Schell Memorial Bridge
Spanning the Connecticut River on East Northfield Road
Northfield
Franklin County
Massachusetts

HAER No. MA-111

HAER
MASS,
6-NORTH,
7-

PHOTOGRAPHS
WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
Department of the Interior
Washington, DC 20013-7127

HISTORIC AMERICAN ENGINEERING RECORD

SCHELL MEMORIAL BRIDGE
HAER No. MA-111

Location: Spanning the Connecticut River on East Northfield Road, one-quarter mile west of the intersection of State Highway 63, approximately one mile south of the Vermont-New Hampshire border, Northfield, Franklin County, Massachusetts
UTM: Northfield, Mass., Quad. 18/780520/4731780

Date of Construction: 1903

Structural Type: Steel cantilever Pennsylvania-type through truss bridge

Engineer: Edward S. Shaw, Boston

Fabricator/ Builder: New England Structural Company, East Everett, Massachusetts (superstructure);
Ellis & Buswell, Woburn, Massachusetts (substructure)

Owner: Town of Northfield, Massachusetts

Previous Use: Rural vehicular and pedestrian bridge

Present Use: Barricaded and abandoned, 1985

Significance: The Schell Memorial Bridge is the third oldest of five known Pennsylvania truss bridges identified in the Massachusetts Department of Public Works database. It is a unique variation--at least in Massachusetts--of a Pennsylvania truss, in that it was designed to function as a three-span continuous truss under live load, and as a simple truss span with cantilevered ends under dead load. The bridge also has some unusual Cothic Revival decorative elements. The bridge is a significant artifact of Northfield's social history, in that it was built for the town by one of its most prominent citizens, Francis R. Schell.

Project Information: Documentation of the Schell Memorial Bridge is part of the Massachusetts Historic Bridge Recording Project, conducted during the summer of 1990 under the co-sponsorship of HABS/HAER and the Massachusetts Department of Public Works, in cooperation with the Massachusetts Historical Commission.

Lola Bennett, HAER Historian, August 1990

Description

The Schell Memorial Bridge is a 515-foot, riveted steel cantilever Pennsylvania-type through truss. The bridge was designed to function as a three-span continuous truss under live load, and as a simple truss span with cantilevered ends under dead load. This was accomplished by means of freight car springs, placed under the abutment ends of the bridge, to counter upward movement of the ends when the bridge had a live load in the center. The upper chord is a polygonal curve in outline, and is comprised of three plates and four angles, latticed underneath. The lower chord is comprised of two plates and four angles, latticed top and bottom, except at the center of the bridge, where the plates are connected with tie plates. The upper and lower chords are connected by a series of verticals, diagonals, sub-struts and sub-ties. The verticals are either two plates and four angles, double-latticed on two sides; or four angles, single-latticed. The verticals directly over the piers are comprised of four plates and four angles. The main diagonals, hangers and sub-struts, are generally comprised of four angles, but the heavier diagonals are built up of two plates and four angles. Upper lateral bracing consists of transverse struts (four angles, latticed) between panel points, and single angles crossing between the struts at every other panel. Lower lateral bracing consists of angles crossing between panel points. Steel floor beams, which are built-up of web plates and four flange angles, are riveted to the lower end of the vertical members. The original wooden stringers have been replaced with steel stringers, which support a wood block deck, paved with asphalt. The portals are defined by the inclined endposts of each truss, with cast iron finials at the top, and an ornamental Gothic portal strut crossing overhead. The portal strut is pierced with small Gothic arches and trefoils. Other unique details include Gothic-arch sway bracing between the panel points directly above the piers, stone pylons with pyramidal caps, and connecting low stone parapets at each end of the bridge. The bridge rests on quarry-faced granite ashlar piers and granite-faced concrete abutments. (See Figures 1 and 2, Appendix D, and field photos.)

Northfield

The town of Northfield is situated about twelve miles northeast of the town of Greenfield, and directly south of the Massachusetts border with Vermont and New Hampshire. The Connecticut River divides the town into two parts, with the village center being located on the east side. Due largely to the surrounding topography, with the river to the west and clustered hills to the east, the village is laid out in a linear pattern along a very straight stretch of road, running nearly parallel to the river.(See Figures 3 and 3a.) Today, the village of Northfield appears much the same as it did in the nineteenth century, with a wide main street lined with trees, manicured lawns, and tidy woodframe houses. Long boasted of for its serenity and beautiful vistas, Northfield is perhaps best known for its association with the famed evangelist, Dwight L. Moody, and the schools that he founded within its borders.

Dwight L. Moody

Dwight Lyman Moody was born at Northfield, February, 1837, the son of Edwin Moody, a brick mason, and his wife Betsey. Four years later, Edwin Moody died, leaving his widow to care for nine children. Dwight attended school until the age of thirteen, and then went to work on nearby farms to help support his family. At seventeen, he left home to seek his fortune in Boston, where he found employment at a shoe store owned by two of his uncles. While there, he began to attend church, and through the interest of his Sunday school teacher, "he experienced what he ever afterward recalled as his conversion."[1]

In the fall of 1856, Moody left for Chicago, where he worked as a shoe salesman, and became very successful. Over a period of several years, however, religion and human welfare began increasingly to claim his time and interest, and eventually he left business behind, and became involved in a program of evangelistic services, prayer meetings, philanthropic relief and welfare work. In 1873, Moody embarked on a trip to Great Britain for a series of evangelistic meetings. Great numbers of people welcomed him in his travels through England, Scotland and Ireland. At London, 285 meetings were held, with an estimated total of 2,530,000 people attending.[2]

Moody's visit lasted more than two years, and was said to be the cause of a tremendous religious awakening in Great Britain. Moody, and his traveling companion and organist, Ira Sankey, returned to the United States in "a blaze of public curiosity and interest, which brought them many more invitations than they could accept."[3] At that point, however, Moody returned to Northfield, where he had decided to live, and during the next twenty years of his life, he undertook numerous evangelistic campaigns across North America.

At the same time, his heart was drawn to the needs of the people near his home, and in 1879 he established a school at Northfield Village, for girls of limited means, the Northfield Seminary for Young Ladies.(See Figure 4.) Three years later, Moody established a similar school for boys, the Mount Herman School, just across the Connecticut River, in the neighboring town of Gill. Beginning in the summer of 1880, Moody held a national conference of Christian workers at the Northfield Seminary. These summer conferences eventually brought world-wide reknown to the otherwise peaceful and unassuming village of Northfield.

In 1899, Dwight L. Moody's evangelistic work was abruptly curtailed by illness. He died at his home in Northfield, at the age of 62, on December 22, 1899. Of his life, it was said:

> A man of prayer, he was tirelessly and far-sightedly a man of work. "There is no use asking God to do things you can do yourself," he said. A layman, Moody inspired ministers; an evangelist, he understood the importance of Christian education; unschooled, he commanded the admiration and cooperation of University students and teachers; a man of large business ability, he devoted himself unreservedly to what he conceived to be the greatest business in earth or heaven--the saving of souls.[4]

Francis R. Schell

Quite inadvertantly, Dwight L. Moody was to have an impact on the town of Northfield that went beyond the schools he founded and the summer conferences he established there. In the winter of 1889, when Moody was holding a series of meetings in New York, he met Mr. and Mrs. Francis R. Schell, who were interested in the summer conferences at Northfield. Francis Schell was the only son of Robert Schell, one of four brothers who were immensely successful as bankers and jewellers in New York City.[5] At Moody's invitation, the Schells went to Northfield in the spring of 1890 and stayed at the Northfield Hotel, which was owned and operated by the Northfield Seminary. They stayed in one of the unfinished cottages built on the property, and Mr. Schell apparently became so attached to it, that he purchased it and about ten acres of land. He began improving the grounds, adding on to the cottage, and purchasing more land, until he had acquired about 125 acres.[6] He and his wife occupied this house every summer during the conferences.(See Figure 5a.)

In 1900, Francis Schell inherited his father's considerable fortune, and decided to build a country estate at Northfield. "The Chateau," as it came to be known, was designed by architect Bruce Price, and modeled after a French chateau that the Schells had admired on one of their trips to Europe.(See Figure 5b.) When completed in 1903, the residence had thirty-six rooms, twenty-four bathrooms, twenty-one fireplaces, a main hall capable of seating 200 people, and an interlaced double-spiral stairway.[7] The Schells spent the rest of their summers at their new estate, until 1928, when Francis Schell died.

Francis Schell had a great fondness for the town of Northfield, and perhaps an even greater fondness for Dwight L. Moody and the Northfield Schools. This was demonstrated in 1901, when, in an act of extreme generosity, Schell offered to pay for a bridge that was badly needed by both the town and the schools.

The Bennett's Meadow Bridge

For many years, the only crossings over the river at Northfield were by means of ferries. The best-known of these were: Stebbins Ferry, also known as Bennett's Meadow Ferry, just below the village center; Munn's Ferry, about a mile downstream; and Stacy's Ferry, at Northfield Farms, in the southern section of Northfield.(See Figures 6 and 7.)

The first bridge over the Connecticut River at Northfield was built in 1849, when the Vermont & Massachusetts Railroad laid tracks through the town and erected a double-deck, covered wooden bridge across the river near the village center. The upper deck was used by the railroad, while the lower deck was a highway toll bridge.(See Figure 8.) The lower portion was sparingly lit with small windows and a series of kerosene lamps, and from all accounts, was quite a frightening place to be whan a freight train was passing overhead.[8] For half a century, this wooden structure was the only bridge in Northfield, until the year 1899, when the first highway bridge was constructed at the place known as Bennett's Meadow.

In 1897, a bill was proposed in the legislature for the authorization of the construction of a highway bridge across the Connecticut River at

Northfield. Many people, including the county commissioners, opposed the bill, feeling that the ferry system was adequate, and that the cost of building the bridge would mean an increase in taxes.[9] The bill passed, however, and the county commissioners were directed to build the bridge at a cost not to exceed $40,000, to be apportioned between the county and the towns of Gill and Northfield.[10]

Shortly thereafter, the discussion became even more heated, over where the bridge should be located. While Dwight L. Moody had kept out of the discussion fairly well until that time, he let it be known at the town hearing that a bridge at the Bennett's Meadow location would be of great value to the Mount Hermon School--leading some to speculate that Moody himself had been the initiating force behind the bridge bill.[11] After a two-day town hearing, the matter was finally settled, with the Bennett's Meadow location being selected.

The Northfield Bridge, also known as the Bennett's Meadow Bridge, was completed in 1899, and was a 613-foot arched cantilever, designed by Edward S. Shaw, a civil engineer from Boston. The principle behind this bridge, which was designed to eliminate obstructions in the river flow, was described as follows:

> The idea of the bridge is new to this section of the country, but is recognized in bridge construction as sound and is represented in several of the staunchest structures in the country. The bridges across the Connecticut for highways are generally suspension bridges, while the other and older type is the wood truss bridge with comparatively short spans resting on stone piers. The suspension bridge is comparatively cheap and has the advantage of spanning the stream, without obstruction to the passage of ice and logs, the two elements of danger to bridges, aside from the floods; but the suspension bridge is not regarded as the most desireable, from the standpoint of durability and strength.
>
> The principle in the proposed bridge is the cantilever, modified in this plan to what Mr. Shaw calls a "reversed cantilever." The support of the iron superstructure is wholly the two piers, one of which stands on a ledge of rock on the west bank of the stream and the other at the edge of the stream at low water. Thus the river is wholly unobstructed and except at high water the piers offer no obstruction.[12]

The marvels of engineering, however, were a moot point for residents of Northfield who felt that they had been treated unfairly in being assessed 70 percent of the cost of the bridge.[13] The whole incident stirred up resentment that was felt long afterward, and had a lasting effect on decisions made by the town, not the least of which was the construction of another highway bridge just a few years later.

The Schell Memorial Bridge

Shortly after the Bennett's Meadow Bridge was completed, the state railroad commission condemned the 50-year-old railroad bridge just upstream.

The railroad--by that time known as the Central Vermont Railway--then petitioned the legislature for authority to build a new bridge in cooperation with the town of Northfield.[14] At first, it appeared that the town favored the construction of another joint railroad and highway bridge, and an agreement was reached by which the town was to pay $10,000 toward the cost of a steel bridge.[15] As time went on, however, a growing percentage of the population expressed interest in a separate highway bridge, which would not only relieve them of paying rent for their portion of the railroad bridge, but would also do away with the nuisances caused by passing trains--namely soot, smoke, and runaway horses. One of the strongest proponents of a separate bridge was the Northfield Seminary, which advocated building the bridge farther up the river, and asked for a delay in the plans. The bridge they projected would greatly shorten the distance between the Moody Auditorium at the Northfield Seminary (where the summer conferences were held) and the nearest railroad station at South Vernon, Vermont. On June 19, 1901, the state legislature passed an act authorizing the town "to construct and maintain a highway bridge, with suitable approaches, across the Connecticut river in said town at a point to be selected by the town."[16] The cost of this bridge, however, was estimated at $35,000, an expense the town felt it could not possibly bear.[17] For quite a few months the discussion waged on, with much resentment building on the part of those individuals who felt that too much money had been spent on the Bennett's Meadow Bridge, and that the town was always showing favoritism to the enterprises of the Moody schools.[18] Hoping to win the town over, the Seminary offered to pay $23,000 toward the cost of the bridge, but that still left the town with the problem of coming up with an additional $12,000, which was several thousand dollars more than they had been expecting to put up for the joint bridge with the railroad.[19]

At that point, apparently, Mr. Ambert G. Moody (D.L. Moody's nephew), representing the Northfield Seminary, approached Francis Schell with the proposal that Schell might donate money to the project, and have the bridge constructed as a memorial to Schell's recently-deceased father.[20] While the idea of a memorial bridge appealed to Mr. Schell, he also wanted to help out the schools founded by his dear friend, the late Dwight L. Moody. Ultimately, (whether for strictly altruistic reasons, or not) Schell offered the entire sum of money for the bridge. In his proposal to the town, Schell wrote:

> Desiring to leave an enduring memorial to my honored father, Robert Schell, in Northfield, and also desiring that a bridge be built across the Connecticut River at a point within 500 feet north of the boundary line between lands of the Northfield Seminary and one William D. Alexander, I hereby for myself, my executors and administrators, do offer, covenant and agree that if the Town of Northfield shall cause a bridge to be constructed at such location under the provisions of the Acts of 1901, Chapter 530 or any amendments thereof, within two years from date, I will, and my executors and administrators shall, pay to the said Town the cost of such bridge to an amount not exceeding Thirty Two Thousand Dollars... All payments will be made by check to Mr. Ambert G. Moody and be endorsed over to him.
>
> Two such memorial tables as I shall desire shall be placed

> and maintained upon said bridge. It is my wish and expectation that the building of the bridge be begun at once and the dates of said payments are established upon that basis. I make this offer in order that the Town of Northfield and Northfield Seminary may be permanently benefitted, and I desire no formal or informal opening of the bridge to take place when the bridge is done, simply begin to use it.
>
> In witness whereof I hereunto set my hand and seal this 28th day of August, 1901.
>
> Francis Robert Schell.

