LINVILLE CREEK BRIDGE
(Bridge No. 6154)
Spanning Linville Creek at Virginia State Route 1421
Broadway Vicinity
Rockingham County
Virginia

HAER No. VA-97

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
Northeast Region
U.S. Custom House
200 Chestnut Street
Philadelphia, PA 19106

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HISTORIC AMERICAN ENGINEERING RECORD
LINVILLE CREEK BRIDGE
(BRIDGE NO. 6154)

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LOCATION: Virginia State Route 1421 over Linville Creek, Broadway vicinity, Rockingham County, Virginia.
USGS Broadway, VA Quadrangle, Universal TransverseMercator Coordinates: 17.691260.4275140

DATE OF CONSTRUCTION: 1898

ENGINEER: Edwin Thacher

BUILDER: Wrought Iron Bridge Company, Canton, Ohio

PRESENT OWNER: Virginia Department of Transportation

SIGNIFICANCE: The Linville Creek Bridge is a rare surviving example of a metal pin-connected bridge truss designed and patented in 1881 by Edwin Thacher. The truss design combines triangular and suspension systems to eliminate defects inherent in the triangular and quadrangular truss systems in common use at the time. Edwin Thacher made significant contributions to metal truss and reinforced concrete bridge design and construction in the late nineteenth and early twentieth centuries.

PROJECT INFORMATION: The Linville Creek Bridge was recorded in 1993-1994 by the Cultural Resource Group of Louis Berger & Associates, Inc., Richmond, Virginia, for the Virginia Department of Transportation (VDOT). The recordation was undertaken pursuant to provisions of a Programmatic Memorandum of Agreement (Draft) among the Federal Highway Administration, VDOT, the Virginia SHPO, and the Advisory Council on Historic Preservation concerning management of historic metal truss bridges in Virginia. Project personnel included Richard M. Casella, Architectural Historian; Alison Helms, Historian; and Rob Tucher, Photographer.

DESCRIPTION

The Linville Creek Bridge (VDOT Bridge No. 6154) is a single-span, pin-connected steel truss through bridge. The bridge carries Virginia State Route 1421 in a northeast-southwest direction over Linville Creek, approximately 0.1 mile west of the intersection of State Routes 1421 and 42 in Rockingham County, Virginia. The bridge spans a floodplain approximately 100' wide on the east side of the creek, as well as the creek itself, which is approximately 30' wide at that point. The bridge is at a height of approximately 14' above the water which flows north at a maximum depth of about 4'. The immediate area around the bridge is rolling open pasture. The tracks of the Southern Railway run parallel to the stream 100' to the east of the bridge.

The truss is of a type patented in 1881 by Edwin Thacher which combines a primary triangular system and a secondary suspension system. Previously, the Linville Creek Bridge has been incorrectly identified as a double-intersecting Whipple truss to which it bears a resemblance. The primary triangular system consists of a top and bottom chord, two center struts inclined toward the ends, and two center ties which connect the struts and endposts. The secondary suspension system consists of inclined suspenders which connect intermediate panel points with the endposts and center struts. The remaining vertical suspenders and struts (posts) assist the suspension system in carrying intermediate panel point loads. The inclined suspenders have no fixed connection with the bottom chord and carry the intermediate floor beams only. All members of the bridge are iron or steel, joined with pinned, riveted, or threaded connections. The truss is 24' high, 14" wide, and 135'-11" long, with eight panels 16'-8-1/2" wide.

Top chords and inclined endposts are riveted box-sections, 12" x 6" overall, built with 1/4" top plate, 6" x 2" side channels, and 15" x 1-1/2" x 1/4" single bar-lattice bottom webbing. The truss rides on plate-and-roller and friction bed plate type bearings measuring 12" x 21". Bottom chords consist of paired loop-welded eyebars of three sizes: 1-1/2" x 3/4" bars connect the endposts and the first post; 1-1/2" x 7/8" bars connect posts one and two; and 2-1/2" x 1" bars connect post two and the center suspender. A unique feature of the bottom chord system is that it is adjustable at the pedestals by means of threaded ends on the first chord member. This eliminates a pin connection at this point and provides a means of squaring and tightening the truss members after assembly.

The riveted bar-lattice posts are 5-1/2" wide by 9" deep overall, made up of four 2-1/2" angles riveted into two T-sections and connected by 1-1/2" x 13" x 1/4" bar-lattice. The inclined center struts are joined at the top and consist of built-up riveted box-sections measuring 8" x 4". The struts are built with two 4" x 1-3/4" channels with flanges turned out, connected with 8" x 4" x 1/4" stay plates on the top and bottom spaced 4' on center. The center struts are reinforced with a tensional tie system added in 1968 by VDOT. The tie system interconnects the midpoints of the center struts with the top of the adjacent posts by means of 1" diameter threaded rods and angle plates (VDOT 1968).

