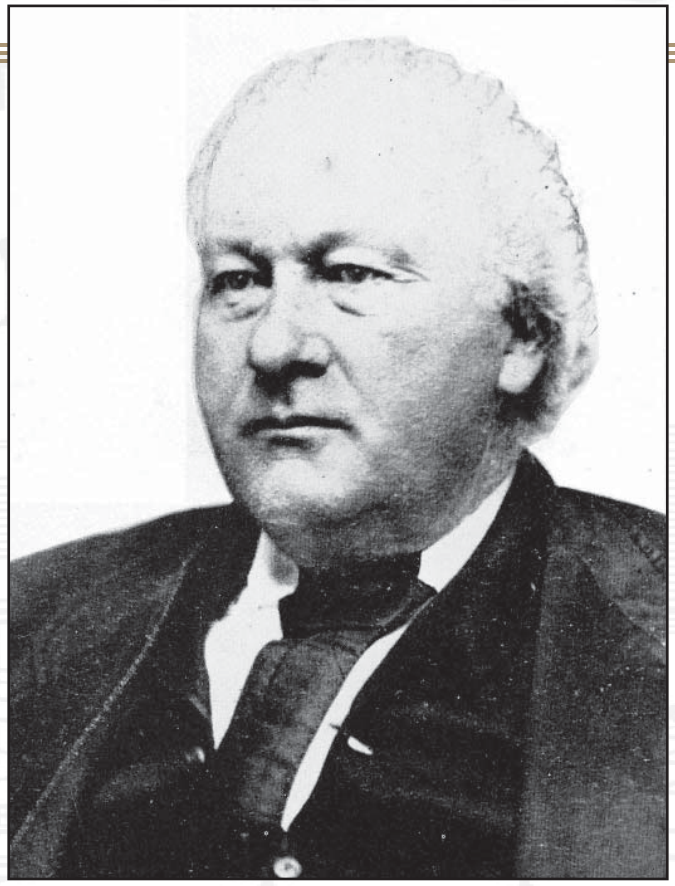
A Self-Taught Engineer…

Wendel Bollman (1814 – 1884)

By Dr. Frank Griggs, Jr., P.E.



Wendel Bollman

Bollman was born in Baltimore, Maryland, January 21, 1814, the son of German immigrants and the seventh of eight children. He attended local schools for 5 to 6 years, as his father died when he was only 11 years old and he needed to financially help out his family. He entered into an apprenticeship in a family friend's apothecary (drug) store in Shepherdstown. One year later, he opened his own drug store in Harpers Ferry. He became ill in 1827 and returned to Baltimore for treatment. After recuperating, he was apprenticed to a carpenter in the city.

The First Stone laying for the Baltimore and Ohio Railroad took place on July 4, 1828 and Bollman marched in the parade. He was soon working, at the age of 14, on the railroad as a carpenter, under the supervision of Lt. George Whistler, laying wooden rails for the line from Baltimore toward Ellicott Mills. The B&O was initially experimenting with various ways of laying the track. The British method consisted of sinking large square stones into the ground on a diamond pattern and then anchoring wooden timbers to them. The other method was to place wooden cross sleepers, similar to today's ties, and then spike the longitudinal timbers to the sleepers. A simple wrought iron strap was then spiked to the top of the timbers. After working there a short time laying track, Wendel resumed his apprenticeship and learned his trade. Between 1830 and 1837, he worked as a carpenter building houses in Baltimore and as far west as Harpers Ferry. He married Ann Smith and began his family of 10 children.

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In 1837, Bollman became associated with bridge building on the B&O. Lewis Wernwag and Benjamin H. Latrobe were building a bridge across the Potomac River and C&O Canal to initially connect the B&O line with the Winchester and Potomac Railroad. The bridge was completed, but Latrobe determined the masonry work was inferior. He ordered the bridge to be placed on falsework, the masonry rebuilt and the woodwork strengthened. By then, Bollman was one of the better-known carpenters in the area and he was asked by James Murray, an engineer for the B&O, to assist him and Wernwag in rebuilding the bridge.

After it was completed and opened in 1837, Latrobe promoted Bollman to bridge foreman for the entire line. Most of the bridges that were built on the line at that time were masonry arches, with the exception of the Harper's Ferry Bridge and another by Wernwag over the Monocacy River to the east. The line from Harper's Ferry to the west, however, would have many wooden bridges, and Bollman was active in building and later designing them. In 1848, he was appointed Master of the Road, making him in charge of the right of way and all bridges. He was aware that wooden bridges, no matter how well they were built, had a life expectancy of 10 to 15 years before they would decay and have to be taken out of service and replaced. In the late 1840s, Latrobe was planning to replace his wooden bridges with structures built from cast and wrought iron. The first iron bridges on American railroads were by Richard Osborne (1845) and James Milholland (1847). The first successful cast and wrought iron bridges had been designed, patented and built by Squire Whipple earlier in the decade over the Erie Canal in New York. In the late 1840s, Whipple also built several short span iron bridges for the New York and Erie Railroad and its Newburg Branch. They were, however, later removed by the railroad after a Rider iron bridge failed in 1849, and the New York & Erie RR lost faith in iron and reverted back to wooden bridges.

