Raritan River Fink Through-Truss Bridge
(Hamden Bridge)
Spanning the South Branch
of the Raritan River
on County Route #2
Clinton Vicinity
Hunterdon County
New Jersey

HAER No. NJ-18

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
Department of the Interior
Washington, D.C. 20240
Location: Spanning the south branch of the Raritan River, on County Route #2, in Hamden, Clinton Vicinity, Hunterdon County, New Jersey

Date of Erection: 1857-8

Owner: Board of Chosen Freeholders Hunterdon County

Use: Vehicular Bridge; demolished by automobile collision September, 1978

Significance: At the time of its demolition in 1978, the Hamden bridge was one of only two Fink Through-Truss Bridges known to remain in the U.S. (The other is in Tuscaraurus County, Ohio. See The Ohio Historic Bridge Inventory, Evaluation and Preservation Plan, Ohio Department of Transportation, 1983: p. 43). Albert Fink formulated a structural suspension system that was an early and effective method of spanning relatively large distances with cast and wrought iron components. The bridge at Hamden is an excellent example of the Fink Truss design.

The bridge is essentially a rectangular box measuring 100 feet by 15 feet by 19 feet high. Vertical compression members are spaced at 12 foot intervals and are hexagonal shaped cast iron. The end verticals are also cast iron, but are of heavier construction. All diagonal tension members are wrought iron, while the top chord lateral bracing is primarily cast iron. The floor beams and stringers are believed to be wrought iron. Researchers should note that some parts of the bridge have been replaced with steel I-beams and pipes.

The Hamden bridge is nearly identical to an illustration of Albert Fink's first patent (#10,887) dated May 9, 1854. Albert Fink (1827-1897) is regarded as the "father" of 19th century railway economics and statistics in America, but of equal importance, he was an innovative iron bridge builder in the 1850s.

(continued)
Fink was a German refugee who came to America in the late 1840s and began work as an engineer for the Baltimore & Ohio Railroad in 1849. The earliest pioneers in iron bridge construction were usually the canal and railroad companies, because of their interest in increasing bridge durability and longevity. The life span of wooden bridges was increased by covering them (this reduced weathering and rot), yet this in turn increased the cost of construction, and increased the chances of their being damaged by fire.

Local highway construction was generally handled by local designers and builders, while early iron bridge construction was generally pursued only by the large railroads and canal companies. Thus, the construction of the Raritan River Bridge in iron was quite unusual for a local municipality.

The Hunterdon County Board of Chosen Freeholders argued throughout the summer of 1857 as to whether to construct the Hamden Bridge of wood or iron. A decision had been reached at the June 9th Board Meeting to construct a three span wooden bridge. Only after a presentation by Aaron H. Vancleve, President of the Trenton Locomotive & Machine Manufacturing Co., did they agree to consider the alternative of constructing an iron bridge. The Board debated through July and August whether the additional expense of an iron bridge could be justified. Finally, on August 29th the Board voted unanimously to build the bridge in iron.

A contract was written with the Trenton Locomotive & Machine Manufacturing Co. by September 15. The structure was finished by February, 1858, and load testing was performed before the Board on February 9, 1858. An estimated load of eleven tons and 50 men was accommodated. Evidently the Board was well pleased, for they contracted for another similar bridge in September of 1858.

The Trenton Locomotive & Machine Manufacturing Co. was founded by Aaron Howell Vancleve and his brother-in-law, William R. McKean. They purchased the Trenton foundry of Sutton & Crooks, known as the Mercer Works, sometime after 1842. The foundry was located on the Delaware River adjacent to Cooper & Hewitt's Trenton Iron Co.
By the early 1850s the scale of activities had been enlarged to include production of gasworks for Augusta, GA; Jersey City, NJ; Newburyport, MA; and Petersburg, VA. They also produced locomotives for several prominent rail companies. The foundry was incorporated as the Trenton Locomotive & Manufacturing Co. in March, 1854. They advertised a diverse line of products: railroad machinery, mill gearing, gasworks, waterworks, iron bridges, iron buildings, iron screw piles (Lighthouses), stationary engines, and boilers. The company is now a branch of U.S. Steel and most of the 1853 buildings survive.