The center ties connecting the top of the endpost and the bottom of the center strut consist of paired loop-welded eyebars measuring 3" x 3/4". Inclined suspenders consist of loop-welded eyebars measuring 3/4" square. A single suspender connects the top of the center struts with the bottom of post one, and a pair of suspenders connects the endpost and the bottom of post one.

Hip verticals and the center suspender consist of one 1-1/8" rod with loop-welded eyes and two 1" rods with loop welded eyes at the bottom, and threaded ends at the top. The threaded ends of the 1" rods are joined with a steel plate to a 1" diameter U-bolt which saddles the top chord.

Portal struts and portal braces are 6" x 3" riveted T-sections built with 3" angles. Secondary portal braces are 2" angles, and all portal members are joined with connection plates. Upper lateral struts are 5" I-sections, pinned to each post with U-type connection plates. Upper lateral bracing rods are 3/4" in diameter with bent loop-welded eyes and adjustable sleeve nuts. Other than the portal bracing described, there is no intermediate sway bracing.

The floor beams are 12" x 5" rolled I-beams, hung from the bottom chord pins at each post by 1" diameter beam hangers and beam hanger plates. Six rolled I-beam stringers measuring 8" x 4" are spaced approximately 24" on center and rest on a 6" x 3" I-beam which in turn rests on the floor beams. There are two systems of lower lateral bracing, both consisting of loop-welded eyebars with adjustable sleeve nuts. The primary system consists of 2" diameter bars connecting the ends of alternate floor beams. The secondary system consists of 1" diameter bars which connect the ends of adjacent floor beams.

The bridge decking consists of 4" x 10" pressure-treated wood planks, coated with asphalt and attached to the stringers with carriage bolts and deck clips. The roadway is 11' wide and edged with 4" x 5" wood curbing raised 5" off the decking with wood blocks spaced approximately 4' on center. The bridge does not have railings. Modern 12" W-type galvanized steel guardrails attached to I-section steel posts run the length of the bridge on both sides.

Both ends of the bridge rest on U-type abutments of coursed quarry-faced ashlar limestone. The east abutment is approximately 8' high and 16' wide. The west abutment has been repaired with cast-in-place concrete to a height of 6'.

Two plaques on the end post read:

Wrought Iron
1898
Bridge Co.
Builders
Canton, Ohio.

and

Linville Creek Bridge
Virginal Historical Landmark

HISTORICAL INFORMATION

Background

Agriculturalists of European descent began to settle in the Linville Creek Valley near its junction with the North Fork of the Shenandoah River in the eighteenth century (see Figure 1). The first industries in the area included milling, distilling, and mining. By 1792, there were 142 heads of families residing near the junction of Linville Creek and the North Fork of the Shenandoah. The community which developed on the point of land between the creek and the river was initially named Custer's Mill, and later Broadway (Hess 1976:166; Wayland 1912:203).

During the latter part of the American Revolution, a considerable number of Germans belonging to the religious body known as the German Baptist Brethren, or Dunkers, moved to the northern Shenandoah Valley from Pennsylvania to take up new land that was both affordable and fertile (Loth 1986:416; Wayland 1907:22-23). The Brethren located all over western Virginia, concentrating most heavily in Rockingham and Augusta counties (Zigler 1908:map). George Kline, Jr. (also spelled Klein), moved to Virginia from Berks County, Pennsylvania, sometime prior to 1795, and established a farm on the west side of Linville Creek near present day Broadway. George's son John Sr. moved to Dauphin County, Pennsylvania, and later followed his father to Virginia in 1811. John Sr. located with his wife Elizabeth and their four children on the east side of Linville Creek near Linville Creek Church, in sight of his father's farm (Hays 1908) (see Figure 1).

John Kline, Sr.'s, son John was elected deacon of the Linville Creek Church in 1827, became minister in 1830, and was ordained elder on April 13, 1848. He became an outstanding and influential leader of the Dunker denomination (Hays 1908; Zigler 1908:223). Between 1840 and 1864, Elder John Kline traveled between 4,000 and 5,000 miles on horseback in Virginia and other states, preaching, founding congregations, and attending to church matters. His tours to Ohio and other northern states, and his sermons preaching anti-slavery and anti-war principles, aroused antagonism and suspicion during the Civil War. He was threatened repeatedly and cautioned by friends to curtail his activities, but in spite of their warnings he continued to travel and preach. Kline was ambushed and shot to death while on horseback on June 15, 1864, as he approached his home near Broadway (Hess 1976:170-171; Wayland 1912:250, 434; 1943:411; Zigler 1908:143). The ford which developed across Linville Creek near Elder John

Kline's home, on the crossroad originating at Linville Creek Church on Middle Road (now known as State Route 803), became known as Kline's Crossing.