Legend has it that Bollman started experimenting with model metal bridges in the B&O shops, combining some intuition and some computation. In 1849, Albert Fink, a German educated civil engineer, came to work for the railroad. It is thought that Bollman learned engineering skills from Fink. He, possibly with the assistance of Fink, came up with a bridge design that effectively reversed the system used by Latrobe on the Harper's Ferry and later wooden bridges. In these bridges, Latrobe and Wernwag had built in compression struts, which were extended from the pier up to several top chord panel points, effectively making a series of King Post trusses. This method was fine for short span bridges.

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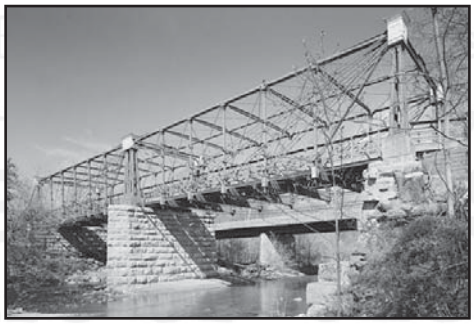
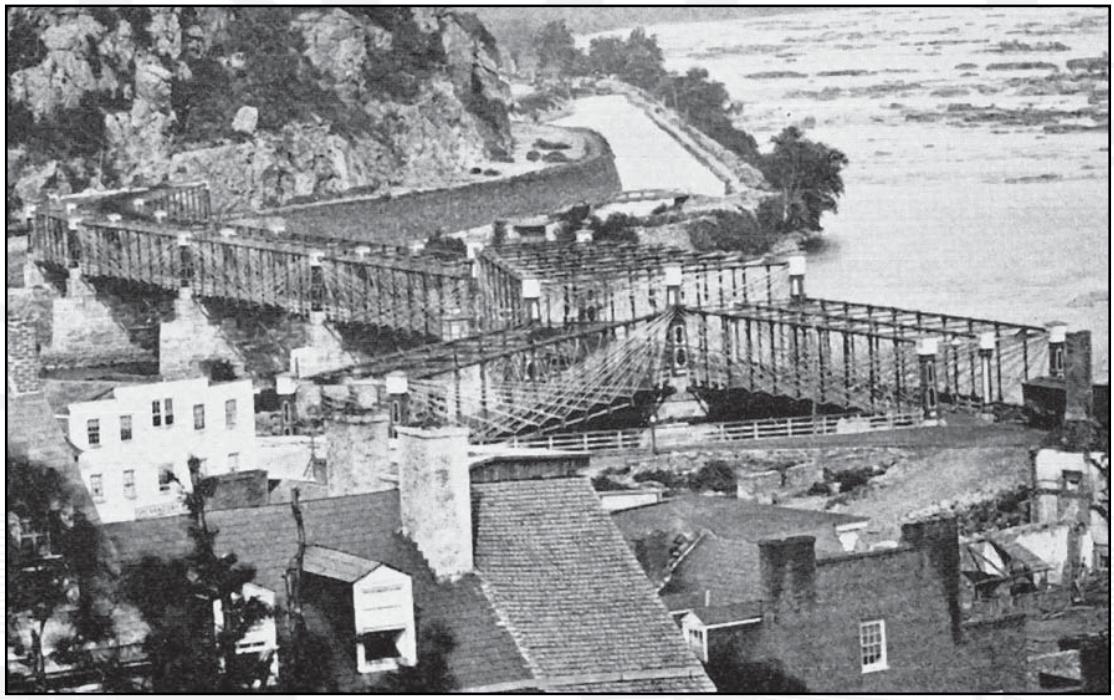


Bollman Bridge — Savage, Maryland. Photo courtesy of HAER

However, for long span bridges with multiple panels, the struts needed to be longer and at a flatter angle resulting in large lateral loads on the pier or abutment. Bollman turned the system upside down and ran wrought iron tension diagonals from the outer top chord panel points down to all the lower chord panel points. This threw large lateral loads on the upper end panel points, but the load was inward. He resisted this compressive load with cast iron, and on occasion wooden, upper chord members that he called stretchers.