References:

Hunterdon County Board of Chosen Freeholders; Minutes, 1841-1863; Flemington, NJ

Karschner, Terry; National Register Nomination Form, August 1, 1974

"Plans of Bridges Built By The Trenton Locomotive & Machine Manufacturing Company," Promotional Brochure, ca. 1854, Collection of the Smithsonian Institution

Transmitted By: Kevin Murphy, Historian HAER, June 1984
FINK THROUGH-TRUSS BRIDGE
(Raritan River Fink Through-Truss Bridge)
(Hamden Bridge)
Hunterdon County Government Complex
(moved from the South Branch of the Raritan River)
Flemington Vicinity
Hunterdon County
New Jersey

ADDENDUM TO

Raritan River Fink Through-Truss Bridge
(Hamden Bridge)
Spanning the South Branch of the Raritan
River on County Route #2
Clinton Vicinity
Hunterdon County
New Jersey

WRITTEN HISTORICAL AND DESCRIPTIVE DATA
REDUCED COPIES OF MEASURED DRAWINGS
PHOTOGRAPHS

Historic American Engineering Record
National Park Service
Department of the Interior
P.O. Box 37127
Washington, D.C. 20013-7127
ADDENDUM TO
RARITAN RIVER FINK
THROUGH-TRUSS BRIDGE
HAER No. NJ-18
(Page 4)

HISTORIC AMERICAN ENGINEERING RECORD

FINK THROUGH-TRUSS BRIDGE
(Raritan River Fink Through-Truss Bridge)
(Hamden Bridge)
HAER No. NJ-18

This report is an addendum to a three-page report previously transmitted to the Library of Congress in 1984.

Location: Formerly spanning the South Branch of the Raritan River, near Hamden, Clinton Vicinity, Hunterdon County, New Jersey. Sold for scrap in late 1980s. A few scattered pieces remain at the Hunterdon County Government Complex, west of Flemington, Flemington Vicinity, Hunterdon County, New Jersey.

UTM: 18.508240.4494590
Quad: Pittstown, NJ

Date of Construction: 1857-1858

Fabricator: Albert Fink

Present Owner: Office of the County Engineer, Hunterdon County Administration Building, Main Street, Flemington, NJ 08822

Present Use: None

Significance: At the time of its collapse in 1978 it was one of the last two surviving examples of cast- and wrought-iron bridges using Albert Fink's patented suspension truss system. It was also one of the oldest standing metal truss bridges in the United States.

Historian: Robert W. Hadlow, August 1991
This Fink Through-Truss Bridge was more than just a curious survivor of the nineteenth century bridge builder's art. Until its collapse in 1978, the bridge was in nearly original condition, except for decking, an outstanding example of the patented Fink truss. At that time it was one of only two surviving examples of this important early truss system. It also appears that prior to its collapse it was one the oldest metal truss bridges in the nation. The span was a fitting monument to the genius of Albert Fink and a fine example of the simple yet elegant works erected by American foundrymen in the decade before the Civil War.

To Build a New Bridge

The decision to build an iron rather than a wood bridge involved months of political wrangling. On 28 May 1857, the Board of Chosen Freeholders of Hunterdon County, New Jersey visited the location of a proposed bridge at Hamden. Voting ten to four that "there be a new bridge built upon the site," the Board established a committee of "Messrs. Sked, Cregar and Anderson" to draw a plan for the bridge. The committee reported that "a [timber] truss design of three spans, one span 40 feet, one span 36 feet and one span 28 feet in length and the lane width of the old bridge and the whole to be raised one foot higher than the old bridge now standing would be a suitable bridge for the present site." The Board chose members Anderson and Cregar to superintend its construction. A month passed before the Board again discussed the project, but in the interim Freeholder Cregar evidently became interested in the possibility of erecting an iron bridge at Hamden and contacted a firm that appeared very eager to do so. After a series of summer meetings the Board abandoned its timber truss design and authorized construction of an iron bridge. It had taken nearly as much time to decide to build the bridge as it did to erect it!