Elder John Kline was an enthusiastic promoter of the Manassas Gap Railroad, which he believed would provide wider economic opportunity to the people of the mountains who lived in poverty (Hess 1976:171). The railroad, which extended north from Harrisonburg, was completed in 1854, and Broadway Depot and post office were established the same year (Hanson 1969:180; Hotchkiss 1866). After the Civil War, the Manassas Gap line became the Valley Branch of the Baltimore and Ohio (B&O) Railroad (Hotchkiss 1877; Lathrop and Griffing 1885:30).

The town of Broadway was incorporated in March 1880. The name of the place, according to local folklore, was adopted from the daredevils and miners who caroused on the streets of the town, and described themselves as being on the "broad way" (Wayland 1912:203). After the railroad was built, the town expanded on the east side of Linville Creek, along two main streets laid out parallel to the B&O railroad tracks. By 1885, a myriad of products were available from the manufacturers and dealers established in town. These included drygoods, groceries, clothing, hardware, household goods, salt, cigars, flour, lumber, paint, furniture, agricultural implements, mill irons, wagons, and other tools (Lathrop and Griffing 1885:37).

Mr. E.D. Root, a wealthy businessman from New England, built a palatial home in Broadway in 1880, and established a newspaper there in 1888. In 1890, with Root acting as first Vice President, the Virginia Valley Land and Improvement Company, made up primarily of executives from New York City and Broadway, Virginia, began to promote Broadway as an "Ideal City" (Hess 1976:168; Virginia Valley Land and Improvement Company c.1890:2). The company acquired 400 acres of land on the west side of Linville Creek, opposite the town, with a mile of frontage on the river. They proposed to lay out, in a magnificent and artistic manner, houses with terraces, and bridges, and to install modern improvements, including wide avenues and electric lights. The company challenged anyone anywhere to produce a building site equal to theirs in beauty (Virginia Valley Land and Improvement Company c.1890:4). The company depended heavily on the natural resources of the area, including waterpower, mineral springs, iron, lead and zinc ores, marble, clay, and timber, to draw investors and industrialists to Broadway (Virginia Valley Land and Improvement Company c.1890:5-7).

This speculative effort, like many other land development efforts launched in the Shenandoah Valley in the early 1890s, was not successful. Investment slowed during the Panic of 1893, and in July 1894, during a hailstorm, a cyclone hit Broadway cutting a path from Brock's Gap north to Timberville. The Virginia Valley Land and Improvement Company disbanded, and E.D. Root moved to Harrisonburg (Hess 1976:168). After this disappointing attempt to become a thriving city, the town of Broadway was sustained by steady growth in agriculture, milling, and timber-related industries. By 1912, the population of the town was about 700 (Wayland 1912:203).

History of Linville Creek Bridge

Linville Creek Bridge was built at Kline's Crossing, at the south end of Broadway during the winter of 1898-1899, replacing a wire footbridge which was washed away in the flood of September 29, 1896. The flood had occurred after an intense rainstorm fell over a large part of the northern Shenandoah Valley, resulting in $15,000 to $20,000 estimated damages to the public roads and bridges of the county (*Rockingham Register* 1896). The bridge was constructed just south of the ford at Kline's Crossing, on a short road which ran in an east-west direction across Linville Creek and the Valley Branch of the B&O Railroad, to join with Middle Road at Linville Creek Church (Lathrop and Griffing 1885:30). At the time the bridge was built, D. Hays owned the property on the east and west sides of Linville Creek (Rockingham County Road Papers-Report of Viewers, filed October 17, 1898; Showalter 1939:18).

The petition for Linville Creek Bridge was brought before the Rockingham County Court in September of 1898 and filed among the Rockingham County Road Papers. The document, signed by E.S. Pennington, J.P. Miller, A.R. Miller, and others, read in part:

> Your petitioners respectfully represent that a substantial wagon bridge across Linville's Creek at Kline's Crossing, about one half mile south of Broadway is a public necessity; that the ford in the creek has always been very bad & dangerous and can never be made safe and good; that the travel over the road to and from Broadway and the various mills and churches in the vicinity is very heavy and constant, and that the public will be greatly benefitted by the erection of such bridge; and petitioners further represent that the county had heretofore maintained a wire foot bridge over the creek at said ford, which said foot bridge has been swept away by floods and the rebuilding of which would cost several hundred dollars... (Rockingham County Road Papers-Petition, E.S. Pennington and others, filed September 1898)

The petitioners proposed to generate by subscription the funds necessary for the construction of the abutments, stone work, and fills for the bridge, and asked that the county appropriate sufficient funds to pay for the superstructure (Rockingham County Road Papers-Petition, E.S. Pennington and others, filed September 1898).

