Pennsylvania and Virginia.

After the American Revolution, the border dispute between the two states was settled by extension of the Mason Dixon Line. Finley became active as a Federalist politician, supporting the government during the 1794 citizen's tax revolt. He also served the public for many years as Justice of the Peace, County Commissioner, Judge of the Court of Common Pleas, and briefly as a member of the Pennsylvania legislature. For this reason, he is usually called Judge James Finley. He was active with the local Presbyterian Church, where he functioned in a leadership role as an elder when the Laurel Hill congregation split into halves over a doctrinal dispute.

Judge Finley has been cited as Father of the Modern Suspension Bridge, a well-deserved accolade based on his efforts to introduce this style of structure in the form now used all over the world. In June 1810, he presented his theories and methods in an elegant essay appearing in a Philadelphia magazine, *The Port Folio*. The essay was later expanded into an instructional booklet published at Uniontown the following year. Apparently he used the booklet as a sales tool, furnishing it to other builders in exchange for a patent license and a fee. In the essay, Finley stated he built his first bridge in 1801. We have no record that he built any other bridges, yet eight other Finley bridges already had been built by licensees by the time the booklet was published.

Suspension bridges with iron chains, hung in curves, had been well known in Asia for hundreds of years. In all documented cases, the traveling surface was laid directly upon the catenaries of the supporting cables. James Finley's treatise was the first to emphasize the significance of a rigid, level roadway. He achieved this by elevating his chains above the roadway on A-frames at the piers or abutments to a height of two-thirteenths of the span. By experimenting with models, he had learned this sag ratio allows a chain to "support as much weight as it could bear". In his pamphlet, he explained his method for measuring and connecting vertical suspenders. He included detailed instructions for creating adequate anchorages. When emphasizing the low total cost of a chain bridge vs. a timber truss structure, he added a recommendation with an eye toward safety: "The chains in all cases shall be able to support five or six times the weight of the bridge".

James Finley's 1808 patent drew a lot of attention, some of it negative. In 1812, Thomas Pope published a book advancing his own theories about the construction of wooden bridges. He reprinted Finley's theories as a "promotion of fair play" accompanied by a half dozen negative criticisms. Pope concluded that Finley's bridges were "mere temporary expedients". Conversely, in 1813 one of the foremost of the early American civil engineers, Benjamin Henry Latrobe, asserted: "It would give me sincere satisfaction if anything I could suggest were of any service in enabling Judge Finley to overcome any inconvenience or objection which may exist in the general introduction of the chain bridge throughout our country." Latrobe proposed a corkscrew twist of the links as an improvement over conventional chains made from bar iron.

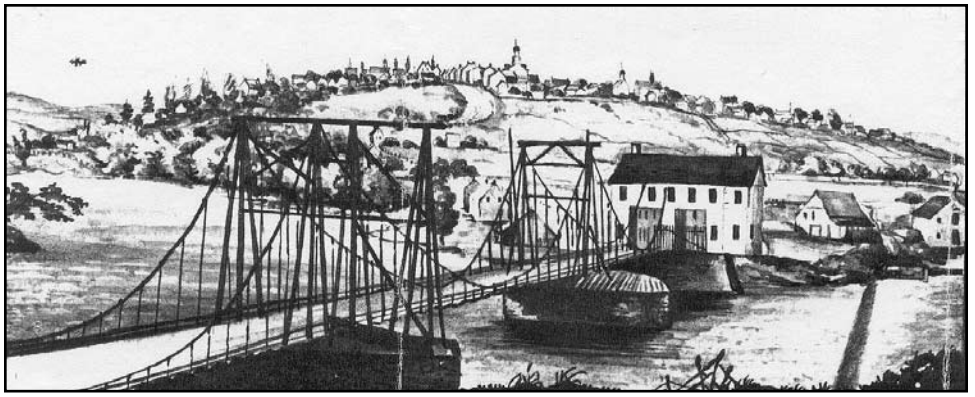


Latrobe sketch, Juniata Crossings Bridge. Collection of the Maryland Historical Society.

Finley's activities were publicized in Europe by the French engineer Joseph L.E. Cordier, whose two-volume *Histoire de la Navigation Intérieure* (1819-20) devoted a large portion of his chapter on American bridges to the subject. Cordier used the term idée ingénieuse when describing the chain bridges. It was the American licensees, however, who brought the Finley bridges into prominence. John Templeman built at least four, and he also obtained two bridge patents of his own as spin-outs. Templeman's bridges over the Schuylkill (1809) and the Merrimack (1810) were cited as outstanding examples by Cordier. The site of his Potomac bridge (1808) is still called Chain Bridge, VA to this day. Another licensee, Jacob Blumer, built at least three chain bridges over the Lehigh. The total number of Finley patent chain bridges that were built remains undetermined. Professor Eda Kranakis of the University of Ottawa has identified 21 sites from Massachusetts to Kentucky, and several others are mentioned occasionally in contemporary literature.

Most of the chain bridges built in Finley's lifetime were basic single span structures supported by two chains, with the roadway hung between the chains. Although some of the first bridges failed prematurely, others demonstrated exceptional longevity. Two fundamental causes of the early failures were ascribed as: inadequate support from chains and fixtures that were used, or decay due to inadequate weather protection of the wooden structural components.