(See Appendices A and B.)

On September 17, 1901, Mr. Schell's offer was unanimously accepted by the town, putting to rest the year-long stalemate.[21] Plans commenced immediately for the construction of the new bridge.

Construction

Edward S. Shaw, the engineer who designed the Bennett's Meadow Bridge, had previously been asked to design this new highway bridge as well. As first projected, the bridge was "designed for utilitarian purposes only, with three simple and independent spans," but after Mr. Schell decided to have the bridge erected in memory of his father, the plans were changed substantially.[22] The newspaper related this as follows:

> This bridge was accepted by the town of Northfield at a meeting called for that purpose last fall, and the plans then submitted to the town, and the proposition made called for a bridge costing $32,000; this bridge was to be a three-span bridge. Upon careful consideration, it was found that the original plan would result in a structure that was not pleasing architecturally. In order to remedy this lack, especially as it was to be a memorial and it was desired that no detail should be wanting to its perfection, an additional cost of $6000 was authorized by Mr. Schell, and now a bridge will be erected with a single ground arch leaping from one bank of the river to its opposite 400 feet away.
>
> Bridge builders who have seen the plans of the proposed structure characterize it as highly artistic in effect and beutiful in all its details. In fact, it is stated that the New England Structural Company, to whom the contract is awarded, submitted a bid for the contract only after the plans had been modified as described above and the superstructure designed in such a manner as to make it a great credit to the company that was fortunate enough to erect it.[23]

The revised plans for the Schell Memorial Bridge showed a structure very similar to the Bennett's Meadow Bridge, designed by Shaw several years earlier.(See Figure 9.) The Schell Bridge, however, was to have considerably more ornamental details than the earlier bridge.

Unfortunately, work had to be delayed for a year, "owing to the difficulty of getting steel,"[24] and thus, construction did not begin until the spring of 1903. The abutments and piers were built by the firm of Ellis & Buswell of Woburn, Massachusetts, and the superstructure was erected by the New England Structural Company of East Everett, Massachusetts.(See Figure 10.)

Once the abutments and piers were completed, the shore arms were constructed between them, using falsework on the shore. The rest of the steel superstructure was cantilevered out over the water, using temporary earth loads on each pier to counter the weight of the steel. The material for the bridge was delivered to the west bank, where it was picked up and set in place by means of a 1-3/4" diameter wire cable, suspended between two wooden towers, one on either side of the river, thus eliminating the need for falsework in the river. The trusses were erected one panel at a time from each side, with the erecting and riveting crews switching from side to side.(See Appendices C and D.) On November 21, 1903, the newspaper reported:

> The Schell memorial bridge across the Connecticut river is completed and will be used as soon as the grading is finished. This is a beautiful structure of iron of the modified cantilever type built at the expense of $42,000.[25]

At Mr. Schell's request, bronze tablets were placed at either end of the bridge, bearing the following inscription:

> This bridge is erected in memory of
> Robert and Mary Schell of New York,
> by their son, Francis Robert Schell
> 1903

<u>Conclusion</u>

After Francis Schell died in 1928, his widow sold their estate to the Northfield Schools, but The Chateau eventually fell into disrepair and was torn down in the 1960s, leaving only the bridge as a reminder of the Schell's days at Northfield. Today, the plaques have long since been removed, the bridge is barricaded with metal plates across the portal ends, and weeds are growing up around it, yet it has the same type of air about it that one might ascribe to a grand palace left to ruin--of the long-ago aspirations of great men.

Now nearly ninety years old, the Schell Memorial Bridge has remained virtually unaltered over time, with the exception of the floor system which was replaced in 1932 with new stringers and a wood block deck.[26] The bridge was maintained by the state until the 1970s, when Highway 142 was rerouted over a new highway bridge at Bennett's Meadow, at which time the Schell Bridge became the sole responsibility of the town. In response to a 1977 engineering study, the town studied proposals for the bridge's rehabilitation or replacement, but concluded that they just did not have the money to fund such an undertaking. The bridge has been closed since 1985, and the town is awaiting assistance from the state to replace it.

The Schell Memorial Bridge is architecturally significant as the third oldest of five Pennsylvania truss bridges identified in the Massachusetts

Department of Public Works database. It is a unique variation (at least in Massachusetts) of a Pennsylvania truss, in that it was designed to function as a three-span continuous truss under live load, and as a simple truss span with cantilevered ends under dead load. It also has some unusual Gothic Revival decorative elements. The Schell Bridge is historically significant because of its association with Francis Schell and the Moody schools, and is a very interesting and unique artifact of Northfield's social history.

Edward S. Shaw

Edward S. Shaw was a civil engineer who lived in Cambridge, Massachusetts, and maintained a professional office in Boston during the late-nineteenth and early-twentieth centuries. Although the number of significant Massachusetts bridges attributed to him attest to his talent, Shaw apparently led a rather unassuming life, and little was ever recorded about him; however, nearly all contemporary mentions of his work pay tribute to his engineering expertise. For example, a newspaper article on the construction of the Bennett's Meadow Bridge said that Shaw was "regarded as one of the most expert bridge engineers in New England."[27]

Shaw was first listed in Cambridge city directories in 1873. He was listed as a student, boarding at 10 Kirkland Place, the home of George S. Shaw, a dealer in "fancy goods." George S. Shaw was not listed prior to 1873. The following year, 1874, the directories carried the same listing. Beginning in 1875, and ending in 1918, Edward Shaw was listed as a civil engineer in Cambridge directories. During this period, Shaw was also listed in Boston city directories. The first listings, in 1881 and 1882, say that he was a draughtsman for the Boston & Lowell Railroad. Beginning in 1883, he was listed under the heading of "Civil Engineers and Surveyors," and advertised his specialty as the design of "Bridges, Roofs, Railroad Stations and Buildings." By the early 1900s, Shaw was advertised as a "Bridge and Structural Engineer." The last listing for Shaw in the Boston city directories was in 1919, the year that he died in Cambridge, at the age of 65.

Among the eleven other surviving Massachusetts bridges known to have been designed by Shaw are: the Holyoke Bridge, between Holyoke and South Hadley, 1890 (HAER No. MA-18); the Willimansett Bridge, between Holyoke and Chicopee, 1891; the Shelburne Falls Bridge, between Shelburne and Buckland, 1890 (HAER No. MA-96); spans 1, 2 and 3 of the Merrimac Bridge, between Haverhill and West Newbury, 1883 and 1895 (HAER No. MA-103); the Chapman Street Bridge at Canton, 1888; and the Essex Bridge, between Salem and Beverly, 1897.

New England Structural Company

In 1892, the Norton Iron Company was established in Everett, Massachusetts, to manufacture the "Norton Door Check," said to be the first practical device of its kind that had been invented.[28] Orlando W. Norcross was president, and Lewis C. Norton was treasurer. Orlando Norcross was also engaged, with his brother, James A. Norcross, in the widely-known Worcester building and contracting firm of "Norcross Brothers."[29]

The Norton Iron Company soon expanded to include the manufacture of iron used in building construction. This development opened up a wide market, and in 1898, another company was formed, The New England Structural Company, specializing in structural steelwork for buildings and bridges.[30] Within thirty years, this company could boast of being "the largest fabricator of structural steel in New England."[31]

Soon after the company was founded, an office was established in Boston, while the fabricating plant remained at East Everett. The New England Structural Company was listed in both Everett and Boston directories between 1899 and 1938. The company flourished under the direction of president Walter B. Douglass, an 1891 graduate of M.I.T., and treasurer Charles N. Fitts, a classmate of his.[32] Both men had worked at the Norton Iron Company shortly after their graduation, and eventually took charge of the company's affairs, and remained in their respective positions until 1938, at which time the company apparently dissolved.

Ellis & Buswell

Jacob M. Ellis was born in Canton, Maine on November 8, 1843. He was the son of a farmer, and one of twelve children. After receiving his education in the public schools, he became a stone mason and builder. At the age of 32, he moved to Woburn, Massachusetts, and established his business, "J.M. Ellis & Company" in 1879.[33] This company built many of the bridges and railroad stations along the Boston & Maine Railroad.[34] In the late 1890s and early 1900s, Ellis was associated with John W. Buswell of Winchester, Massachusetts, and although directories only referred to the company as "J.M. Ellis & Co.," company letterheads and news articles dating to the construction of the Schell Bridge, indicate that the company was known as "Ellis & Buswell."(See Figures 10 and 11.) Jacob Ellis died in July of 1908, but according to city directories, his sons carried on the business until sometime in the 1920s.[35]

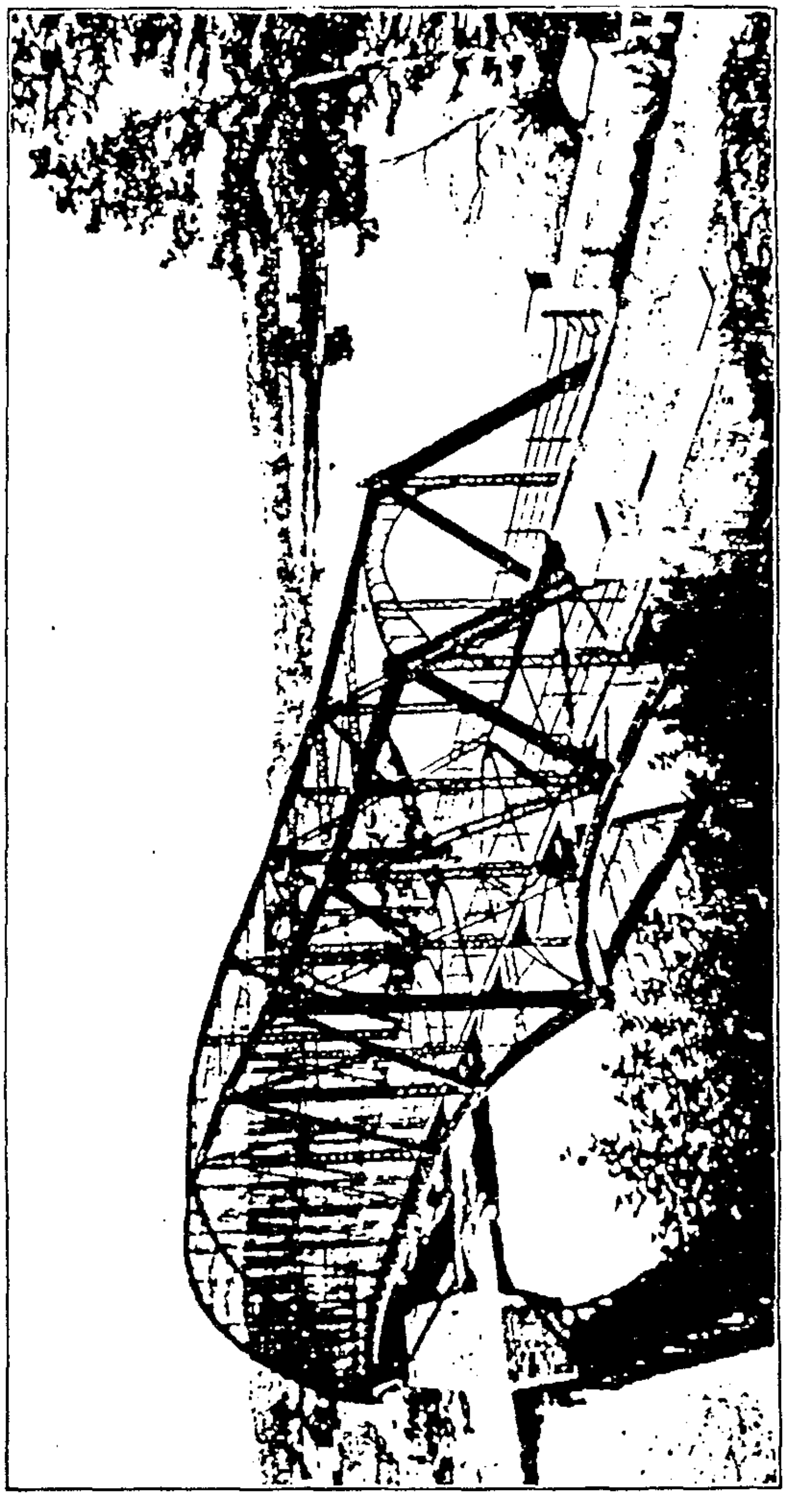


Figure 1. View of Schell Memorial Bridge, looking northwest.
(Souvenir Program, Northfield Tercentenary, 1973.)

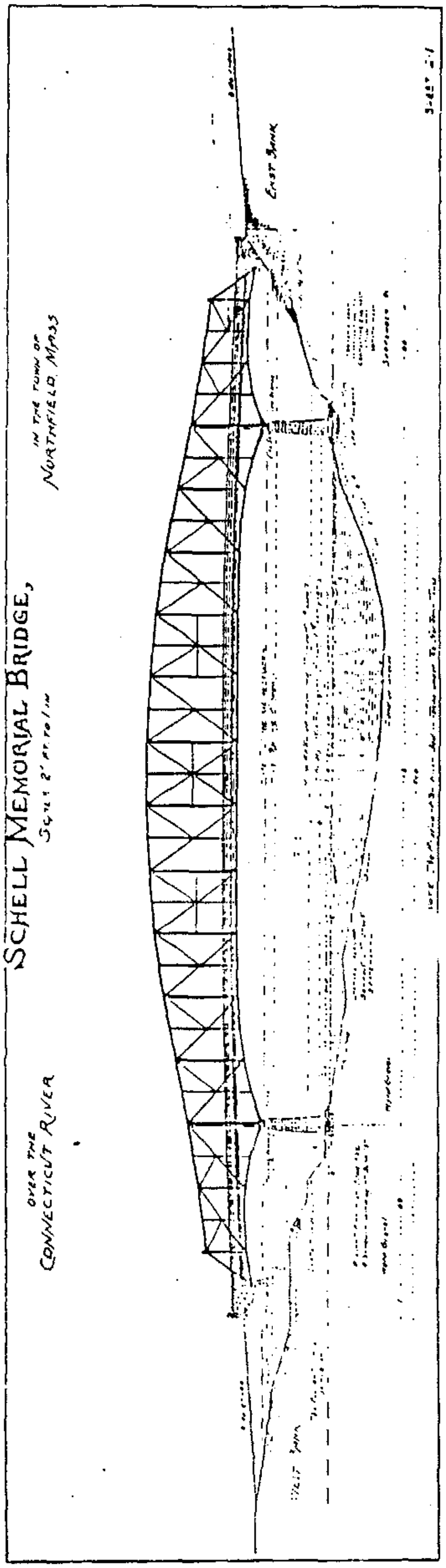


Figure 2. Plan for Schell Memorial Bridge, Edward S. Shaw, 1901.