On September 19, 1898, the county court appointed a committee made up of J. Hanse, George W. Reherd, and G.R. Eastham to examine the site for the proposed bridge. The committee filed a lengthy report describing their recommendations about one month later, on October 17 (Rockingham County Road Papers-Report of Viewers, filed October 17, 1898). The committee determined in their October 12 site visit that the most suitable location for the proposed bridge lay just below the existing ford. One span of about 92-1/2' was required to eross the river at the recommended point. It was suggested that the eastern approach be composed of trestling

raised about 7' above ground, extending from the end of the span back about 134' to the railroad. Trestling was recommended instead of filling so that the flow of the creek would not be obstructed during floods. It was proposed that one of the old spans of the Port Republic Bridge, recently dismantled, might be utilized in place of trestling, because the length, 134', would fill the space exactly. The western approach to the bridge was to be constructed with about 5' of fill extending 60' onto D. Hays property, cutting off about one eighth of an acre of fine agricultural land, for which Hays requested $20 in damages (Rockingham County Road Papers-Report of Viewers, filed October 17, 1898).

Two stone abutments were required to support the ends of the iron span. The one on the west was to be raised 4' above ground surface, and the one on the east was to be raised 6'-6" above ground surface. The two supports were to be 90' apart in the clear and about 3-1/2' thick at the top, and 16' wide. Both were to be made of large rocks bedded in cement, the eastern one with rubble facing on all sides. A wing wall on the upper side of the fill on the west side was to extend about 30' back so as to effectively prevent the creek from breaking through or washing around the fill on that side. The abutments and fill were to rest on the solid bedrock underlying the creek and to raise the bridge about 2' above the high water mark (Rockingham County Road Papers-Report of Viewers, filed October 17, 1898).

If it was decided that the old bridge should be used instead of the trestling, the petitioners informed the bridge commissioners that they would build the abutments and approaches and haul a span of the old Port Republic Bridge to the site free of charge to the county. For their part, the county was requested to erect the iron span measuring 92-1/2' in length and 20' in width, and pay the $20 in damages to Mr. Hays; expenses which the committee estimated would total $800 (Rockingham County Road Papers-Report of Viewers, filed October 17, 1898).

If it was not agreed that the bridge should be constructed as recommended, then the committee suggested that the existing ford be improved by anchoring a 20' or 30' long oak log to the bedrock on the lower side of the ford, and on the upper side if necessary, and then filling the crib with rock to the top of the logs. The proposed improvements, estimated to cost only $40 or $50, would make the ford one of the best on the creek. The committee stated that they would have recommended the ford be improved in this manner instead of constructing the bridge, had not the local people been willing to contribute such a large part towards the bridge construction (Rockingham County Road Papers-Report of Viewers, filed October 17, 1898).

The county court agreed to build the bridge, but the final plan extended the length of the superstructure from 92 1/2' to 134' and eliminated the proposed trestling on the east side of the structure. The court ordered that the Board of Supervisors appropriate $800.00 for the construction. The Board voted that one-half of the cost was to be payable out of the county levy by December 1, 1899, and the remainder on July 1, 1900 (Rockingham County Board of Supervisors Minutes 2:330).

On December 23, 1898, the county secured a bond for $300 from E.S. Pennington, J.P. Miller, and B.A. Myers which defined them as the parties responsible for furnishing and hauling the lumber necessary for constructing the bridge. The bond stated that the work was to be completed by April 15, 1899 (Rockingham County Road Papers-Bond, filed January 14, 1899).

The county court appointed G.R. Eastham and N.F. Kline commissioners to contract for and superintend the construction. It appears that the bridge was completed during the spring and summer of 1899, as part of a larger project to build three bridges near Broadway: one of 47' crossing Turly Creek, one of 57' crossing Coal Creek, and one of 134' crossing Linville Creek. The superstructures for all three of the bridges were built by the Wrought Iron Bridge Company of Canton, Ohio, and the contract for the masonry of all three was awarded to C.E. Hulbert, the lowest bidder. The lumber for all three bridges was furnished by Fitzsimmons & J.P. Miller. The superstructure for the bridge over Linville Creek was paid for last, at a cost of $775.00. The lumber charge for the Linville Creek Bridge was calculated for 6,692 board feet, including flooring, and came to $80.30 (Rockingham County Road Papers-Report on Broadway Bridges, undated).