At a later Board meeting, Aaron H. Van Cleve, president of the Trenton Locomotive and Machine Manufacturing Company, exhibited a number of plans for iron bridges fabricated by his firm. Presumably, these were the plans shown in the firm's promotional literature, which included a rendering of a Fink truss. As a result of Van Cleve's presentation, the Board moved to substitute a one-span iron bridge for the three-span timber structure approved on 28 May. The debate dragged on through the summer, but the Board finally authorized the Trenton Locomotive and Machine Manufacturing Company to build the Fink through-truss bridge at its meeting of 15 December.
Construction began in September and finished sometime before the Freeholders' meeting of 9 February 1858. On that date, the Board travelled to the site to observe the application of a live load of eleven tons and fifty men. The members voted to "accept" the bridge after its painting and the installation of a bridge plate. It also moved to install additional handrailing and, curiously, to have the stonework painted.

Description of the Bridge

The Trenton Locomotive and Machine Manufacturing Company fabricated the bridge according to the patented Fink suspension-truss system. A Fink suspension truss consisted of relatively few primary components used repetitively, resulting in a simple symmetrical structure. It was economical to produce, easily erected, and resulted in a bridge with a light and almost ethereal appearance. Albert Fink achieved an economy of material by using components of cast-iron in direct compression and others of wrought iron in direct tension, on a rather deep structure with a span-to-depth ratio of about 1 to 5.3

The principal cast-iron components were the end piers, the top chord, and the vertical columns. Wrought iron was used for all tension diagonals and the transverse floor beams. Eight panels with trusses 12'-6" each (center to center on joints) gave a span length of 100'. Vertical cast-iron columns measured 18'-8", resulting in a length to the center line of the top chord of 19'-2". Horizontal distance between trusses, center to center, was 15'-9", creating an effective roadway width of 14'-9".

The cast-iron members were noteworthy examples of the founder's art, with well-executed joints and restrained architectural details such as column capitals and transverse joints. The cast top chord was composed of 12'-5" and 25' octagonal stretchers with machined socket joints. This provided a continuous member for the entire length of the bridge, since the fitted joints were capable of transmitting movement, although not the full capacity of the octagonal midspan cross-section.

Both column capitals and transverse struts had flanges or "bells" at their ends that fit shallow sockets in the cast-iron chord joints. These projections were so short that they acted as pinned or rotating joints at the ends of the members, insuring they would take only compressive loads and would not bend.
End supporting members were piers rather than parts of the truss, functioning as roller bearings to support the trusses and at the same time permitting longitudinal movement to accommodate changes in loads and temperature.

End posts were "T" shaped with integral base plates. To ease the problem of their manufacture and transportation to the site, one leg of each member was cast separately and later bolted to the other and the base plate. In addition, elliptical holes were cast in each of the vertical members. More than any other feature, cast-iron components gave the bridge its unique character.

Wrought-iron members served in direct tension only and were fabricated of rods or rolled bar stock with either threaded ends or forged "eyes." The bridge was literally held together by tightening the various tension members, since the cast-iron components were fabricated with only socket joints and were fitted together.

Floor beams, or water beams as they are commonly called in the area, were 10"-deep wrought-iron girders fabricated with pairs of back-to-back angles riveted to a 1/4" web plate. They may date from the original floor system since the maximum rolled sections available in the 1850s were only 9" deep. However, the rather crude hangers and the fact that several beams were cut off directly through rivet holes was in marked contrast to the careful workmanship exhibited throughout the rest of the structure. One might speculate that these were added during one of the many deck reconstructions and could have been salvaged from another structure.

The latest deck consisted of corrugated metal planking with a bituminous concrete wearing surface. Undoubtedly, the original deck was of timber and was composed of 2" x 4" oak on edge. Longitudinal wooden stingers probably supported it and these, in turn, rested upon transverse iron or timber floor beams.