Latrobe accepted Bollman's designs. In his 1849 Annual Report to the Board, Latrobe noted he had contracted "for the reconstruction of the large Bridges at Little Patuxent and at Bladensburg which will be executed in a few months. It is proposed to erect a super structure of Iron upon stone abutments, at each place with increased span, for greater security against future floods." The Little Patuxent Bridge was near Savage, Maryland and the Bladensburg Bridge was across the Anacostia River. They were short span bridges, the Savage Bridge being only 76 feet in length and costing $23,825. With these two bridges the B&O began the process of replacing its wooden bridges with iron trusses on Bollman plans.



Harpers Ferry Bridge with Bollman Trusses, post Civil War C&O Canal background, Harper's Ferry foreground

Advertisement 1858

"Bollman started experimenting with model metal bridges in the B&O shops..."

Bollman's first major span, however, was at Harper's Ferry in 1851 when he was given the task of replacing the 124-foot Winchester and Potomac RR bridge span with an iron truss setting on Wernwag's and Latrobe's pier and abutment. All iron parts for the bridge were cast or fabricated in shops of the railroad in Baltimore and delivered to the site by rail. The bridge, with three parallel trusses to accommodate the rail tracks and turnpike roadway, was set on granite towers. The span was very successful and accelerated the efforts of the B&O to replace all its wooden bridges with iron.

After completing the Winchester span, Bollman was awarded a patent for his "Suspension Bridge" on January 6, 1852.

As can be seen by his patent drawing, every lower chord panel point is supported by tension diagonals reaching back to the ends of the span. His patent covered both a through truss and a deck truss, and he built bridges on both plans. He claimed in his patent application, "My improvement consists in the mode of bracing bridges, and constructing the trusses, by which I carry the whole load upon the bridge, at any given point at the center or either side thereof directly back to the abutments, and at the same time retain all the forces of thrust and tension within the truss frame, resting the weight merely upon abutments or piers, without any anchors or other similar device." He then, like S. H. Long before him, wrote a pamphlet entitled "Iron suspension and trussed bride as constructed for the Baltimore and Ohio Rail Road Co. at Harpers Ferry, and on the Washington branch of this road." In it he described his design and construction methodology so others could build to his patent.

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Wendel used rudimentary calculation techniques based upon what he called "this first principle of the Lever." He further wrote, "the combination of cast and wrought iron, — the former in compression the later in tension — with section, strain, and value of metal, in the most concise and connected manner, it is prudent to state that, this matter is produced not only for those readers who may be versed in higher Mathematical attainments, but for those devoted rather to practice than mere abstract theory; and who by understanding the data, can derive some immediate advantage from further comparison and enquiry to the performance of work confided in the country to practical men." He also noted "the permanent principle in bridge building, sustained throughout this mode of structure and in which there is such gain in competition with every other, viz: The direct transfer of weight to the abutments, renders the calculation simple, the expense certain, and facilitates the erection of secure, economical and durable structure."

Most of the bridges built by the B&O for the next 20 years were built by Bollman or to his patent, with the exception of some longer span bridges built to a patent issued to Albert Fink in 1854. Latrobe, with his acceptance of the Bollman and Fink designs, became one of the first prominent railroad engineers to endorse the use of iron in railroad bridges.

Robert Vogel in his fine article on "Engineering Contributions of Wendel Bollman" gave a complete list of Bollman's bridges on the B&O. In 1858, Wendel formed W. Bollman & Co. with J. H. Tegmeyer and James Clarke, advertising he was ready to build bridges, roofs, engine houses, machine shops, etc. This was one of the first major bridge building companies in the United States and had actually been in business since 1855 offering to build bridges for others than the B&O. Their main efforts were in building bridges to Bollman's patent, but they branched off into all areas listed in their advertisement.

During most of the Civil War, Bollman did not build many bridges, but after the war he organized the Patapsco Bridge and Iron Works in Baltimore. That lasted until 1884, when Bollman died. His companies built bridges throughout the eastern United States, Cuba, Mexico, and Chile. He also built a swing bridge over Quincy Bay, Illinois for the Chicago, Burlington, and Quincy Railroad in 1868, and a unique Water Pipe Truss to carry Lombard Street over Jones Falls in Baltimore. His company, and that of Squire Whipple and his nephews, were the first major bridge fabricators in the United States and accounted for most of the iron bridges built in the 1850s and 1860s.

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His main contribution to bridge building remained his "suspension truss" that was built between 1850 and late 1870s. Many leading engineers of the time criticized the bridge as requiring an excessive amount of iron compared to the Fink, Warren and Whipple Trusses that gradually replaced it just before and after the Civil War. Only one Bollman Suspension Truss remains and is located in Savage, Maryland near where he built his first bridge in 1850. This bridge, with two 80-foot long spans, was originally built on the B&O main line in 1869. It was moved to the current site in 1880 where it has been restored and preserved as a National Historic Engineering Landmark.