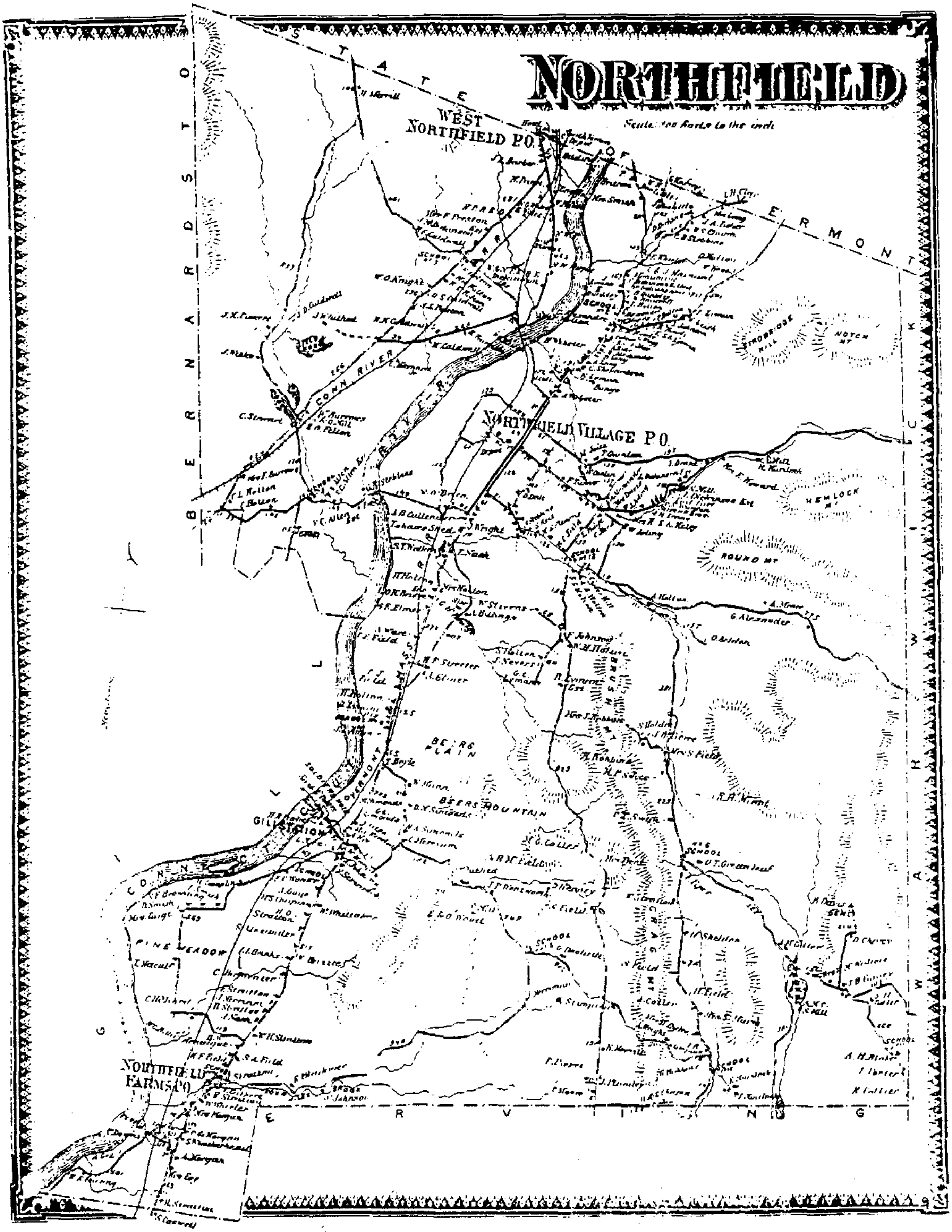


Figure 3. Map of Northfield, Massachusetts, F.W. Beers, 1870.

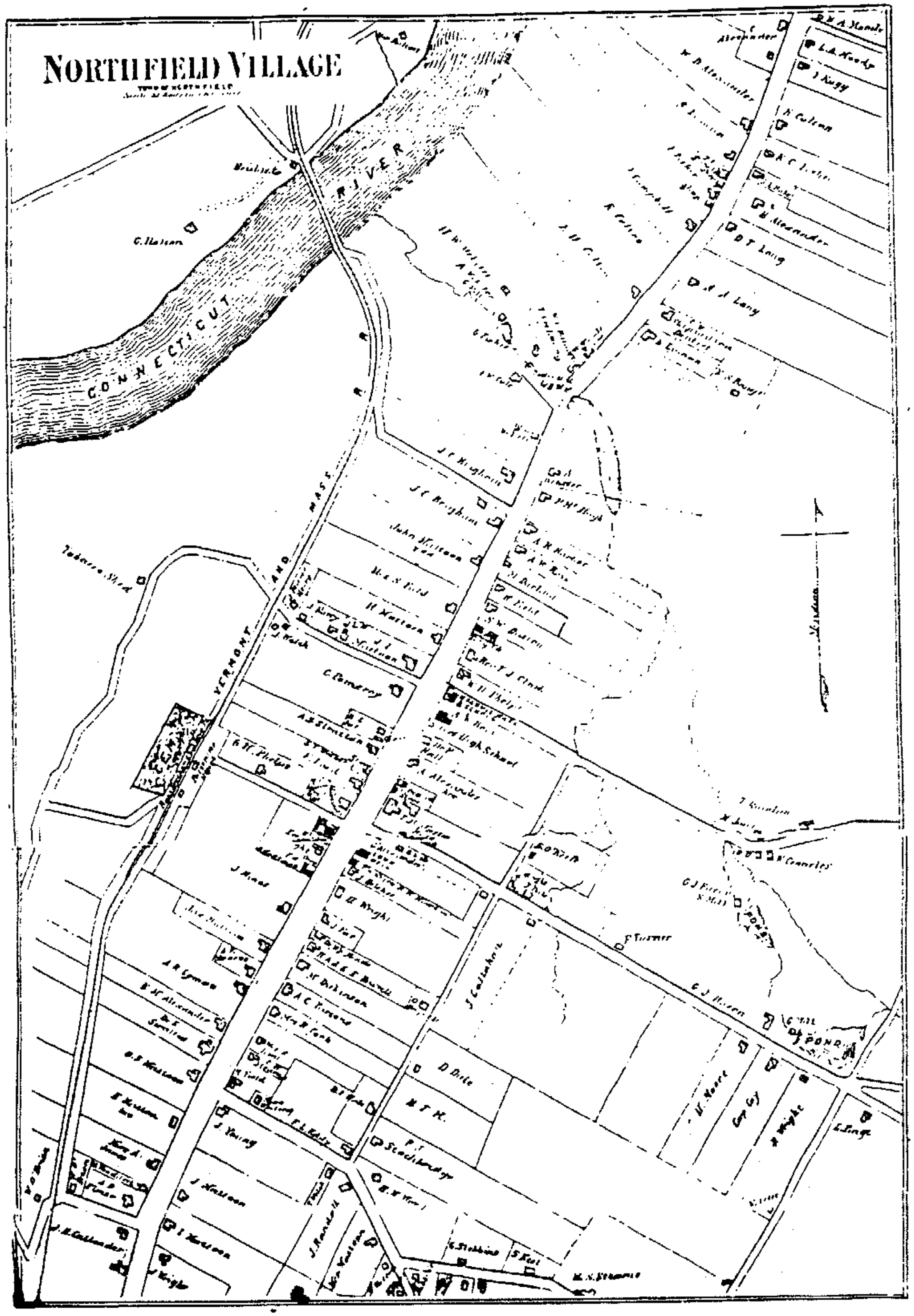


Figure 3a. Map of Northfield Village, F.W. Beers, 1870.

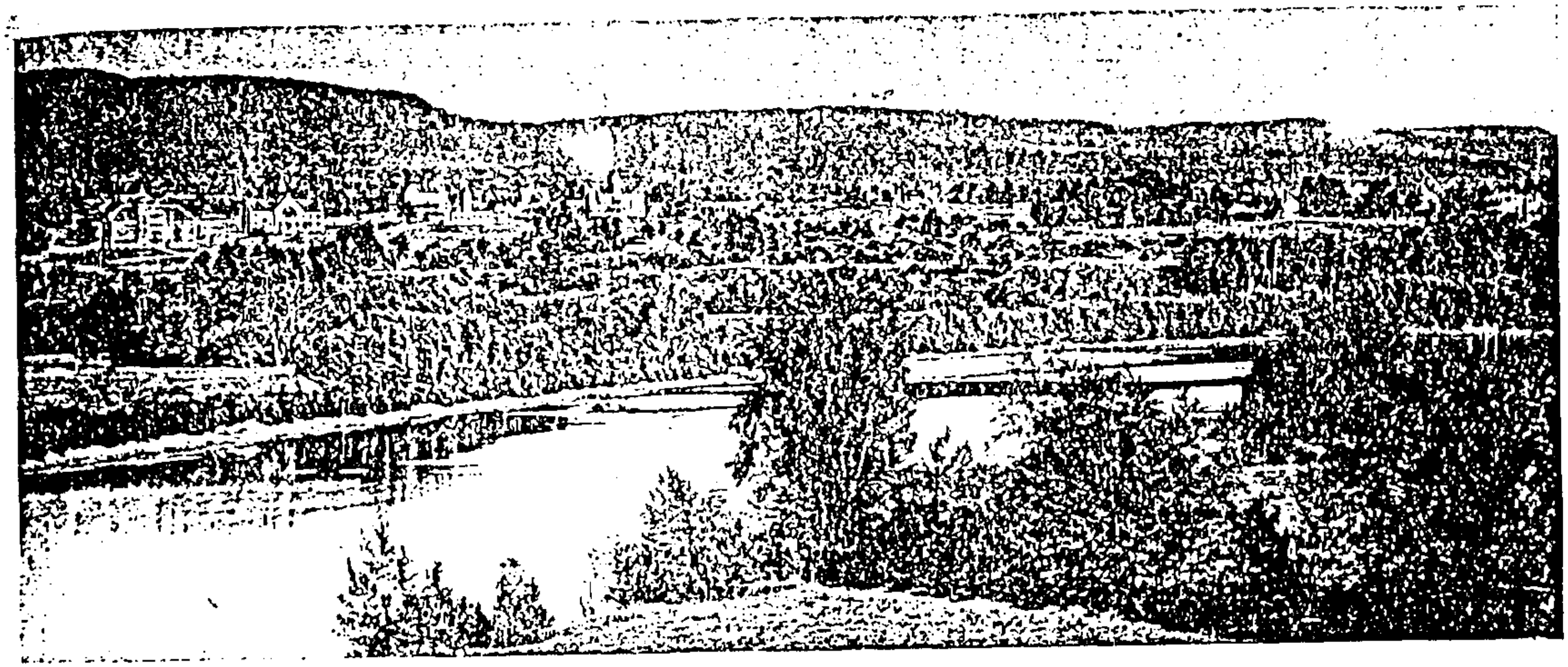


Figure 4. View of Northfield Seminary, looking east from west bank of the Connecticut River. (Centennial Gazette, 1892.)

Figure 5a. Schell summer residence at Northfield.
(Centennial Gazette, 1892.)

Figure 5b. "The Chateau," built for Francis Schell at Northfield, 1900-03.
(Photo, dated 1956, from the collection of Whitfield W. Moretti, Acton, Massachusetts.)

Figure 6. Photo of Munn's Ferry at Northfield.
(Souvenir Program, Northfield Tercentenary, 1973.)

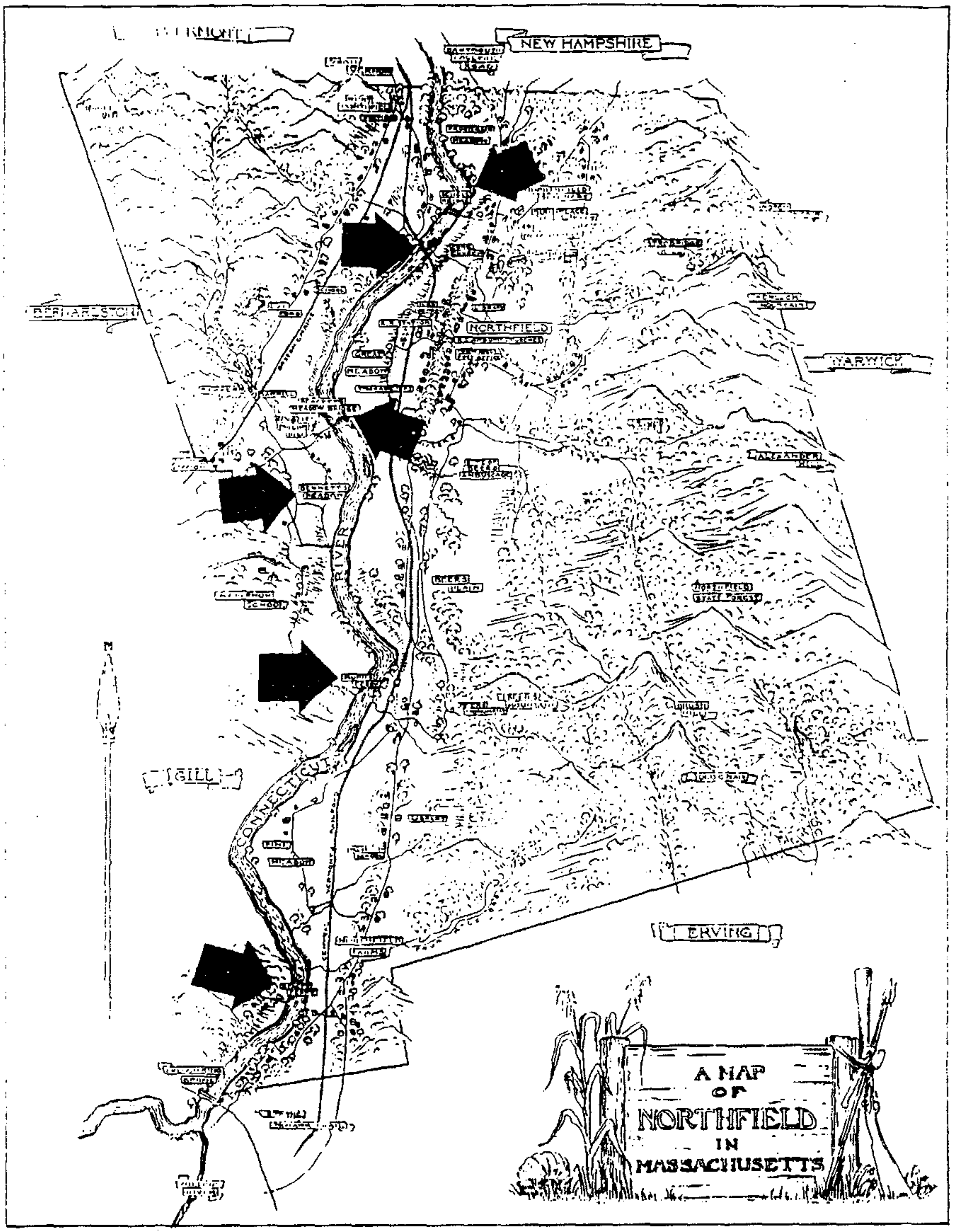


Figure 7. Map of Northfield, showing locations of ferries and bridges. (Whittlesey, 1936.)