Abutments were built for an earlier bridge and were raised 1' for the new bridge. Presumably, the Board made this recommendation to add clearance for the Raritan's periodic freshets. The abutments were laid up with large undressed stones typical of the period. They gave a rustic appearance, making a striking and pleasing contrast to the light iron work of the superstructure. A large iron plate, the full width of each abutment, anchored bolts that passed through large stone bearing blocks supporting cast-iron base plates.
Repair and Maintenance

During more than a century of service, several bridge members were repaired or replaced. One column was fractured and spliced together with wrought-iron or steel straps and two others were replaced entirely with rolled-steel sections. Hunterdon County also replaced one of the light perforated cast-iron struts with a $4\frac{1}{16} \times 3\frac{1}{16}$ I-beam. Damage to the end piers was repaired by welding plates on the webs of the cast-iron members.

It is likely that several decks have replaced the original, which was undoubtedly of timber. According to bridge maintenance records, in 1956 the county installed the most recent deck of I-beam stringers and metal bridge planking with a bituminous wearing surface.

The Collapse of the Bridge

From 1858 until 1978, the bridge remained serene in its picturesque setting serving local traffic. Then, at 9 o'clock Monday evening, 2 October 1978, a car swerved "to miss an animal" and hit either the first or second cast-iron vertical of the upstream truss. Neighbors heard a loud report, like an explosion. In actuality, the cast-iron vertical failed in a brittle manner, which resulted in a redistribution of forces in the truss. This happened in such a way that the entire truss failed in a classic case of "progressive collapse," followed by the complete disintegration of the second truss. The county engineer's office hauled the bridge components to a site near Flemington, awaiting a decision on restoring or replacing this historic structure.4

At the time of the collapse, the American Society of Civil Engineers, through its Committee on the History and Heritage of Civil Engineering, was considering the nomination of the bridge as a National Historic Civil Engineering Landmark. The bridge has since received this honor, posthumously, pending its reconstruction.

Industrial Archeological Investigation

The remains of the collapsed Fink Truss Bridge were removed to a property near the Hunterdon County Library, between Flemington and Frenchtown. Emory L. Kemp, professor of civil engineering of West Virginian University, completed a study of the span's failure. He carefully evaluated all components to determine the causes of the progressive failure, to establish the number of
members surviving intact, and to obtain a complete set of field measurements and photographs. A summary of his conclusions follows.

Scrutinizing each structural member for failures, the archeological team sampled both the cast and wrought iron for metallurgical and physical testing. This investigation revealed that nearly every cast-iron member that failed did so at a section where large voids and/or other casting imperfections were present. These flaws greatly reduced their strength. In one top-chord member, a large opening was visible in an intact portion where the cross-section was a simple hollow octagon. These faults were the result of casting techniques used in the 1850s. Of particular difficulty for fabricators was the casting of slender thin-walled members such as bridge components.

In the nineteenth century, cast iron was essentially an unrefined product with widely varying physical and chemical properties. The presence of significant amounts of carbon and phosphorus improved the "flow" of the molten metal but added significantly to the brittleness of the finished casting. In the case of the Fink Truss Bridge at Hamden, the long columns, verticals of 18'-8" and horizontal stretchers of up to 25', caused special problems. The difficulty was to cast a member that was straight, had a concentric core, and was free from voids caused by trapped gases. Structural members of the bridge were remarkably straight and outwardly appeared to be excellent examples of the founder's art. The voids, however, were of great concern because grey cast iron, by its very nature, is a brittle material with little ductility. To overcome these inherent weaknesses, fabricators used cast iron only in direct compression, where no bending would take place under normal dead and live gravity loads. Nevertheless, the columns were very vulnerable to lateral impact loadings, such as being struck by automobiles.

Several cast-iron end piers were repaired by the addition of solid steel plates welded over the perforated webbing. None of the four end piers survived the collapse intact. In fact, only two columns and two top-chord components, or stretchers, survived without fracture. In general, wrought-iron members did not fail, but became a twisted mass of iron, rather like a large plate of spaghetti. Many survived intact, if badly twisted and bent.