After the bridge was completed, Jacob P. Miller submitted to the court the bill for $80.30 for lumber. This bill had originally gone unpaid by the court when the bridge was completed, because the court had understood that the petitioners were to raise money sufficient to pay for all the necessary lumber. The petitioners, in fact raised only enough funds to pay for the work on the abutments and fills, which did not leave enough to cover the cost of the flooring. On September 17, 1900, the Road Board of Plains District certified in writing their opinion that Miller's claim was just, and the court subsequently ordered that J.P. Miller be paid the $80.30 (Rockingham County Road Papers-Certificate of the Road Board of Plains District, filed September 17, 1900, and copy of accompanying court order, undated).

Linville Creek Bridge was listed on the Virginia Landmarks Register November 15, 1977 and on the National Register of Historic Places April 15, 1978 (VDHR file 82-127).

Edwin Thacher and the Thacher Truss

Edwin Thacher (1839-1920) graduated Rensselaer Polytechnic Institute in 1863 with high honors and a degree in Civil Engineering. He worked briefly with the Cedar Rapids and Missouri River Railroad before joining the Civil War as an Assistant Engineer of the United States Military Railroads in Tennessee. After the war he worked as Principal Assistant Engineer on the construction of the Louisville, Cincinnati and Lexington Railroad. In 1868 he joined the Louisville Bridge and Iron Company as an Assistant Engineer for the construction of the Fourteenth Street Bridge over the Ohio at Louisville, a bridge over one mile in length. This began Thacher's forty-four year career in bridge engineering which included eight bridge related

patents and the design of over 2,000 steel and about 200 concrete bridges. Supplementing his creativity was an exceedingly high aptitude for mathematics, evidenced by his Thacher Cylindrical Slide Rule, patented in 1881, and by his many sets of published tables for calculating bridge stress coefficients, both of which were widely used in engineering offices (ASCE 1921:921, 922).

After eleven years with Louisville Bridge and Iron, Thacher went to Keystone Bridge Company in Pittsburgh as a Design Engineer, rising to Chief Engineer in 1883 before leaving for Decatur Bridge and Construction Company in 1887. While at Keystone, he patented his slide rule and a bridge truss (1881), and made a significant contribution to the design of bridge columns by calculating and compiling a table of the ultimate strength of wrought-iron columns. His data demonstrated the applicability of the "right-line formula" for sizing bridge members and was widely adopted by bridge engineers. It was not determined if Keystone produced any of Thacher's patented trusses (ASCE 1921:921; 1972:116; Waddell 1916:258, 259).

In 1889 Thacher returned to Louisville and opened a private engineering practice where he designed bridges for southern railroads and served as a branch office for Shiffler Bridge Company of Pittsburgh. It was at this time that Thacher became interested in steel reinforced concrete bridges, the area of bridge engineering that he would make his most significant contributions (Johnson 1929:386; Waddell 1916:28)

Thacher was a partner in Keepers and Thacher, a Detroit engineering firm from 1894 to 1900, followed by a partnership in the Concrete Steel Engineering Company of New York until his retirement in 1912. In 1895 he designed the Kansas River Bridge in Topeka; at 693' it was the largest reinforced concrete bridge at the time and the first to utilize the elastic theory of arch design. He published one of the earliest specifications for concrete steel bridges in 1899, and patented one of the first deformed reinforcing bars for concrete known as the "Thacher bar," a predecessor of modern "re-bar" (ASCE 1921:921; 1972:116; Thacher 1899:179, 181).

The Thacher Truss, patented May 31, 1881, is a unique combination of triangular and suspension systems allowing a variety of configurations to suit various bridge requirements (Figures 4 and 5). The objective of Thacher's patent was to design a truss free of the defects common to all forms of triangular and quadrangular trusses in use at the time, the most popular being variations of the Warren and Pratt trusses. In his patent he identified eight defects inherent in these types of trusses, and described the methods by which his truss overcomes these defects. For example, Thacher found the adjustable counter ties of quadrangular trusses easily and commonly misadjusted resulting in undesirable stresses and strains. Additionally, counter ties were subject to strain reversals from impact loads and expensive to manufacture. The absence of adjustable diagonal members is an obvious feature of Thacher's truss. Another distinctive feature of some versions of Thacher's truss, evident in the Linville Creek Bridge, is the use of inclined struts at the center panel to resist both compressional and tensional strains. An important

yet visually discrete feature of the truss is the use of both vertical and inclined suspension members to carry the floor beams at intermediate panel points, that is, panel points not at the joints of the primary truss. Thacher designed a special connection which isolated the strains developed in the intermediate panel points from being transferred to the lower chord. Another unique feature of the bottom chord system is that it is adjustable at the pedestals by means of threaded ends on the first chord member. This eliminates a pin connection at the pedestal and provides a means of squaring and tightening the truss members after assembly (Thacher 1881; 1884:3, 4).