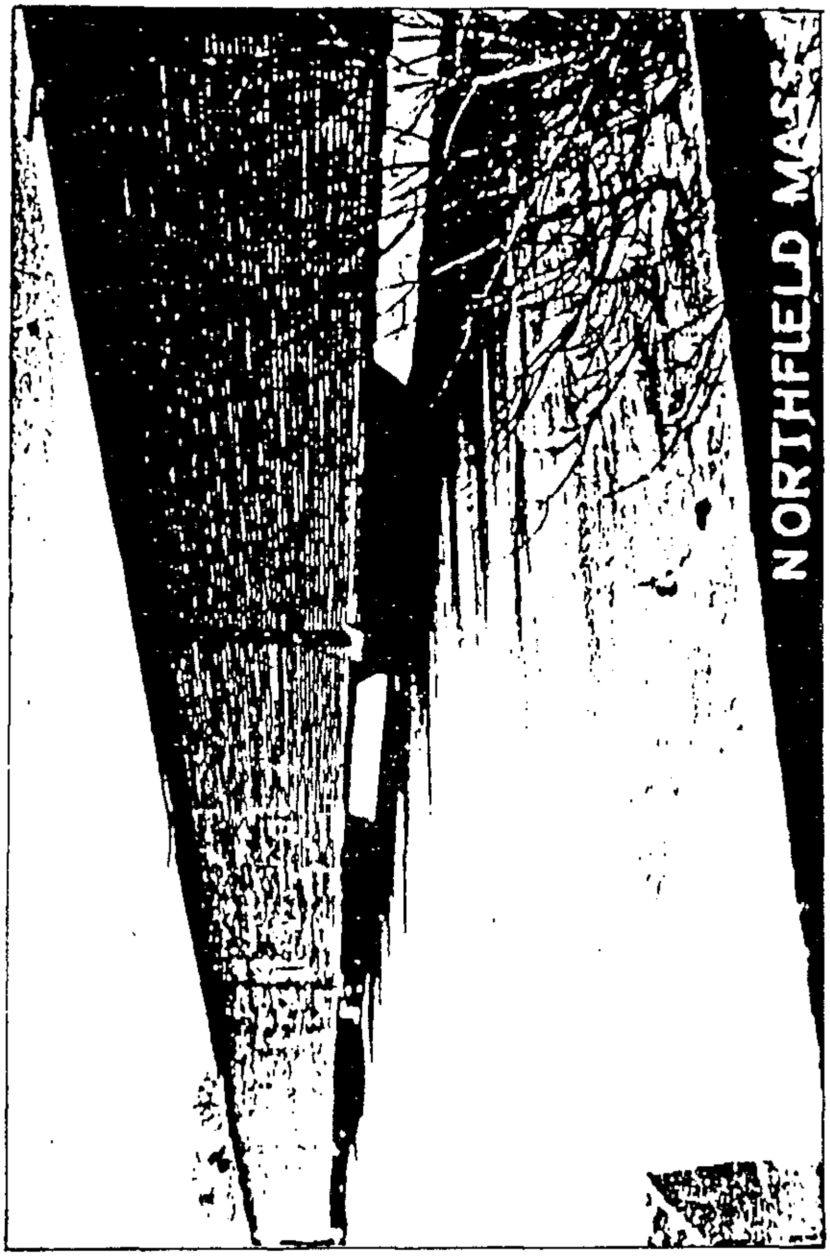
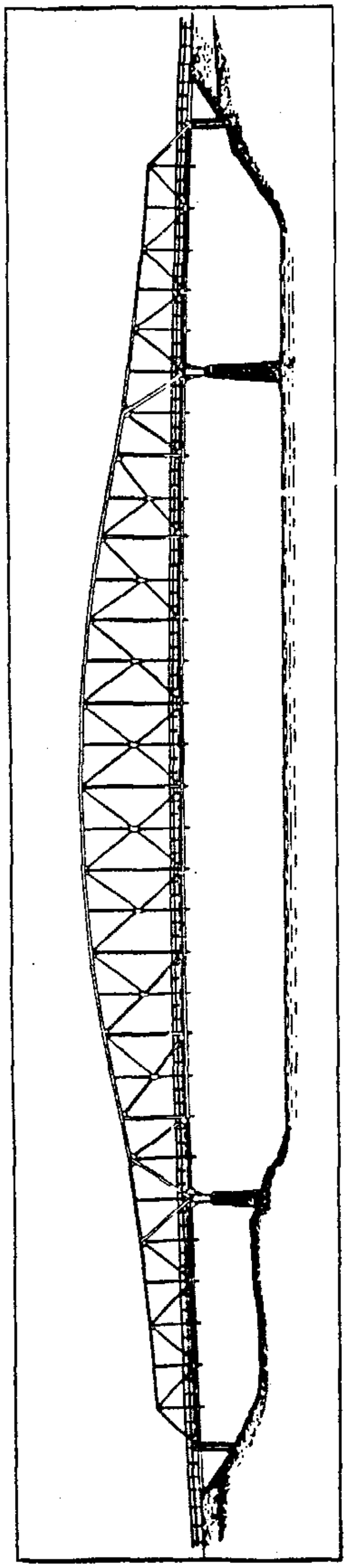


Figure 8. Photo of 1849 railroad bridge at Northfield. (*Souvenir Program, Northfield Tercentenary*, 1973.)



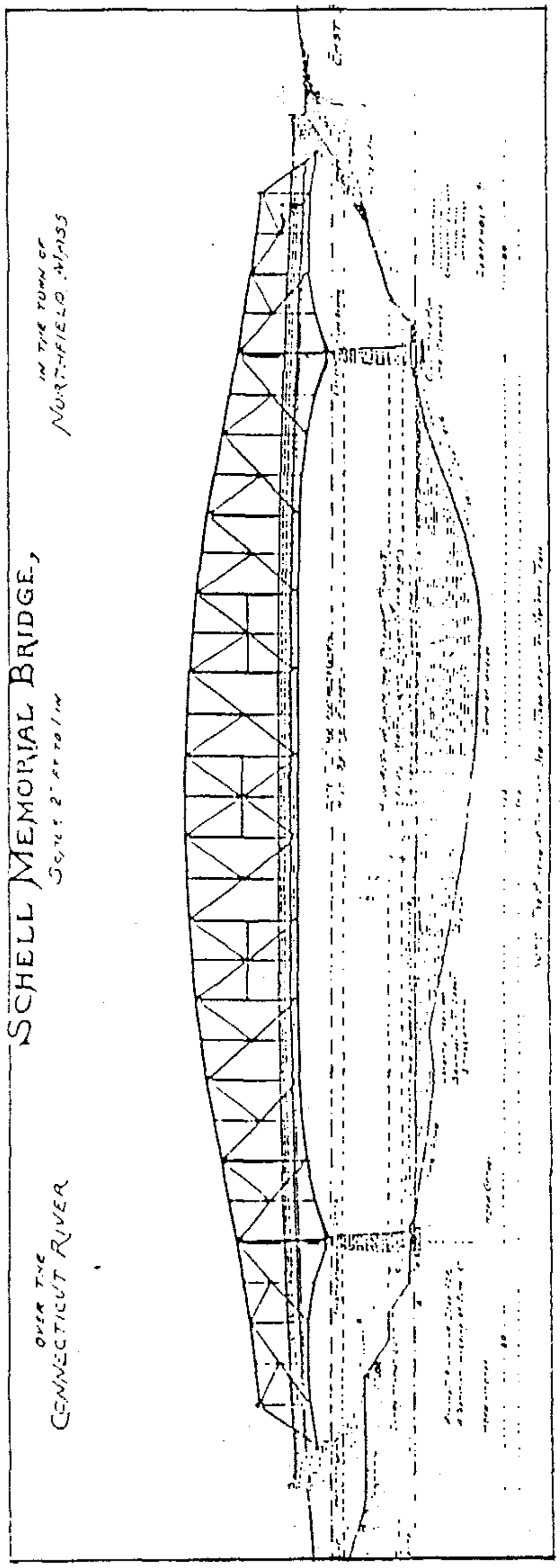


Figure 9. Comparison of elevations of Bennett's Meadow Bridge, 1899 (top) and Schell Memorial Bridge, 1903 (bottom), both designed by Edward S. Shaw.

NEW ENGLAND STRUCTURAL COMPANY,

DESIGNERS AND BUILDERS

OFFICE AND WORKS:
SECOND STREET,
EVERETT, MASS.

STEEL BUILDINGS AND BRIDGES.

BOSTON OFFICE:
110 STATE STREET,
BOSTON, MASS.

TELEPHONE MAIN 0964.

BEAMS CHANNELS ANGLES TEES BARS PLATES.

ADDRESS ALL COMMUNICATIONS TO THE COMPANY.

EVERETT, MASS.,

Woburn, Mass., Jan.2, 1903. *189*

M Town of Northfield, Mass.

To ELLIS & BUSWELL, Dr.

→ *Bridge Builders and General Contractors.* ←

Estimates given on all kinds of Stone Masonry, Earth and Rock Excavation, etc.

J. M. ELLIS. Woburn, Mass.
JOHN W. BUSWELL. Winchester, Mass. | Telephone 2, Woburn.

OFFICES, 29 Salem St., Woburn, and at Master Builders' Association
100 Devonshire Street, BOSTON.

Figure 10. Letterheads for the New England Structural Company (top) and Ellis & Buswell (bottom). (From Schell Bridge files in the Office of the Town Clerk, Northfield, Massachusetts.)

JACOB M. ELLIS,

Stone Mason
Builder
Contractor

TEAMING AND JOBBING.

Concrete Work a Specialty.

Telephone number, 10-3.

(Woburn 200th Anniversary Memorial, 1892.)

J. M. ELLIS & CO.

CONCRETE PAVERS.

Concrete Walks, Drives, Gutters, etc., laid to order. Contractors for laying Stone Work of Every Description.

Sand, Gravel and Loam for Sale.

OFFICE, 193 MAIN STREET - - WOBURN.

Residence, Franklin, cor. Flagg Street.

(Middlesex County Directory, 1879-80.)

Figure 11. Advertisements for J.M. Ellis and Company.

Northfield, Mass., August ~~26th~~ 28th 1901.

Desiring to leave an enduring memorial to my honored father, Robert Schell, in Northfield and also desiring that a bridge be built across the Connecticut River at a point within 400 hundred feet north of the boundary line between lands of the Northfield Seminary and one William D. Alexander, I hereby for myself, my executors and administrators, do offer, covenant and agree that if the Town of Northfield shall cause a bridge to be constructed at such location under the provisions of the Acts of 1901, Chapter 530 or any amendments thereof, within two years from date, I will, and my executors and administrators shall, pay to said Town the cost of such bridge to an amount not exceeding Thirty Two Thousand Dollars in seven installments as follows;

December 15th.	1901,	Four Thousand Dollars ($4000.00)
February 15th.	1902,	Four Thousand Dollars ($4000.00)
April 15th.	1902,	Four Thousand Dollars ($4000.00)
June 15th.	1902,	Four Thousand Dollars ($4000.00)
August 15th.	1902,	Four Thousand Dollars ($4000.00)
October 15th.	1902,	Four Thousand Dollars ($4000.00)
December 15th.	1902,	Eight Thousand Dollars ($8000.00)

All payments will be made by check to Mr. Ambert G. Moody and be endorsed over by him.

Two such memorial tables as I shall desire shall be placed and maintained upon said bridge. It is my wish and expectation that the building of the bridge be begun at once and the dates of said payments are established upon that basis. I make this offer in order that the Town of Northfield and Northfield Seminary may be permanently benefited. and I desire no formal or informal opening of the bridge to take place when the bridge is done simply begin to use it.

In witness whereof I hereunto set my hand and seal this 28th. day of August, 1901.

Witness.

[illegible]　　　　Francis Robert Schell

APPENDIX A: Francis Schell's Proposal, 1901.

NORTHFIELD'S GOOD FORTUNE

Aug 31 1901

Francis Schell Gives the Town a Bridge Over Connecticut.

In Memory of His Father, Robert Schell—A Magnificent Benefaction of $32,000—Structure to be a Half-Mile Above the Railroad Bridge.

For a number of months Northfield has been agitated over the bridge question. A solution was reached this week when Francis Schell of New York, a former resident there and who is now building a magnificent mansion in Northfield, signed an agreement for the gift of a bridge over the Connecticut river, to be built as a memorial to his father, Robert Schell. For several months Mr. Schell has had this in mind, and during the month of June made a tentative proposition which was the occasion of passing the legislative bill allowing Northfield to build a bridge.

The terms of the contract provide that the bridge shall be located within 300 feet north of the boundary line between land owned by the Northfield Seminary and W. D. Alexander, or about half a mile above the present bridge; that two plates with inscriptions shall be maintained thereon, and that work shall be commenced at once and the bridge be completed as soon as possible. Payments to the town are to be made bi-monthly in amounts to meet the expenses. Mr. Schell gives the town $32,000, the sum which the bridge is estimated to cost according to plans recently submitted by S. Shaw of Boston, architect of the Bennett's Meadow bridge. This is a most happy outcome of the controversy instituted by the Central Vermont Railway Company when they introduced their bill into the legislature last winter, asking for authority to rebuild the bridge now used jointly by the railroad company and as a travel bridge, requiring the town to pay a proportionate part of the cost of the new structure. The interest and convenience of Northfield Seminary are greatly subserved by a bridge at this point as it places them equally as near the South Vernon station as the Northfield. It is practically putting two railroad stations in town, and the Seminary is to be congratulated. The reluctance of people in breaking away from old habits and associations has been manifested in the opposition to the propositions which have been advanced toward breaking away from the joint arrangement with the railroad company. But the strongest opposition will be met when they realize that they can go from the Northfield postoffice to the South Vernon station, over a macadamized road part of the way, and over a better road all the way, than the one they are now using, and with no greater distance to travel, so that with the better facilities the south end of the street is in closer proximity to the B. & M. railroad than at present. Under these conditions the town cannot fail to be benefited and it will be but a short time before they will wonder why they even for a day considered the project of renewing the arrangement requiring them to use the bridge in common with the railroad.

Mr. Schell's proposition will have to come before the town at a regular town meeting for their acceptance, to be called soon. At this time the town will also consider and determine whether they will build a bridge at this point and accept Mr. Schell's offer. They are very unlikely to turn down such a proposition, in face of the fact that the railroad is obliged to replace the present structure with a new bridge, and in view of the Schell benefaction the road will probably get leave from the Legislature to put in a single bridge.

The appearance of the new bridge will be very like that of the one at Bennetts meadow. It is on the cantilever principle. There will be two piers and two abutments. The middle span will be 324 feet in length, resting on piers at either side of the river. There will be short spans of 64 feet each between the piers and the abutments. The roadway will be 18 feet wide.