In the late 1980s, what was left of the Fink Through-Truss bridge was scrapped. Only a few small scattered pieces remain in the county's road maintenance shop yard.
Project Information

This recording project is part of the Historic American Engineering Record (HAER), National Park Service. It is a long-range program to document historically significant engineering and industrial works in the United States.

The Cast- and Wrought-Iron Bridges Recording Project was co-sponsored in 1991 by the Historic American Engineering Record and the West Virginia University Institute for the History of Technology and Industrial Archaeology. Fieldwork, measured drawings, historical reports, and photographs were prepared under the general direction of Dr. Robert J. Kapsch, Chief, HABS/HAER; Eric N. DeLony, Chief and Principal Architect, HAER; Emory L. Kemp, Director, Institute for the History of Technology and Industrial Archaeology; and Dean Herrin, HAER Staff Historian.

The Recording Team consisted of Christine Ussler (Architecture Faculty, Lehigh University), Architect and Field Supervisor; Christine Theodoropoulos, P.E. (Architecture Faculty, California State Polytechnic University, Pomona); Wayne Chang (University of Notre Dame), Monika Korsos (Technical University of Budapest, Hungary, US/ICOMOS), Architectural Technicians; Robert W. Hadlow (Washington State University), William Chamberlin, P.E., Historians; and Joseph E. B. Elliott (Muhlenberg College), Photographer.

In 1979, Dr. Kemp and A. G. Lichtenstein & Associates, Inc., prepared a report entitled "A Plan for the Reconstruction of the Historic Hamden Fink Suspension Truss." The Hunterdon County Board of Chosen Freeholders commissioned it to help develop a plan for reconstruction of the bridge. With their permission, much of this report was incorporated into the above history.
APPENDIX 1. Albert Fink (1827-1897) and the Suspension Truss

Disillusioned with political events in Germany in 1848-9, Albert Fink, like so many of his compatriots, emigrated to the United States. Born in Lauterbach on 27 October 1827, he was educated at a polytechnic school in Darmstadt, Hesse. His father was an architect, and young Albert followed his vocation, pursuing courses in both architecture and engineering. Shortly after his arrival in the United States he sought employment with the Baltimore and Ohio (B & O), a company known for its pioneering work in railroad building. After repeatedly seeking an interview with bridge designer Wendel Bollman, the "master of the road," he was hired as an assistant to chief engineer Benjamin Henry Latrobe, Jr.

Fink's rise was spectacular. He soon was put in charge of the structural design and construction of stations and bridges from Cumberland to Wheeling. By the time the B & O completed the line in early 1853, Fink had constructed the first iron viaducts along the Cheat River between Rowlesburg and Kingswood, and had built the great iron bridge, according to his suspension-truss principle, at Fairmont, (then in Virginia). This structure had three 205' spans and was the longest railroad bridge in the country when completed in 1852. After 1853, Fink oversaw construction of the Northwestern Virginia Railroad from Grafton to Parkersburg, in what later became West Virginia.

With the completion of this work in 1857, Fink accepted a position with the Louisville and Nashville Railroad (L & N). By 1859, his energy and ability won him appointment as Chief Engineer and Superintendent of the line's railway machinery departments. During construction of the L & N, he designed a number of bridges using his patented system, including the well-known Green River span at Mufordville, Kentucky, and the great bridge over the Ohio River at Louisville. Fink increasingly involved himself with railway management issues until his death on 3 April 1897.  

Neither the Bollman nor Fink trusses were truly triangular, but were, instead, elaborations on a simple trussed beam. Thus, in both cases, a vertical compression member, supported by iron suspension rods, trussed up the top chord at each panel point. Bollman had devised his suspension truss system as early as 1849, building the first bridge with this truss in 1850 and patenting the design in 1852. In Bollman's, all structural suspension members were carried back to the ends of the truss.
When Fink sought employment with the B & O in 1848, he shared his "bridge designs" with Bollman, who took great interest in the young engineer's ideas but failed to give him a job. Exactly what Fink's designs were or where he got them is not clear, but there is no evidence to suggest that he had designed his truss before arriving in Baltimore. Thus, it is quite likely that Bollman's design inspired him. In a sense, Fink improved upon the Bollman truss by making supports for each vertical column symmetrical and not carrying tensile suspension forces back to the end for each column. The Fink Through-Truss Bridge at Hamden bore a striking resemblance to the great iron bridge at Fairmont and to Fink's patented drawing of 1854.⁶