Wrought Iron Bridge Company, Canton, Ohio

The Wrought Iron Bridge Company was incorporated in 1871, taking over the operation of a foundry which had operated in Canton, Ohio, since 1840. Among the first officers of the company were David Hammond, President; W.R. Reeves, Superintendent; and Jon Abbott, Engineer and Attorney. The early works of the company were focused on the building of wrought iron arch bridges following designs patented by Hammond, Reeves, and Abbott. By 1881, the firm employed 270 men and had built bridges in twenty-five states (Deibler 1973:47, 48; Wrought Iron Bridge Company 1872:2).

In 1892 a new main riveting shop, measuring 256' square, was built, which incorporated the latest advances in bridge building methods and machinery. It was the first bridge shop to use electrically operated machinery. The company operated out of offices in New York City and Chicago as well as the main facility in Canton (*Engineering News* 1898:253).

In 1901, the Wrought Iron Bridge Company was purchased by the newly formed American Bridge Company. The American Bridge Company was formed in 1900-1901 by J.P. Morgan as a consolidation of twenty-eight bridge companies, representing eighty-percent of the structural steel fabricating capacity of the United States. At that time, the Wrought Iron Bridge Company plant had a manufacturing capacity of 5000 tons of steel per year, making it one of the smallest of the twenty-eight companies purchased by the American Bridge Company (United States Steel Corporation 1975:7,15).

According to *A Survey and Photographic Inventory of Metal Truss Bridges in Virginia, 1865-1932*, a study conducted by the VDOT Research Council in 1973, the Wrought Iron Bridge Company built a total of seven metal truss bridges in Virginia including six in the Staunton VDOT Construction District and one in the Richmond District (Deibler 1973). One other bridge constructed by the Wrought Iron Bridge Company, Gholson's Bridge (VDOT Bridge No. 6104), in Brunswick County, is included in the seventeen historic metal truss bridges recorded by Virginia in 1993-1994, of which this report is a part.

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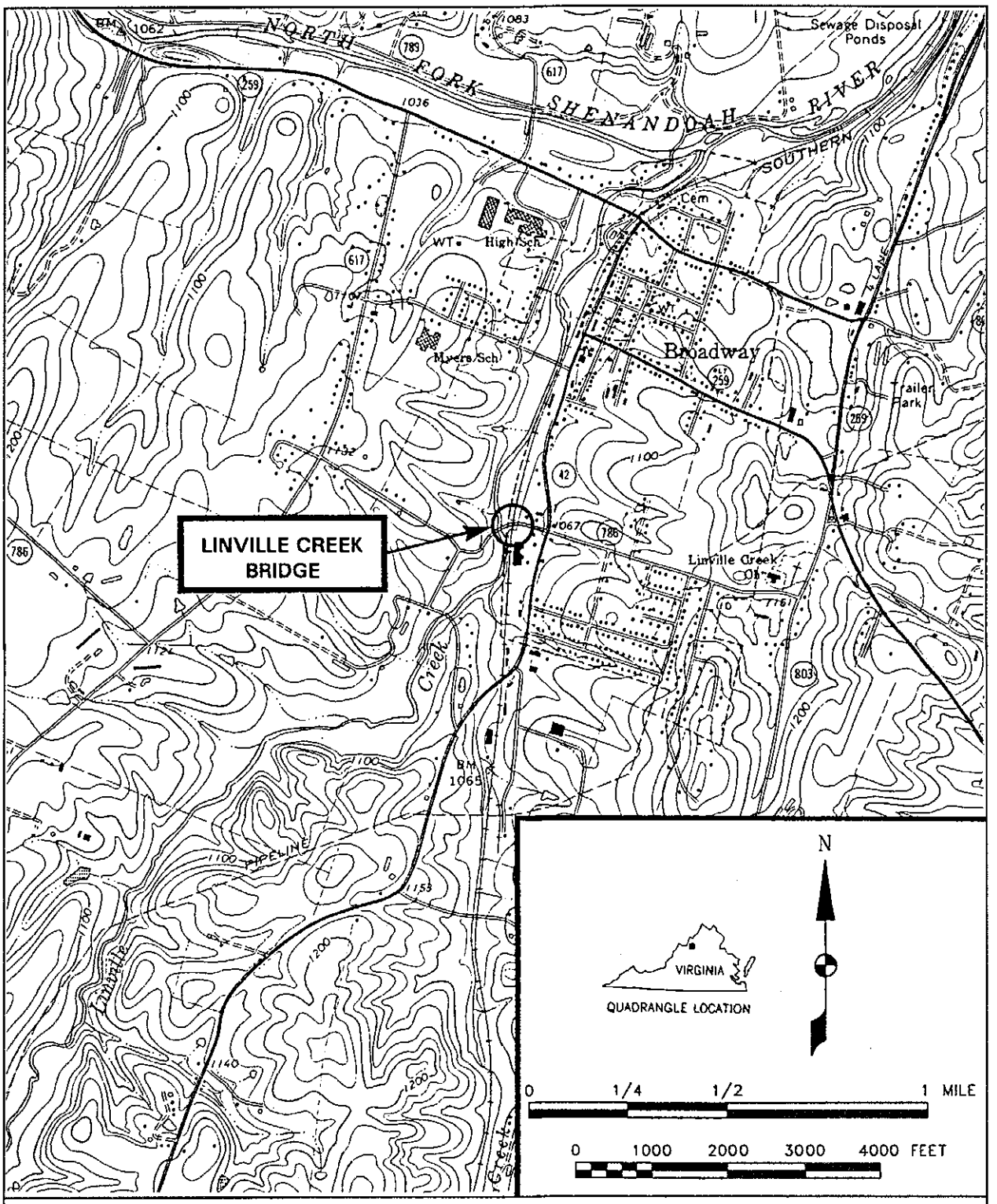