Too much cannot be said of Northfield's good fortune in having the interests of such a man as Mr. Schell centered there. He has acquired a great amount of landed property in the center of the town, and has elaborate plans for its improvement. That he proposes to make it as beautiful as skilled architects can make it goes without saying. It will make Northfield attractive and be an impetus to draw others there. Mr. Schell was prompted to make his generous donation by his welfare in both the town and the Northfield seminary, and they cannot fail to appreciate the gift in the fullest [illegible].

APPENDIX B:

Newspaper article regarding Francis Schell's gift to the town of Northfield. (Greenfield Gazette and Courier, August 31, 1901.)

THE ENGINEERING RECORD. VOL. 40, NO. 14.

THE NORTHFIELD BRIDGE.

The highway bridge across the Connecticut River near Northfield, Mass., has a total length of 613 feet, comprising a center span of 360 feet, two side spans of 108 feet each, and two approach spans of 18 feet each. The bridge has a clear width of 20 feet 3 inches between the two main trusses, which are 576 feet long and continuous over the piers between the main abutments. The bridge is of interest as having the longest steel or iron truss span in New England, and for the method of erection by temporary reinforcement to make it act as a cantilever, until its trusses were completely assembled and connected.

The substructure consists of two masonry piers, two cylinder piers and two iron pile bent abutments. The two masonry piers are near the water edge at low stages of the river, as shown in Figure 1, and are built of rock-faced ashlar masonry with rubble concrete filling. All stones were laid in Portland cement mortar. All mortar was made of one part of Saylors Portland cement and two parts of sand. The concrete masonry footings were made of one part Portland cement, two parts sand and four parts of trap rock. The concrete rubble is made of one part Portland cement, two parts of sand and four parts of gravel screenings with stone up to 100 pounds set in it by hand from 3 to 5 inches apart. On the west shore the foundations are on rock ledge, leveled off for the masonry pier and with hollows filled with fine concrete. On the east shore the excavation was made in a sheet-pile coffer-dam. Inside this spruce piles 10 to 12 inches in diameter at the butt and 35 to 40 feet long were driven and their tops surrounded by concrete, and covered with 3 feet of the same material.

The upper part of each abutment pier consists of two cylinders 4 feet in diameter and 16½ feet high, built of ⅜-inch steel and filled with screened gravel concrete. They are connected at the top by a transverse steel plate girder, as shown in Figure 2. The cylinders are made with 3-inch lap joints and ⅝-inch rivets with 3-inch pitch. The upper 12 inches of concrete in them is made with small stones and the caps are bedded in cement mortar. Each cylinder rests on a concrete pier 6 feet 3 inches square, built inside a sheet-pile coffer-dam. On the west side the piers are carried down to the rock and on the east side they are seated on concrete footings surrounding the heads of clusters of piles. The shore extremities of the girder approach spans rest on bents of cast-iron tarred and painted water pipes, bolted together at the joints and having cast-iron shoes connected to them by tenons projecting 3 inches into the piles, which are filled with concrete. The floor-beams on top of the piles have flanged steel plate brackets bolted to the shore sides, as shown in Figure 3, to carry a timber sill on which the sliding apron for the expansion joint is supported. The filling of the approaches entirely covers these piles and slopes toward the river bank as well as on each side.

On both sides of the river the banks for 50 feet on each side of the axis of the bridge and the approaches up to the highest water level are protected by brushwood mats from 3 to 8 inches thick weighted down with stones. The mats are made with two layers of brushwood or saplings, and are covered with from 9 to 18 inches of stones of not less than 50 pounds, surfaced by hand.

The main trusses are 576 feet long, 45 feet deep at the center and 18 feet at the ends. They are 22 feet apart on centers, and 21 inches wide. The lower chord is cambered 5 feet 4 inches at the center with an approximation to a parabolic curve made with straight sections 36 feet long. The top chord is approximately a reversed curve convex upwards at the center and concave upwards at the ends. Its sections are straight for two panel lengths each, and all web members are framed to fit the camber. The posts are not truly vertical, but are normal to the lower chord. The primary web system diagonals cover two panels each, and are supplemented by secondary verticals and diagonals intersecting at their middle points. All connections are riveted to double-web gusset plates and the trusses are connected at the end posts by portals and by transverse vertical or inclined bracing at intermediate points each side of the pier. The top and bottom lateral systems consist of cross struts and X-brace diagonals at every main truss panel point, and are composed of angles, single or in pairs, riveted to horizontal gusset plates which are riveted to the inside flanges of the chords.

The trusses are bolted to the east pier and are free to move with temperature changes over the other pier and both abutments. Allowance has been made for a total movement of 1 inch for each 100 feet of length, and the bearings were specified to be adjusted for a temperature of 50 degrees. The bearing on the east pier is made with cast iron rockers and on both abutments with steel rollers. At the second panel point from the pier in each of the side spans there is a slip joint in the bottom chord, the adjacent sections of which are connected by web plates riveted at one end and having bolts with slotted holes at the other end. The structure is made of open hearth medium and soft steel. In the center span the top chord is of box section, latticed underneath, with a maximum section consisting of a 21x7/16-inch cover plate, two 16x¾-inch side web plates and four 3½x3½x½-inch angles. The bottom chord is trough-shaped with a maximum section of four 16x7/16-inch vertical web side plates and four 4x4x5/16-inch angles. In the side spans the top and bottom chords are both trough-shaped, double latticed, and their sections contain four 3x2½x¼-inch angles and two 12x¼-inch side plates and four 3x3x¼-inch angles and two 12x¼-inch vertical web side plates respectively.

A general view of a portion of both trusses over one of the piers, showing the characteristic details, is given in Figure 4. A half-section of the roadway is shown in Figure 5, which is a typical detail of the lower-chord connection of truss members and floor-beams. The floor connection is made rigid by the end vertical angles, which are riveted in its web and on both sides of the transverse diaphragm in the vertical post. The horizontal lateral connection plate is also securely riveted to both the lower flange at the bottom chord and the top flange of the floor beam. It thus gives rigidity to the latter and transmits the strain from the lateral diagonals directly.

It was necessary to erect the bridge at a time of the year when the river was full of ice and spring freshets were likely to move it before the bridge was completed. Further than this, the character of the bridge bottom was, for about one-half the channel span, bare rock on a considerable slope with water about 30 feet

APPENDIX C: Article on the construction of the Bennett's Meadow Bridge. (<u>Engineering Record</u>, vol. 40, no. 14, September 2, 1899.)

deep, and on the other side soft sand requiring long piles, so that it would have been difficult and expensive to use falsework.

In view of these considerations it was decided to erect the bridge as a cantilever by means of the temporary trussing and reinforcement to the main trusses, which are shown in Figure 6. The end spans on both sides of the river were first erected complete on falsework in the usual manner. Then the top and bottom chords were reinforced by timber struts clamped tightly to them as noted in the drawing, and the temporary wooden tower, T, about 19 feet higher than the upper chords of the bridge over the masonry piers, was erected and secured at the foot to the bottom chords of the erected trusses. Diagonals, C C, were connected, the end of the truss at L O was anchored to the cylinder pier, and the sand boxes, No. 1, were filled. Then the truss was completed to L10 except the vertical V5 L5, which was not inserted until after the channel span was swung. Guy lines were run from the end of the cantilever to the shore to prevent motion in a horizontal direction and to resist wind strains. The rods BB were connected and the rods CC were removed, sand boxes No. 3 were filled, the erecting traveler run out to the position shown by dotted lines, and the truss was assembled from L10 to L12. Then the rods AA were connected, sand boxes No. 1 were filled, and the traveler was advanced and assembled the truss from L12 to L14. Finally the remaining sand boxes, No. 4, were filled and the end span was loaded with enough additional sand to prevent any tension on the anchor rods at LO from being developed by the completed semi-truss and imposed erection plant.

Work was carried on simultaneously on both sides of the river, as above described for one side, and when the cantilever arms met at the center panel there was ample space to insert the chord sections, for the pier pedestals had been purposely set a little too far apart and the slip joints of the lower chords had been blocked out solid. After the rivets at the last connections had been driven, the rods AA and BB were slackened and the sand ballast removed from the end span. The main timbers of the falsework tower were of yellow pine, and its bracing of spruce. Both sides of the tower were braced as shown in the elevation of one side. In Figure 5 the figures given are for one truss only; dimensions, materials, loads, etc., were the same for the other truss also. The erection strains were computed by the contractor, who has furnished the following information regarding them and the results of this method of erection:

Strain in U1 U3, center of moments at L2 = (94,260x24.6 — 866,980) ÷ 18.9 = + 76 800

Strain in U3 U5, center of moments at L4 = (94,260x41 + 12,150x26.8 — 1,937,980) ÷ 21.1 = + 40,370

Strain in L2 L4, center of moments at U3 = (94,260x15.3 + 12,150x0.4 — 3,500,020) ÷ (— 29) = + 51,460

Strain in L4 L6, center of moments at U5 =

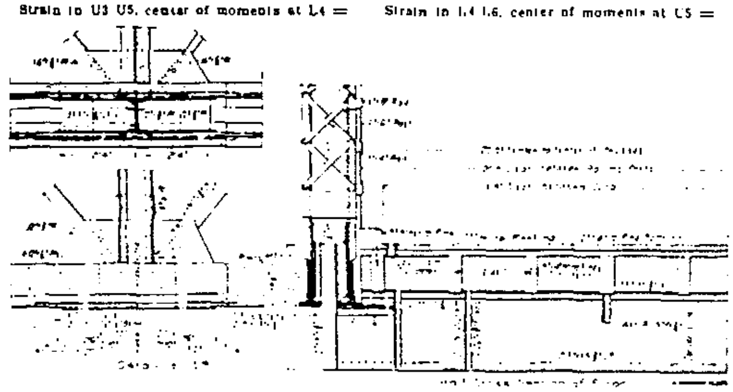


FIGURE 5.—DETAILS OF TRUSS AND FLOORBEAM CONNECTIONS.

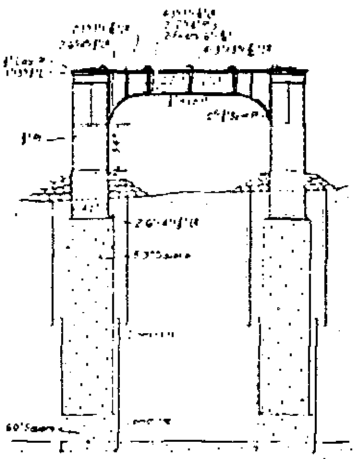


Fig 2 Cross Section on East Pier

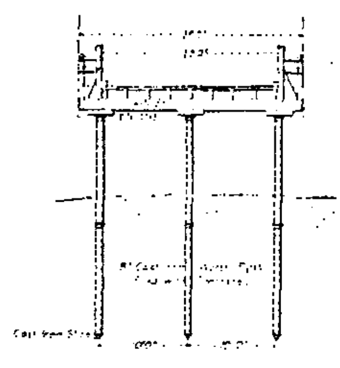


Fig 3 Cross Section on Bank Bent

CYLINDER PIER AND PILE BENT DETAILS.

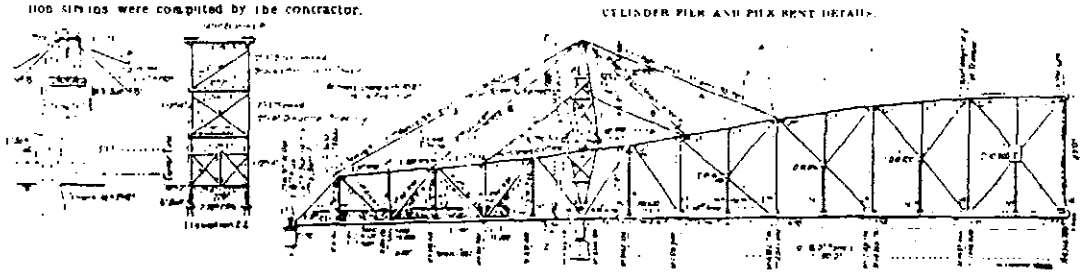


FIGURE 6.—TEMPORARY TRUSSING AND REINFORCEMENT DURING ERECTION.

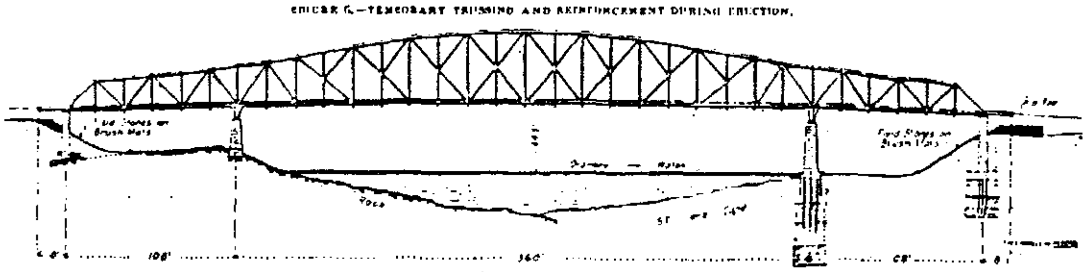


FIGURE 1.—ELEVATION OF BRIDGE.

HIGHWAY BRIDGE ACROSS THE CONNECTICUT RIVER NEAR NORTHFIELD, MASS.

MR. EDWARD S. SHAW, ENGINEER; NEW JERSEY STEEL AND IRON COMPANY, CONTRACTORS.

(94,250x29.7 + 72,150x21 — 3,181,000) ÷ (— 23) = 170,160.

Strain in U5 U7, center of moments at L6 = (94,250x57.4 + 72,150x49.7 — 11,548,700) ÷ 24.8 = — 192,950.

Strain in L6 L8, center of moments at U7 = (— 88,700x28.8 — 14,000x16.2 + 9,462,350) ÷ 27.1 = + 210,570.

Strain in L8 L10, center of moments at U8 = (— 88,700x19.5 + 7,578,900) — 30 = + 194,970.

Table of Lever Arms.

Member.	Lever Arm.	Center of Moments.
[illegible]	18 9 ft.	L2
[illegible]	[illegible]	L4
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	L6
A	[illegible]	L6
B	19 [illegible]	L6
A	61 [illegible]	L6
B	44 5	L6
A	21 8	L2
B	[illegible]	L4
A	[illegible]	[illegible]
A	[illegible]	[illegible]
B	0 [illegible]	[illegible]
A	[illegible]	[illegible]
B	21 0	[illegible]
L6 — L8	[illegible]	[illegible]
A	[illegible]	[illegible]
B	[illegible]	[illegible]
A	29 1	L8
L8 — L10	30 0	L4

Strain in U1 L2. In the triangle ABC on L2 U1, CB is the horizontal component of the vertical load of 11,100 pounds at L2. In the triangle CHL2, make CD equal to the difference between the strains in chords L2L4 and L0L2 less CB, then the hypothenuse GL2 represents the desired strain, which is 9,300 pounds.

Strain in L2U3. In the triangle FGL2, make FL2 equal to EL2 plus panel load of 4,400 pounds at L2; then the hypothenuse GL2 represents the desired strain, which is 67,400 pounds.