By the 1870s, railways found suspension trusses too flexible for increasingly heavier loads. In addition, triangular trusses, such as those of Jacob H. Linville of Altoona, Pennsylvania, were not only stiffer but stronger for a given weight of metal.⁷ Equally important, the industry was growing ever more distrustful of cast iron for structural purposes. Together, these factors heralded the end of the suspension truss bridge. Nevertheless, the Fink truss continues to be successfully employed in roof structures.
APPENDIX 2. The Trenton Locomotive and Machine Manufacturing Co.

The Trenton Locomotive and Machine Manufacturing Company was the offspring of earlier manufacturing firms. In the 1830s, Aaron H. Van Cleve (or Vancleve) and his brother-in-law, William R. McKean, moved to Trenton to establish the "Van Cleve and McKean" machine shop. Later, additional parties joined the firm and the associates changed the name to Van Cleve, McKean, Dripps and Company.

The business expanded and diversified in the 1840s by acquiring the Sutton and Crooks Foundry, established in 1842 and located near the Trenton Iron Company on the Delaware River, at a site known as Mercer Works. In 1854, the Trenton Iron Company became the first in the United States to roll structural wrought-iron shapes with a maximum depth was 9 inches, suitable for numerous applications.

Van Cleve, et al. produced a wide variety of products. The most noteworthy were locomotives and gas works. By the 1850s the firm had expanded to become one of the leading businesses of Trenton, erecting a new shop adjacent to the Trenton Iron Works in 1853. At that time, the company reorganized and incorporated as the Trenton Locomotive and Machine Manufacturing Company. Promotional literature listed various products, including Albert Fink's suspension truss, which he patented in 1854.

The firm's production of iron-truss bridges was short-lived. Responding to the urgent need for armaments early in the Civil War as the Trenton Arms Company, it focussed on war production and ended its manufacture of iron bridges. In 1879 the Trenton Iron Company incorporated the adjacent site into its works, thus ending nearly fifty years of manufacturing activity by Van Cleve, et al. and the Trenton Locomotive and Machine Manufacturing Company. Most of the 1853 buildings survive today as part of the U.S. Steel Corporation.

Following the Civil War, bridge building became a very competitive business characterized by specialized companies actively promoting patented bridge systems. By this time, engineers had learned to avoid cast iron because of its widely varying quality, and lack of ductility and tensile capacity. Thus, foundries no longer led in this field, having yielded to steel fabricators. 8
ENDNOTES

1. "Minutes of the Board of Chosen Freeholders", Hunterdon County, found in Hall of Records, Main Street, Flemington, New Jersey.


3. Information on a deck Fink truss at Lynchburg, Virginia appears in the nomination of the through Fink truss for American Society of Civil Engineers' national landmark status.


6. The professional relationship between Bollman and Fink is virtually unknown, especially their work on the suspension truss patent. In her biography of her father, Fink's daughter leaves the impression that her father's idea for his patented truss was both original and superior to that of Bollman. Robert M. Vogel's work on Bollman leaves little doubt that Bollman had worked out his elaboration of the trussed beam before Fink arrived in Baltimore. The evidence, however, is inconclusive. See Ellen Fink Milton, A Biography of Albert Fink, (Northeast Harbor, Maine, 1951); Vogel, The Engineering Contributions of Wendel Bollman; Vogel, A Biographical Dictionary of American Civil Engineers, Committee on History and Heritage of American Civil Engineering, ASCE Historical Publication No. 2, 1972, s.v. "Bollman, Wendel."
7. C. Shaler Smith, *Comparative Analysis of the Fink, Murphy, Bollman, and Triangular Trusses* (Baltimore, 1866).

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