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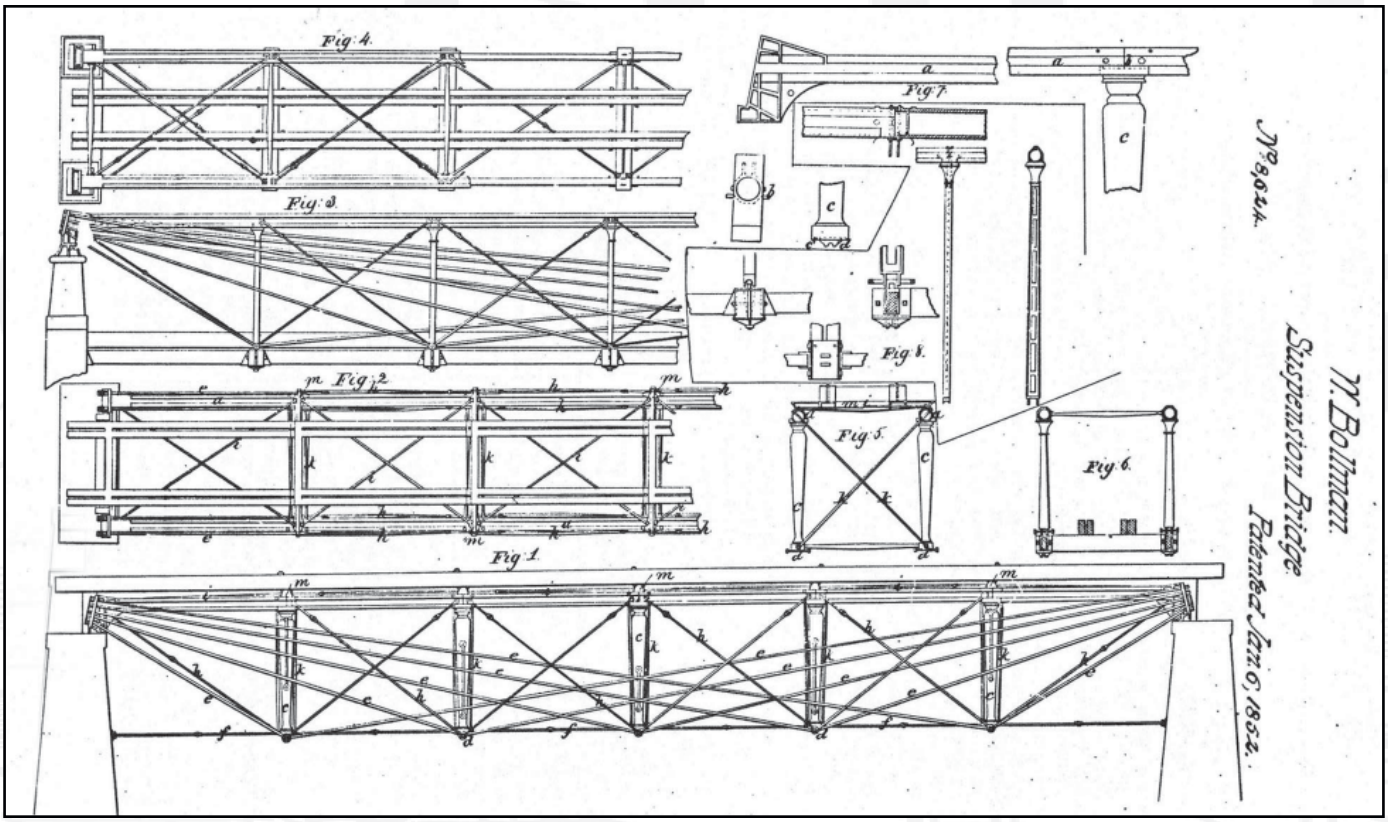

Bollman Patent No. 8,624; January 6, 1852

The Harper's Ferry Bridge, however, is his best-known bridge. He built the first span for the Winchester and Potomac RR in 1851 and replaced all the rest of Wernwag's bridge after it was burned in 1861 by the Confederates.

Throughout the war the bridge was burned, shelled or flooded out many times. Each time, the bridge was rebuilt. After the war, it was rebuilt again with Bollman trusses on all the spans and used by the B&O until 1894, when the railroad built a new bridge upstream. The roadway portion of the bridge continued in use until 1936, when a new bridge was built downstream and the last spans were removed.

Robert Vogel summed up the career of Bollman, stating that he is important "not only because he was perhaps the most successful of the latter (self-taught engineers) class but because he was probably also the last. He may be said to be a true representative of the transitional period between intuitive and exact engineering."▪

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***