Strain in U3L4. In the triangle HIJ on L4 U5, JI is the horizontal component of the vertical load of 45,170 pounds at L4. In the triangle MKL4, make MK equal to the difference between the strains in the chords L4L6 and L2L4, less JI; then ML4 is the strain in U3L4, which is 67,600 pounds.

Strain in L4U5. In the triangle PNL4, make NL4 equal to L4 plus vertical load of 45,170 pounds at L4; then PL4 represents the desired strain, which is 119,500 pounds.

The strains in A and B are assumed at 15,000 pounds per square inch. The strain in A is 94,250x57.4 — 61 = 88,700 pounds. That in B is 72,150x49.7 — 15.5 = 74,000 pounds. The load on one side of the tower is equal to the sum of the vertical components of the strain in A, B, A and B and is equal to 175,700 pounds.

The loads marked D at the panel points are from the weight of the bridge and those marked S are from the sand boxes. For the span L0—L6, the moment marked M at any panel point is the summation of the moments about the panel point of all the loads to the left of that point. For the half-span L6—L16, the moment marked M at any panel point is the summation of the moment about that point of all the loads to the right of it. The moment marked N at any panel point is the summation of the moments about L6 of all the loads between L6 and that panel point inclusive.

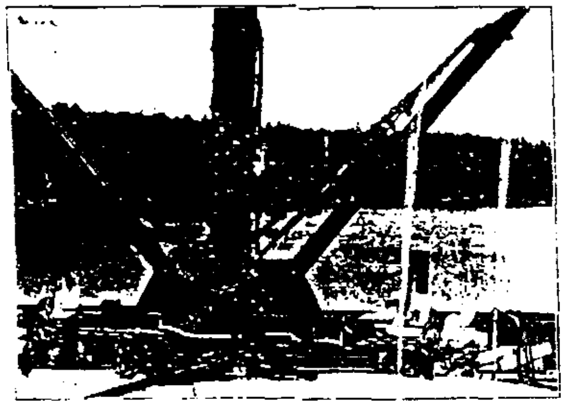


FIGURE 7.—MAKING THE CENTER CONNECTION.

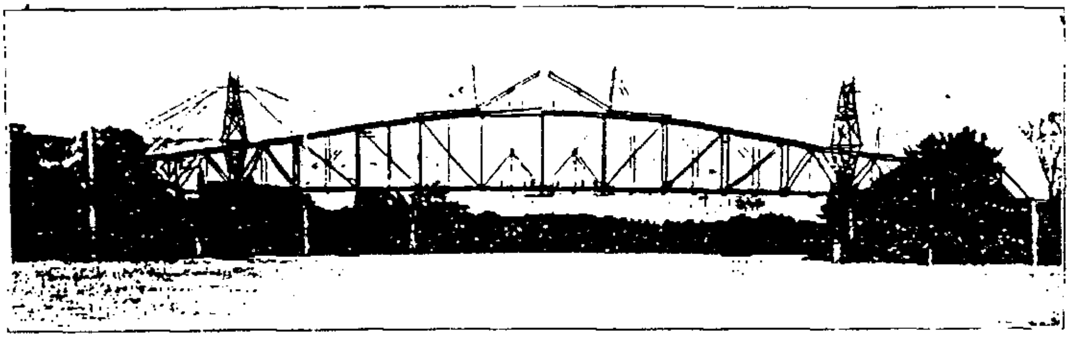


FIGURE 9.—CONNECTING THE LAST PANEL OF THE TIE CHORD.

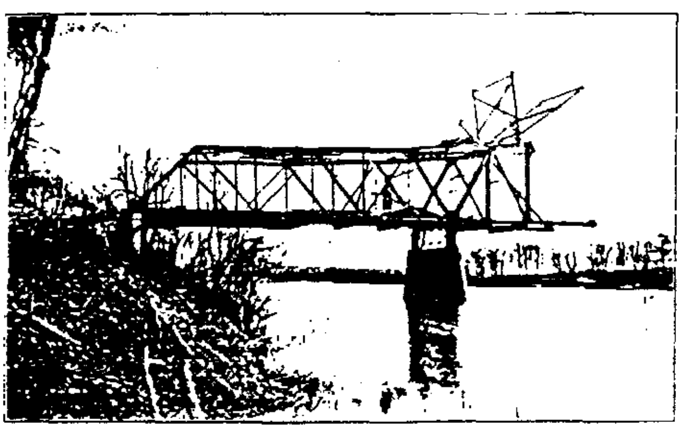


FIGURE 9.—BEGINNING THE CANTILEVER ERECTION.

The half of the bridge resting on the 12-inch rockers was erected 3 inches nearer the shore than its final position, and the center connection was made by drawing the parts together with four 2-inch turnbuckles, as shown in Figure 7. Two men worked one turnbuckle easily at first and with greater effort afterward on account of the pinching of entering connection plates.

The cylinder ends of the bridge were set about 1 inch below the elevations marked on the drawings from which the bridge was made and with the cylinder ends in this position when the erection reached the center of the bridge the center sagged to 7¾ inches below its true elevation. Each half of the bridge was then tilted by lowering the cylinder ends 4 inches, which raised the center of the bridge 5 13-16 inches, or within 1 13-16 inches of the true elevation, and the bridge was drawn together and connected in this position. When the center connection was made, no trouble was occasioned by the ends of any of the chords projecting beyond the others, the connecting members fitting so exactly that all the rivets for the center connections of the bottom chords were driven without any reaming or gouging, reaming being required for only three or four of the rivet holes at each of the center connections of the top chord.

After the load of sand was removed and the cylinder ends of the bridge were brought to their true position, the center of the bridge sagged a little below its true elevation. This sag did no harm, as it simply changed somewhat the curve of the top and bottom chords from that shown on the drawings.

The bridge was not cambered by lengthening or shortening any of the web members, and therefore would have sagged below the figured elevation even if erected on falsework.

Each 26-foot section of the channel span was riveted before the next section was erected, except that the lateral bracing was bolted and was not riveted till after the center connection was made, in view of the possibility of the ends of some of the chords striking before the others were drawn together. The result showed this precaution to have been unnecessary.

When the parts of the bridge were lifted preparatory to making the center connection, the cylinder ends of the bridge being then 5 inches below their true elevation, daylight could not be seen under any part of three of the bearings on the channel piers, but at the fourth, daylight could be seen between the top of the rockers and the shoe plate for about two-thirds of the length of the two rockers at the end toward the

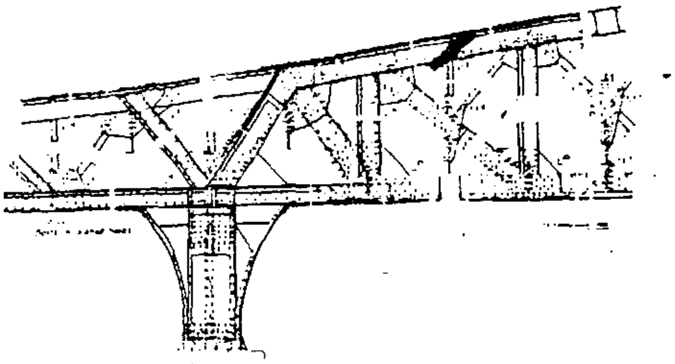


FIGURE 7.—DETAILS OF CONNECTIONS ON PIERS.

center of the bridge. This was probably occasioned by a slight inequality in the setting of the bed plates, and showed the tendency of the shore end of the bearings to take the greater part of the pressure. When the erection was completed and the bridge was in a finished condition daylight could not be seen between any of these shoe plates and their bearings. That the pressure, when each half of the bridge was lifted, was distributed over the bearings on the channel piers as evenly as has been indicated, was due to the elasticity of the bridge. Had the bridge been perfectly rigid, all the pressure, when each half of the bridge was lifted, would have been on the shore ends of these bearings; and lowering the cylinder ends of the bridge 4 inches would have raised the center of the bridge 6 11-16 inches instead of 5 13-16 inches. The elasticity of the bridge was further shown by the fact that guy lines run from panel points L10 to the shore easily moved the projecting ends of the channel span in either direction without moving the cylinder ends of the bridge.

It might seem that the sag of the projecting ends of the channel span would make such an over-hang of the top chords, the top chords being extended and the bottom chords being compressed, as would necessitate raising the center of the bridge to or above its true elevation before the center connection could be made. That it was possible to make this connection with a sag of 1 13-16 inches at the center of the bridge was due in part to the pull of the lower rods, which tended to compress the top chords of the channel span, and in part to the sag at the center of the shore span from the load of sand, which tended to draw the top chords of the projecting ends of the channel span toward the shore. The bottom chord of the channel span after the center connection was made, but while yet in compression, measured ⅛ inch less than the length as given on the drawings from which the bridge was made.

One of the problems of this method of erection was to make each of the sixteen lines of lower rods and each of the four top chords L5 U7 take its due share of the strain. An initial strain was given the 1¾-inch rods by four men turning the sleeve nuts as far as possible with a rope attached to the handle of a wrench with a 37-inch lever arm. An initial strain was given the 2-inch rods by using the engine to pull the rope, the same number of turns of the rope about the capstan-head being used to turn one sleeve nut on each line of rods. After the initial tightening each line of rods was tightened but once, the engine being used for this purpose.

Measurements showed that the stretch of each of the four top chords L5 U7 was quite uniform, and the same was true of the lower rods of the same diameter. The stretch in the chord L5 U7 was 1 inch 3-16 inch in 33 feet 4 inches, indicating a strain of about 16,000 pounds per square inch, which is greater than that shown on the drawing, while the strain in the rods was less than the assumed strain of 15,000 pounds per square inch, being somewhat less for the 1¾-inch than for the 2-inch rods. The strains might have been made nearer the calculated strains by another tightening of the rods, but this was not considered necessary.

As a means of determining whether the calculations for the weight of sand required were correct, and that a sufficient weight had been placed on the shore spans, the shore end of these spans was anchored by bolts passing from a wooden beam to the cylinder piers with about ½-inch space between the nuts and their bearings, so that if at any time as the erection progressed the weight of the channel arm was too heavy for the load placed upon the shore span to balance it, this ½ inch would have been taken up and the weight of the cylinder piers brought into play until such time as more load could be placed on the shore span. This, however, did not occur at any time.

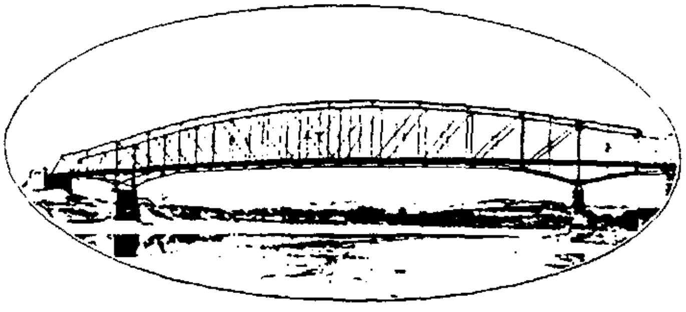
There are about 280 tons of steel in the bridge and it was erected with a force of about 35 men. The commencement of the cantilever erection is shown in Figure 8, which is a view of the pier and cylinder abutment on the east side. The temporary ballast floor has been laid at the end of the side span and the traveler is erecting the last section of bottom chord previous to the installation of the temporary pier tower and truss ends. The hoisting engine is seen in the position it occupied until the erection was finished. A view of the bridge at the connection of the last panel of the top chord is shown in Figure 9. The travelers have advanced until both booms command the center post and gangs of men are at work on suspended platforms making the lower chord connections.

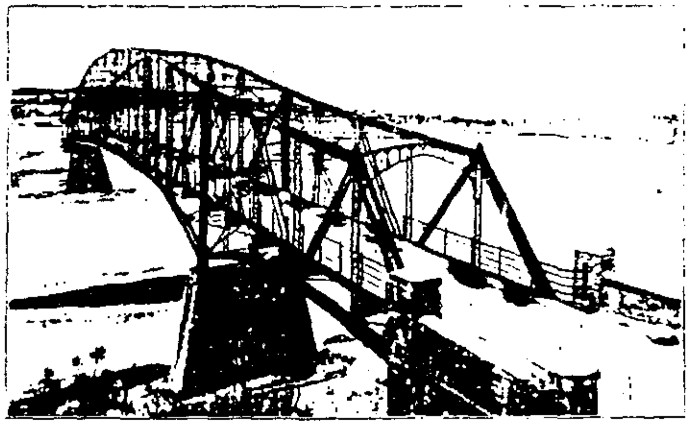
The bridge was designed by Mr. Edward S. Shaw, Boston, and the superstructure was manufactured and erected by the New Jersey Steel & Iron Company, Trenton. The surveys were made by Messrs. Clapp & Abercrombie, Greenfield, Mass., who were also retained as resident engineers. The mill and shop inspection was performed by R. W. Hildreth & Company, New York. Mr. J. W. Carrier was resident engineer and Mr. J. J. Blake was foreman of erection for the contractors.

The Schell Memorial Bridge.—I.

This is a highway bridge crossing the Connecticut River at Northfield, Mass. About a half mile below, in this river, was an old covered timber bridge, carrying a track of the Central Vermont R. R. on its upper deck and a lower highway below. This bridge had become unsafe from age and increase in the railroad traffic, and the new bridge was originally projected simply to take the place of the highway portion of the old bridge and to shorten the distance between the Northfield Seminary and the Moody Auditorium, where large numbers of people assemble at the summer conferences, and the station of the Boston & Maine R. R. and Central Vermont Ry., at South Vernon Junction.

The bridge was first designed for utilitarian purposes only, with three simple and independent spans, but the project for a new structure having been made known to Mr. Robert Francis Schell, of New York and Northfield, he offered to bear the expense of the new bridge, the abutments of which were to bear bronze tablets in memory of his father and mother. It was then decided to alter the design in order to make it more appropriate for its purpose as a memorial bridge, and with this object in view, the relative lengths of spans and the general outline of the bridge in elevation were modified, the three spans were covered by continuous trusses with curved upper and lower chords, and more elaborate and expensive portals, railings and abutments were built. Owing to the original conditions and the fact that certain details of alterations were not decided





The Schell Memorial Bridge across the Connecticut River.

upon until after contracts had been let and work was well under way, the results are not so satisfactory to the designer as they might have been with a more complete knowledge of the purpose and ultimate cost at the outset.

At the location selected for the site of this bridge as being most satisfactory for the approaches, the river is much narrower than at any other available crossing, but just above the bridge the stream widens and trends to the west at a large angle, making the current irregular and oblique to the banks, which are here curved and irregular.

The maximum depth of water is about 25 ft. (at mean low water), with an ordinary or not infrequent spring flood rise of 28 ft., and an estimated maximum rise of 33 ft.

The easterly bank of the river is evidently of glacial formation, consisting principally of boulder clay, with a few strata of moist, sandy clay. It rises quite abruptly from low water to a level well above the east abutment, so that it was necessary to make quite a detour in the approach to avoid an excessive grade.

The west bank, of alluvial formation, consists of a stratified silt, with occasional pockets or thin strata of fine sand, underlaid by coarser sand and fine and coarse gravel.