In January 1812, Finley published a letter in a Philadelphia newspaper defending his ideas. Lamenting a collapse in Kentucky, he insisted: "no part of the chain bridge has failed in any instance, nor has any of the arrangements



Rufus Grider sketch, Allentown Bridge. Collection of Moravian Archives.

proposed been found improper." He attributed the problem to an "obstinate" refusal to assure "the chain shall be able to support at least five times the weight of the bridge". As for decay of timbers, he emphasized any bridge built of wood anywhere would face that identical danger; the larger the bridge, the more wood and the greater hazard. Ultimately it was British civil engineers, starting with Samuel Brown, who adopted a practice of using pinned eye-bar chains made from drilled plates which became the norm in place of Finley's bar-link chains. In America, large barn-like enclosures similar to the weatherboarding used for wooden "covered" bridges, was added to protect the A-frames of the longest lived Finley bridges.

Although Finley's first bridge over Jacob's Creek in Pennsylvania was dismantled in 1833, others survived until modern times and were subjected to considerable scientific structural analysis. Of these, the best known and most studied was Templeman's span at Deer Island, MA, usually called the Essex-Merrimack bridge. He began work on this bridge in partnership with a carpenter named Carr, and in conjunction with Timothy Palmer whose earlier wooden bridge on the site they removed. By erecting substantial A-frames on the existing abutments, ten chains were hung across the main channel of the Merrimack River. From these chains the 240 foot roadway was suspended. The bridge opened for travel in 1810. The chains gave way in 1827, and were immediately repaired by dividing the roadway into two separate parallel spans augmented with extra chains. In 1868, it became a public highway. In 1894, the bridge was upgraded by reinforcing the easternmost span using wire cables and a wooden stiffening truss to allow street railway traffic across. After 99 years of service, the Massachusetts DOT dismantled the chain bridge in 1909, replacing it with a wire cable bridge built on similar lines, still in service. The original iron links were taken to Cornell University for study.

In 1827, another very unusual chain bridge was built over the Merrimack by Thomas Haven. Known as the Newburyport-Salisbury bridge, it had three main spans (201, 212, and 221 feet) and two half-spans (117 and 153 feet) with a draw bridge inserted in the south approach. There were two separated wooden roadways. The chains supporting this bridge were almost 1000 feet in length. The bridge served without incident until 1840, when it was purchased by a railroad company and dismantled, permitting the timbers to be re-used for construction of a double-deck bridge on the same piers. In1903, Nathaniel Haven, a grandson of the builder, used his grandfather's original notes and drawings to prepare a blueprint of the 1827 bridge which he presented to the Historical Society of Old Newburyport. In 1999, the blueprint was rediscovered by Eric DeLony of HABS-HAER.

The patriarch of all Finley bridges was built by Jacob Blumer at Lehigh Water Gap, PA (*Figure 1*). First opened for travel in 1826, the structure survived flood damages in 1841, 1857, and 1862, and the chains withstood a severe fire in 1926 which destroyed the A-frame on the westernmost pier. Although it was rebuilt immediately after the fire, state transportation officials became concerned about the safety of the bridge based upon its age alone. They built a new steel truss bridge nearby. As soon as the new one was completed, the chain bridge was dismantled. With the exception of the periods when it was closed for repairs, this bridge was in continuous use for 110 years. One of the anchoring abutments is still in place, in good condition. Six of the iron links, each about 8 feet long, are preserved in a park at Palmerton, PA.

During a March 15, 2008, symposium at Lafayette College, sponsored by the National Canal Museum, Professor Emory Kemp of West Virginia University said: "The establishment of an iron industry in western Pennsylvania was essential to enable Finley to erect the world's first level-deck chain suspension bridge...In two seminal papers... James Finley proclaims his new suspension bridge invention. These concise papers presenting a wealth of engineering details reveal Finley's knowledge of overseas bridge developments. He also lets the reading public know of his appreciation of the mechanical properties of wrought iron as well as his knowledge of the catenary curve and what we would call the funicular polygon. In an age when master builders produced designs with little or no engineering sensibilities, Finley overcomes this lacuna in engineering design by producing a method for detailed analysis..."

In 1811, Judge Finley wrote: "When it is considered that a thread of wire or a bar of iron of any size may be extended more than three miles before it will break with its own weight...it is impossible to resist the idea that something further may be done in the art of bridgebuilding than has yet been accomplished...Let us pursue the idea of extension to 1500 feet span without any middle pier...I shall at this time only take the liberty of asserting that these things are fairly practicable..." In April 2008, the National Association of Chain Manufacturers secured endorsement from the Pennsylvania Historical and Museum Commission to erect a historical marker at Uniontown, commemorating the bicentennial of James Finley's innovative chain bridge patent.▪

Donald Sayenga is Executive Director of the National Association of Chain Manufacturers, Tucson, AZ. He has written more than one hundred articles about the history of technology, specializing in research about early structural applications of wrought iron.

Figure 1: Lehigh Water Gap Chain Bridge. Central span 160 feet, with two half spans 80 feet each. Dismantled 1933. This photograph, c. 1900, is from the collection of the National Canal Museum, Easton PA.