FIGURE 1: Location Map

SOURCE: USGS 7.5 Minute Quadrangle, Broadway, VA, 1967 (Photorevised 1987)

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SOURCE: Virginia Department of Transportation 1974

FIGURE 2: Original Bridge Report, Bridge No. 6154, September 25, 1974

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FIGURE 3: Original Bridge Report, Bridge No. 6154 September 25, 1974 *SOURCE: Virginia Department of Transportation 1974*

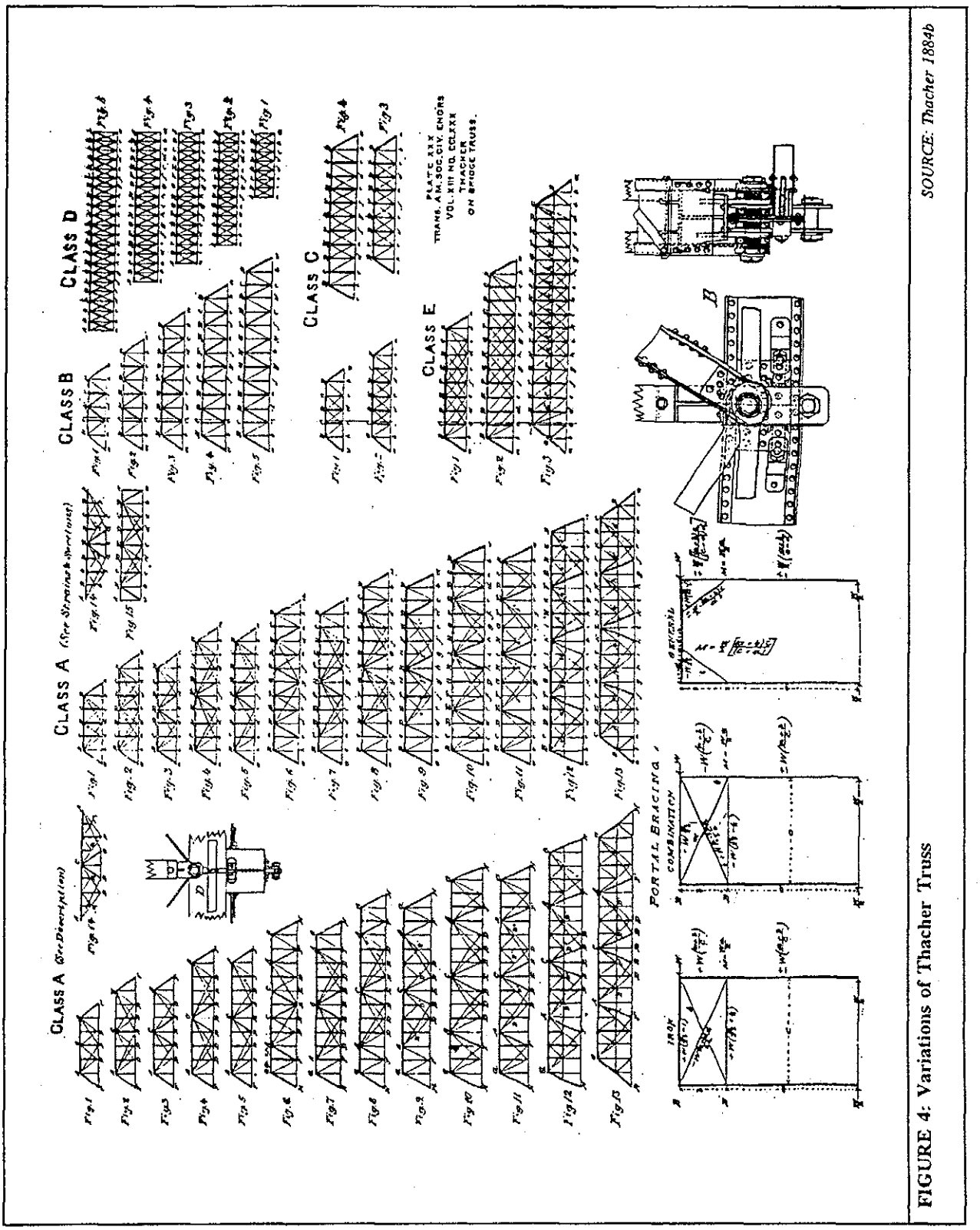

FIGURE 4: Variations of Thacher Truss

SOURCE: Thacher 1884b

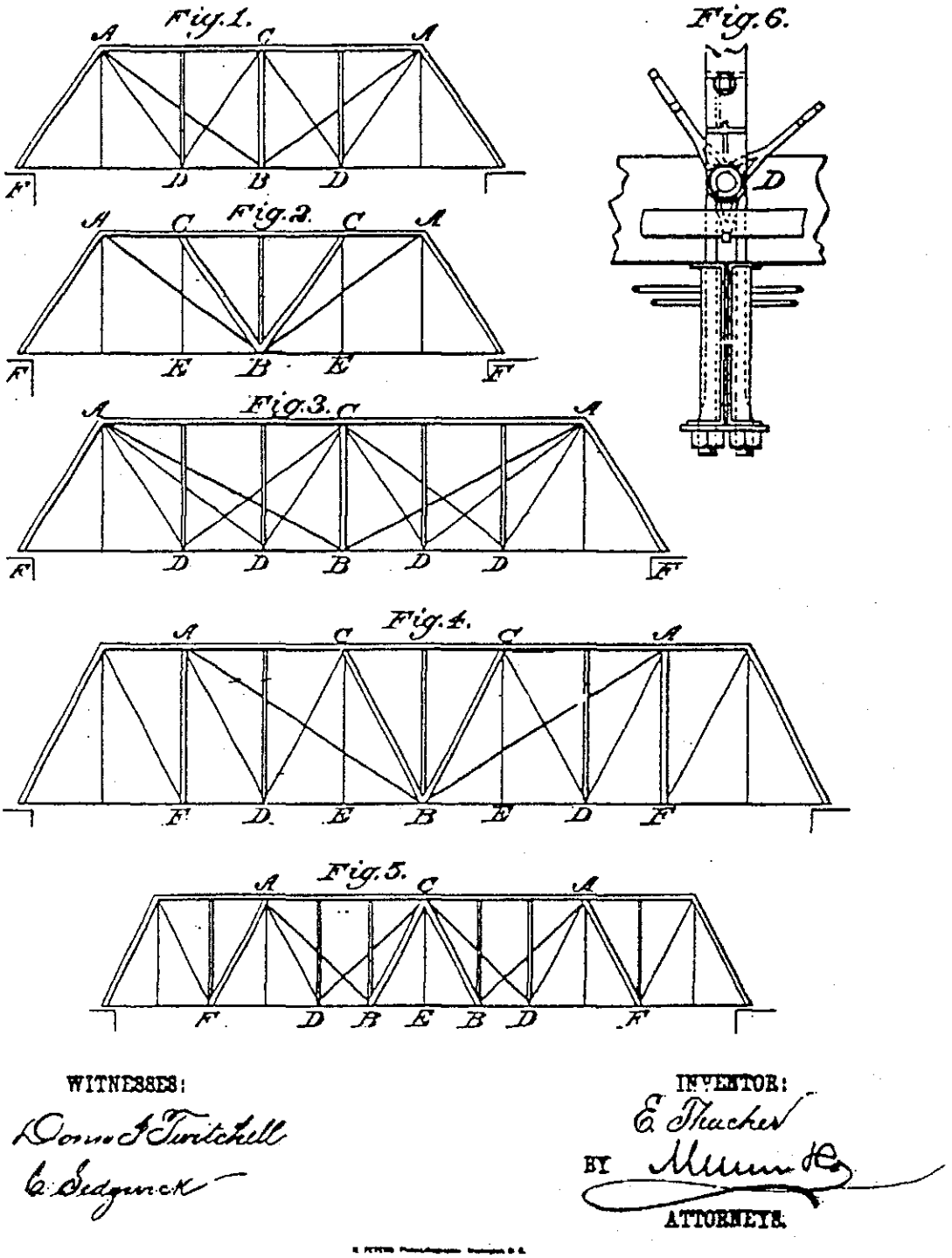

FIGURE 5: U.S. Patent No. 242,396 *SOURCE: Thacher 1881*