The two masonry piers are located just above low water level, giving a river span of 222 ft. on pier centers. The shore span on the east side was limited to 90 ft. by the steepness of the bank, and the west shore span was made the same for symmetry.

The piers, from a level 4 ft. above low water, are of quarry-faced granite ashlar, with pointed face ice breakers, and with tops pointed and bridge seat bearings bush-hammered to level.

The granite facing of the piers was cut at the Lebanon (N. H.) quarries from course plans giving the exact dimensions of each stone, with joints, which were specified to be cut to lay from ½ in. to ¾ in. for 8 in. back from the face on bed and build. The courses have a uniform rise of 2 ft. and a thickness varying from 20 in. for the upper courses, to 24 in. for the lower courses. The principal pier dimensions are 26x6 ft. at the top, 36x9 ft. at the base, and 25 ft. high above top of foundation, or 32 ft. above mean low water.

The granite facing is bonded generally with one header to every two stretchers, and is provided with a base or plinth course projecting 3 in., and a flush coping, the upper corners of plinth and coping being rounded. The face stones are laid in 1:2 Portland cement mortar, and backed or filled with rubble concrete made by embedding field stones in rather wet concrete.

The foundation of the east pier is upon the boulder clay at a depth of 3 ft. below mean low water, and is 13x40 ft. at base and 10x37 ft. on top, built in four courses, the two lower of 18-in. rise and the two upper of 21-in. rise. This foundation was built in a cofferdam made from the excavated material, with some sand bags, the river being not much above its mean low water level when the foundation was laid. The foundation of the west pier is of nearly the same horizontal dimensions as the east one, but is one 18-in. course less in height, and rests upon 56 oak piles in staggered rows [illegible] ft. center to center. The piles average [illegible] diameter at top, [illegible] in. diameter at the [illegible] where cut off, 1 ft. below mean low water, and [illegible] to [illegible] ft. in net length, the shorter piles being generally in the inner rows.

The cofferdam for the west pier consisted of a double row of 3-in. spruce sheet piling on river side and ends of pier, and a single row of the same on the bank side, with earth fill [illegible]. The sheet piling was driven after the [illegible] piles and the enclosure was pumped dry previous to cutting off the butts of the piles and laying the concrete. In this foundation [illegible] of dry broken stone was spread over the sand bottom to dry it before laying the concrete. The 1:2:4 concrete in both foundations was mixed with Alsens imported Portland cement, good clean and coarse, sharp sand found at and near the site of the west pier, and with broken stone, averaging 2 in., and not exceeding 2½ in. The suction hose of the pumps terminated in wells formed by lengths of 18-in. sewer pipe, which were eventually filled with concrete.

The abutments are of concrete faced above the grade lines with small ashlar (granite from the same quarries as that for the piers) and reinforced with steel I-beams. The abutments are wider than the superstructure of the bridge, and their side walls, which are parallel with the line of the bridge, are carried up about 4 ft. above the surface of the roadway, forming parapet walls, coped with cut granite. These parapets are terminated at both ends by substantial stone posts wider than the parapets, rising above them, and covered with caps of cut stone. Two of the larger stone posts are placed at the ends of the bridge seats and outside of the bearings, concealing the bearings from a side or approach view.

The west abutment, here illustrated, is in the form of a rectangular box, open on top and bottom, and supported at its four corners upon concrete piers, which extend down nearly to low-water level and rest upon oak piles. Steel I-beams 8 in. deep are embedded in the concrete about 3 ft. above the tops of the piers which support the abutments, on all four sides.

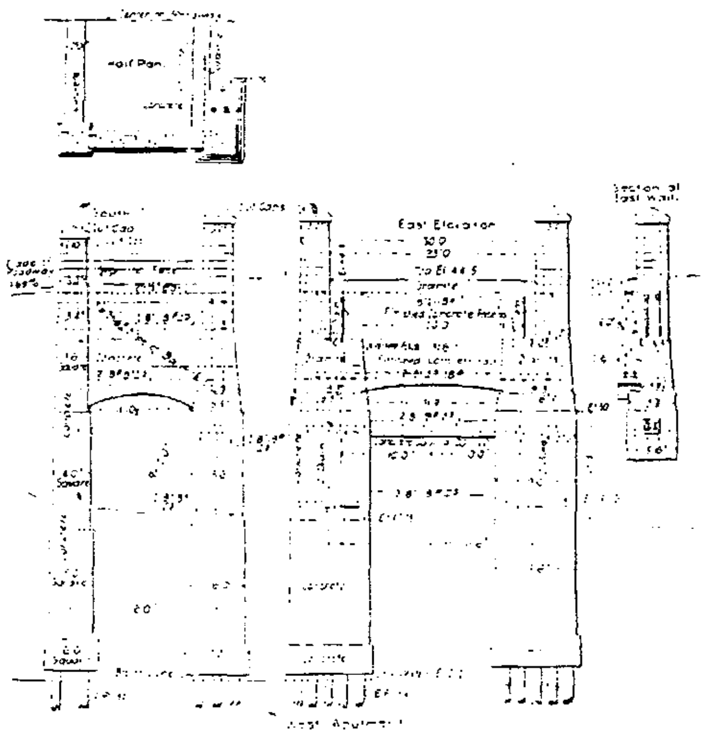
APPENDIX D: Article on the construction of the Schell Memorial Bridge. (Engineering Record, vol. 50, nos. 25-27, December 17, 24, 31, 1904.)

DEC. 17, 1904.

these beams being in pairs, spaced, by clamp irons, far enough apart to fill and ram concrete between them, and additional I-beams and iron bars were built into the concrete higher up, as shown.

The east abutment is founded upon the boulder clay, with the foundations of its side walls stepped up parallel with the grade. The face, or bridge seat, of this abutment is not recessed below the bearing line of superstructure.

Both abutments are provided with pairs of anchor rods at each bearing of trusses, two wrought-iron bars 2 in. diameter, upset, with double nuts on upper end, and with single nut and steel bearing-plate on lower end, these plates bearing up against two short I-beams, which are placed under long I-beams extending across the abutments transversely, two in the west abutment and three in the east abutment.



Typical Details of Substructure.

In the west abutment anchor rods are extended in separate and single lengths about 10 ft. farther down into the supporting piers, and terminate on bearing plates and pairs of steel beams placed in two directions, as shown. All steel beams in abutments are 8 in. 18-lb. I-beams.

The anchor rods were enclosed in wells formed by placing lengths of 6-in. stove pipe in the concrete as it was laid up. After the superstructure was erected these wells were filled with cement grout.

The surfaces of bridge seats, back of the narrow granite facing, and the face of the recess above the bridge seat, have a concrete finish, with granite coping just below roadway surface.

(To be continued.)

THE ENGINEERING RECORD. Vol. 50. No. 20

The Schell Memorial Bridge.—II.

The main trusses are continuous from abutment to abutment, with all of the dead weight borne on the two piers, and without any weight or reaction at the abutments except when a live load is on the bridge. The shore arms are designed to act as cantilevers, extending in a reverse direction, from the piers toward the abutments, when the bridge is unloaded. This purpose is accomplished by means of adjusting bearings placed under the ends of the trusses on the abutments, each bearing being raised or lowered by drawing together or slacking off two cast iron wedges held together and adjusted by screw bolts and nuts.

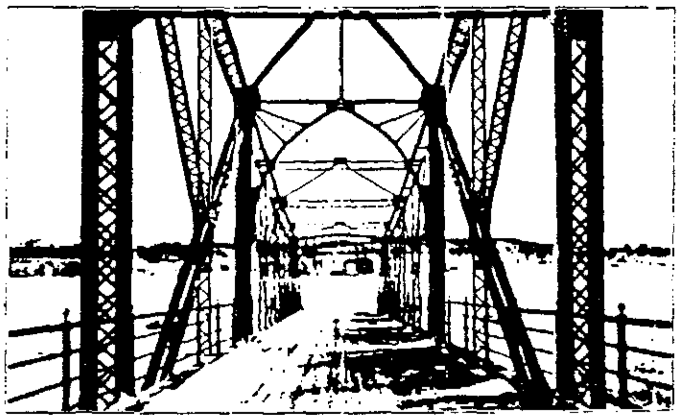
The upper ends of the anchor rods, already referred to, pass through the abutment [illegible] ends of the trusses on which they [illegible] by means of cast iron washers and spiral steel [illegible] springs through which the anchor rods pass. The bearings were adjusted so as to leave a play of 1 [illegible] between the ends of the trusses and the bearings [illegible] and also between the washers on top of the springs and the nuts on the anchor rods. [illegible] though the abutment ends of the bridge are thus left free to expand and contract under temperature changes, their upward and downward motion is checked by the anchor rods and springs, together with the adjustable bearings, so that the deflection of the trusses under moving loads is reduced and the vibration kept down to about the usual amount in a bridge of simple span of the same length.

The trusses rest on cast iron bearings having a total depth of about 2 ft. on both piers. The bearings on the east pier are fixed [illegible] to it, and those on the west pier are provided with sets of five cast iron rockers or segmental rollers, 12 in. deep, [illegible] into the top and bottom castings so as to move with them.

The outline of the upper chords of the main trusses is a polygonal curve, convex upwardly in the central span, and reversed over the piers so as to be concave upwardly in the side spans. The roadway is on a straight grade of 9 in. in 16 ft., or 4.69 per cent. for 141 ft. from each abutment, these grades being connected over the central portion of the bridge by a vertical curve tangent to the grades. The lower chords of the trusses are parallel to this vertical curve throughout its length, but at the ends of the central span and in the side spans they have a greater curvature, and in the latter portions the soffits or under surfaces of the lower chords, are formed in true curves throughout. The upper surfaces of these chords are polygonal or formed in straight lines between web intersections. The curves of the lower chords approximate closely to tangent segments of circular arcs and were laid out, on detail drawings and templates, by thin strips of metal or wood sprung between fixed points.

The middle span of 352 ft. is divided into twenty-two floor panels of 16 ft. each, and the side spans of 80 ft. are divided into five panels of 16 ft. The web system is of the Baltimore type throughout the whole of the middle span and in the two panels adjacent to the piers in the side spans, with vertical posts, diagonals covering two panels, and sub-panel hangers, struts and diagonals. In the three panels next to each abutment the web system is simple triangular. The trusses and laterals have riveted connections throughout, the rivets being generally of [illegible] in. diameter.

The main floorbeams, each consisting of a [illegible] in. web-plate and four [illegible]-in. flange angles, are riveted to the vertical posts and hangers above the lower chords, the posts and hangers being provided with web-plates to extension of the webs of the floorbeams at the points of junction. In three panels adjacent to each pier where the floorbeams are [illegible] the



End Span from Near Pier.

same height above the lower chords, transverse struts formed of four angles, latticed, connect the chords below the floorbeams. The lower lateral diagonals are [illegible] angles, crossing each panel in two directions, each diagonal consisting of two angles in the [illegible] of the middle span toward the piers, and single angles in the central panels of the middle span and in the side spans.

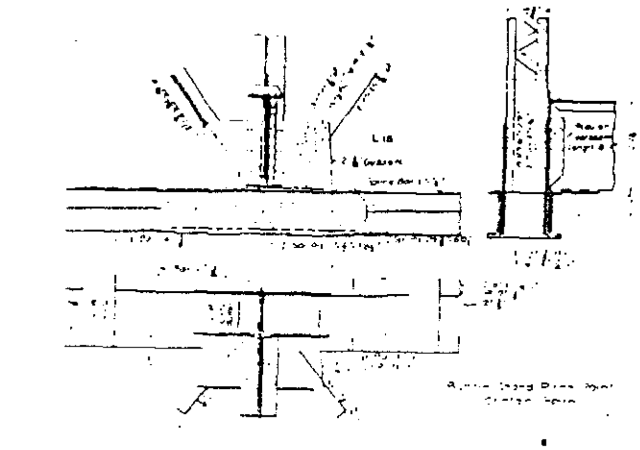
The upper lateral bracing consists of vertical transverse braced frames at every pair of main posts in the middle span, transverse struts each consisting of four angles latticed, in the plane of the top chord at intermediate points and at all points in the side spans, arched portal bracing connecting the posts over the piers, arched portals in vertical planes at the first panel point from each abutment, and single diagonal angles in the plane of the upper chords, extending over two panels, except in the portion of the middle span toward the piers where there are two angles in each diagonal. All of the principal truss and lateral connections are formed of gusset plates, wider than the chords.

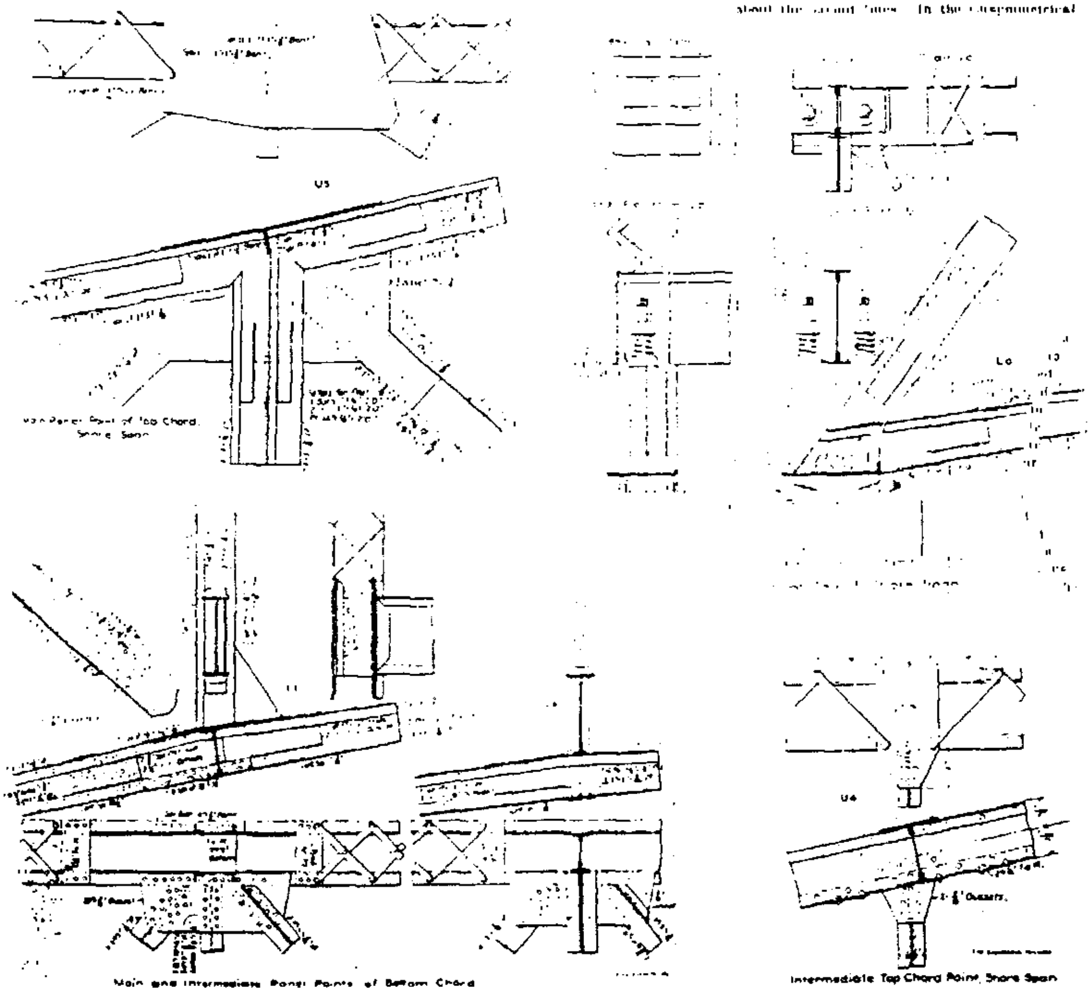
The upper chord is of the ordinary section, consisting of two side plates 16 in. deep, a top plate 20 in. wide, and four 3x3-in. angles, double latticed underneath throughout the portion of the middle span from U_1 to U_1, elsewhere and in the inclined end posts at the abutments the top plate is omitted, latticed bars being substituted. The depth of the side plates is reduced in the side spans to 14 and 12 in., and single splice substituted.

The lower chord consists of two side plates and four angles throughout, latticed top and bottom in the side spans and panels of the middle span nearest to the piers, connected by tie-plates elsewhere.

The main vertical posts over the piers are of special section as shown, the other posts are either two plates and four angles double latticed on two sides or four angles single latticed. Main diagonals, hangers and sub-struts are generally of four angles, but the heavier diagonals are of two plates and four angles. The sub and counter diagonals are of two angles.

The majority of the members of the trusses are of symmetrical cross-section, with the centers of gravity of the sections placed on the stress sheet and layout diagram lines, and with their connections symmetrically disposed about the gravity lines. In the unsymmetrical





Typical Details of Side and Center Spans, Schell Memorial Bridge.

portions of the upper chord, and in the curved portions of the lower chord (which were in compression during erection), the stress line is either at or below the center of gravity of chord section at the middle of a panel length. The layout lines of upper and lower laterals are intersected upon the center lines of the chords in plan.

The steel floorbeams carry eight lines of 6x 12-in. longleaf hard pine stringers, spaced 2½ ft. apart on centers, and bolted on the top flanges of the floorbeams, on which they are gained to varying depths to give a crown to the roadway. The floor planking is a single course of 3-in. chestnut, spiked to each stringer with ½-in. steel spikes. The curbs or wheel guards, which also serve as bases for the railings, are 6x12-in. hard pine, secured to the outer stringers, through the floor planking, by means of ⅝-in. lag screws. The railings are formed of four lines of wrought iron pipe passing through cast-iron posts of special design, spaced 5 ft. 4 in. on centers and secured to the broad wheel guards on which they rest by lag screws. Every third railing post is also fastened to the adjacent post of the truss by means of a ¾-in. bolt in slotted connection.

The steel work was primed with a coat of boiled linseed oil in the shops, and in the field was painted with one coat of No. 31 special and one of No. 16 special paint manufactured by the National Paint Works of Williamsport, Pa.

The quality of steel specified was very nearly that of the present grade of "railway bridge steel" of the manufacturers' standard specifications.

The bridge was designed to carry, in addition to its own weight (determined by detail esti-

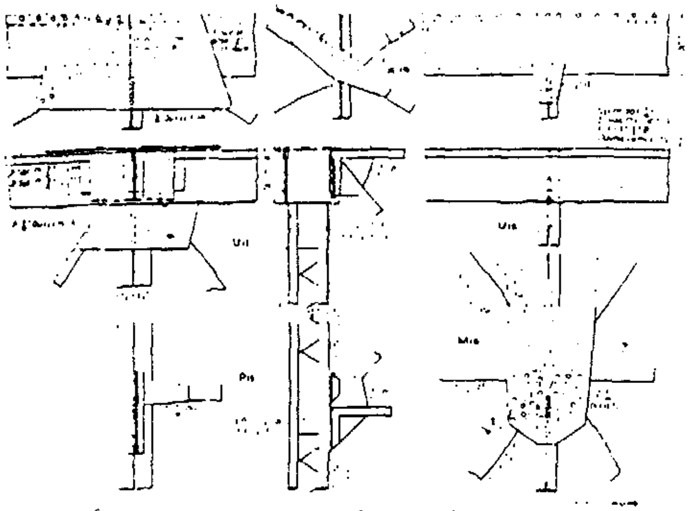
mates), a live load $w = 60 + (2400 \div L)$ in which formula w = live load per square foot of floor surface and L = length of bridge covered by the load to produce the maximum stress in any member. This formula gives a load of 67 lb. per square foot for the condition of load covering the whole of the middle span, 90 lb. per square foot for load covering the side span, and for load covering 22 ft. of length, giving the maximum load on floor and subpanel systems 135 lb. per square foot. With stresses produced by the above loads the unit stresses in tension will not exceed those given by the formulas

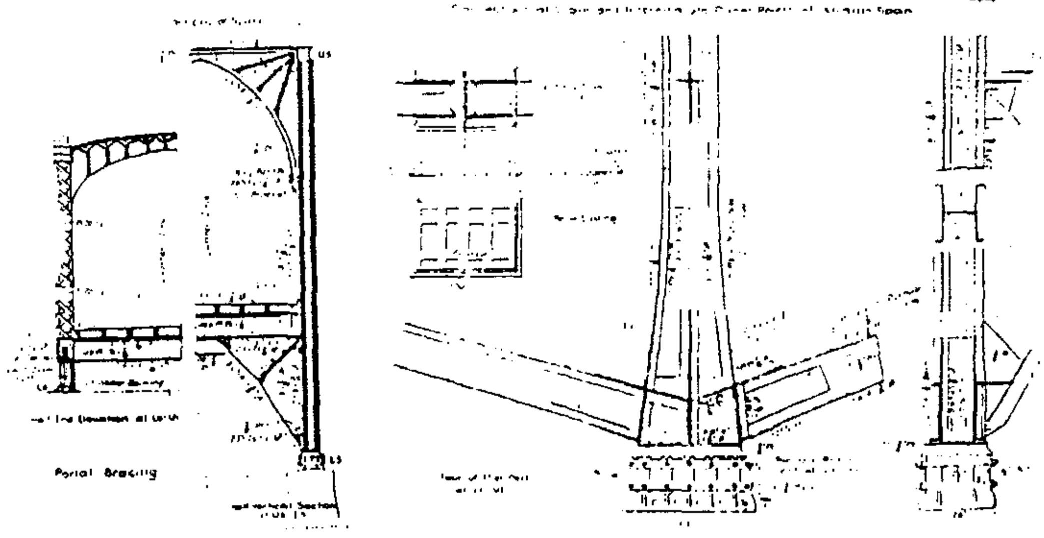
$$s = 10{,}000\,\frac{100 + 4p}{100 + 3p}$$ for general truss members, and

$$s = 8{,}333\,\frac{100 + 8p}{100 + p}$$ for floorbeams, hangers and counters,

in which s = stress in pounds per square inch and p = 100 (minimum stress ÷ maximum stress), or the percentage of minimum to maximum stress. For the chords of the middle span the dead load stress was taken as the minimum stress. Compression members have stresses reduced from the above figures by a special formula. Lateral bracing was designed for a wind pressure of 338 lb. per linear foot of bridge on the lower chord and 225 lb. per linear foot on the upper chord, with unit tensile stresses of 18,000 lb. per square inch.

The bridge having been designed to be erected on the cantilever plan, the strength of the portions of the trusses in the shore spans and near the piers was made sufficient for this purpose. In determining the live load stresses, the live load was assumed to cover the middle span, without resting on the end spans, and also to cover both end spans without resting on the middle span, and in both cases without weight or reaction at the abutments, although, under the maximum live loads, there will doubtless be some positive or negative reaction at the abutments, yet it is believed that the stresses found by allowing for such reactions would be less than the maximum assumed.





Details of Main Vertical Post, Portals and at Center of Channel Span.

The estimated weight of steel in the superstructure, exclusive of railings, is 365 net tons. The cost of the bridge was $42,000.

In the first installment of this description, printed last week, Mr. Schell's full name was incorrectly given, as it is Francis Robert Schell.

(To be continued.)

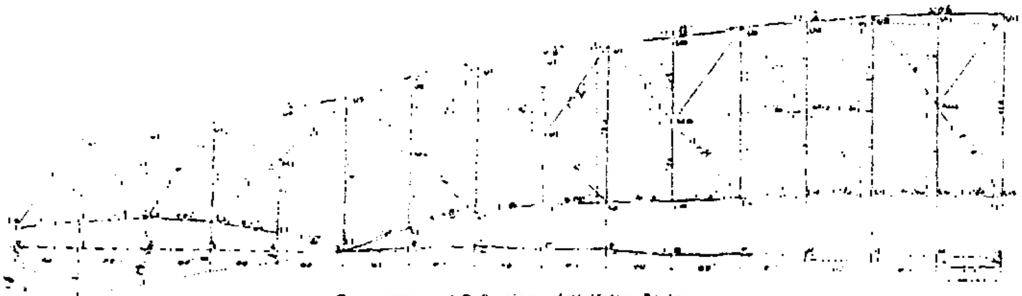
The Schell Memorial Bridge.—III.

Cantilever Erection by Cableway.—Although when completed the Schell Memorial Bridge is a continuous bridge, with a central span of 352 ft. and two shore spans of 80 ft. each, it was treated for the purposes of erection as a cantilever bridge, with the shore arms of the cantilevers counterweighted by temporary earth loads, suspended in wooden cribs from the two panels adjacent to each abutment. All material for the bridge was delivered and stored on the west bank, and was put in place in the bridge by means of a wire rope cableway, supported on two wooden towers, the west tower being about 100 ft. high and the distance between towers 200 ft. This method and the plant used involve a number of interesting features and details, of which there is no published description of previous use.

As the bridge was designed with riveted connections throughout, special care was taken in making the templets, in order that the several parts when brought together in the field without the support of falseworks might be connected with satisfactory results. The skeleton or center lines of members of one of the shore spans and one-half of the middle span were laid out with care on the floor of a large templet room, and all of the templets for a truss were assembled upon the lay-out lines and the marking holes for rivets at connections were bored through main members and splice and gusset plates at the same time.

The deflection of the trusses during erection was computed independently in the engineering office of the contractor, and, graphically, by the designer, with results agreeing well with one another and with the actual results as found by levels taken during erection, due allowance being made for the omission of the weight of a 5-ton traveler at the outer end of each cantilever arm, the weight of which was included in the computed erection stresses and deflections, but which was not used in the actual erection. The ordinates of lower chord panel points were increased from those shown on the contract drawings, the increase at the center of the bridge being about the amount of the computed deflection at this point during erection. Erection stresses were computed not to exceed 16,000 lb. in tension and 14,500 lb. in compression, both per square inch of section, and allowing for the weights of travelers.

Upon the completion of the substructure the distance between the upstream bearings of the piers was ascertained by measuring across the river on the ice at the level of the bases of piers and plumbing up the centers of ice breakers with a transit, and was found to be about 1 in. less than the correct distance, at the assumed mean temperature of 10° Fahr. Before the bridge was erected this distance was checked by the engineer for the contractor, by a measurement at the level of the bearings on tops of piers, made with a steel wire of No. 18 gauge, carried on small sheaves; one end was fixed and the wire hauled taut by means of a counterweight suspended from the other end. The length of span was marked on the wire by clips secured with set screws, and the wire was tested on a measured base line with a known tension at the works of the contractor.



Dimensions and Deflections of Half the Bridge.

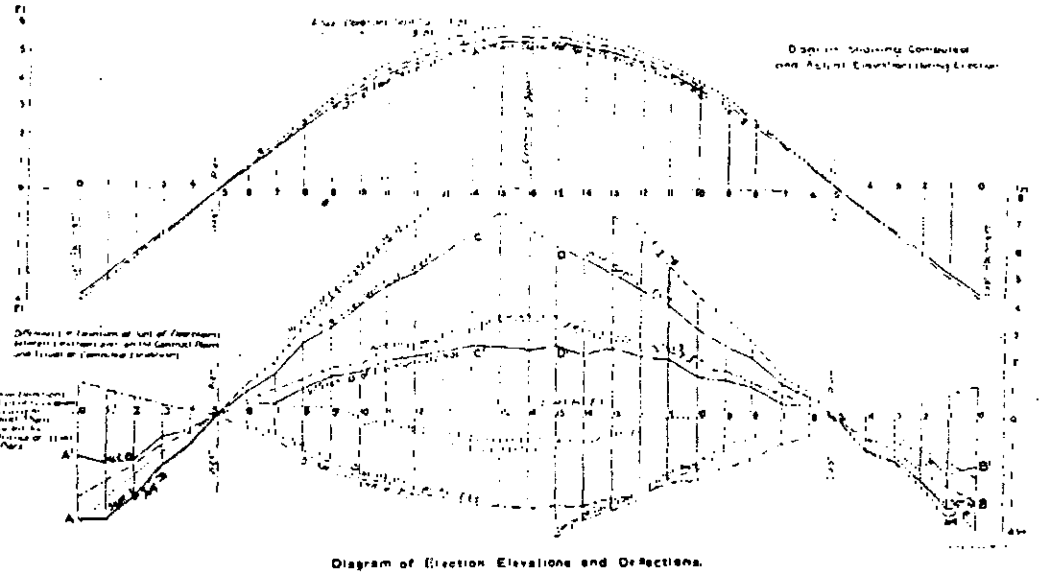


Diagram of Erection Elevations and Deflections.

To compensate for the effects of the inaccuracy in distance, differences of temperature between fabrication in the shops and erection, and the stretch of the lower chords under dead and live loads, it was decided to set the cast iron bearings of the trusses each 1½ in. inshore from the centers of bearings on piers. Moreover, in order to insure plenty of room for inserting the closing lengths of the trusses on a very hot day, the expansion bearings (segmental rollers) on the west pier were inclined at an angle toward the west bank and temporarily locked in that position.

The shore spans were erected as simple trusses upon single bents of falsework placed under the points L and additional shores under the points L. The abutment ends at L were set below their final level and held there by the earth counterweights until some of this earth was removed in order to lower the outer ends of the cantilevers and make the center connections. The springs at the upper ends of the anchor rods were removed during the erection and sleeves of hardwood substituted.

The steel was picked up from its storage position on the west bank by the falls from the cableway. As the west cableway tower is about 100 ft. high, this did not require a very great inclination of the falls, considering that any scattering pieces could be run in under the cable, by hand, upon timber rollers. Only one heavy member could be handled at one time by the cableway, and as it was necessary to shift the cable frequently from one side of the towers to the other (an operation which consumed a good deal of time in the early part of the work, but which was later much expedited), the progress of the erection was not rapid, but was sufficient for the time capacity of the small gang of erectors employed and of the four gangs of riveters following, who were rather late in getting their start.

The cantilevers were erected one panel at a time from each side, the erecting gang shifting

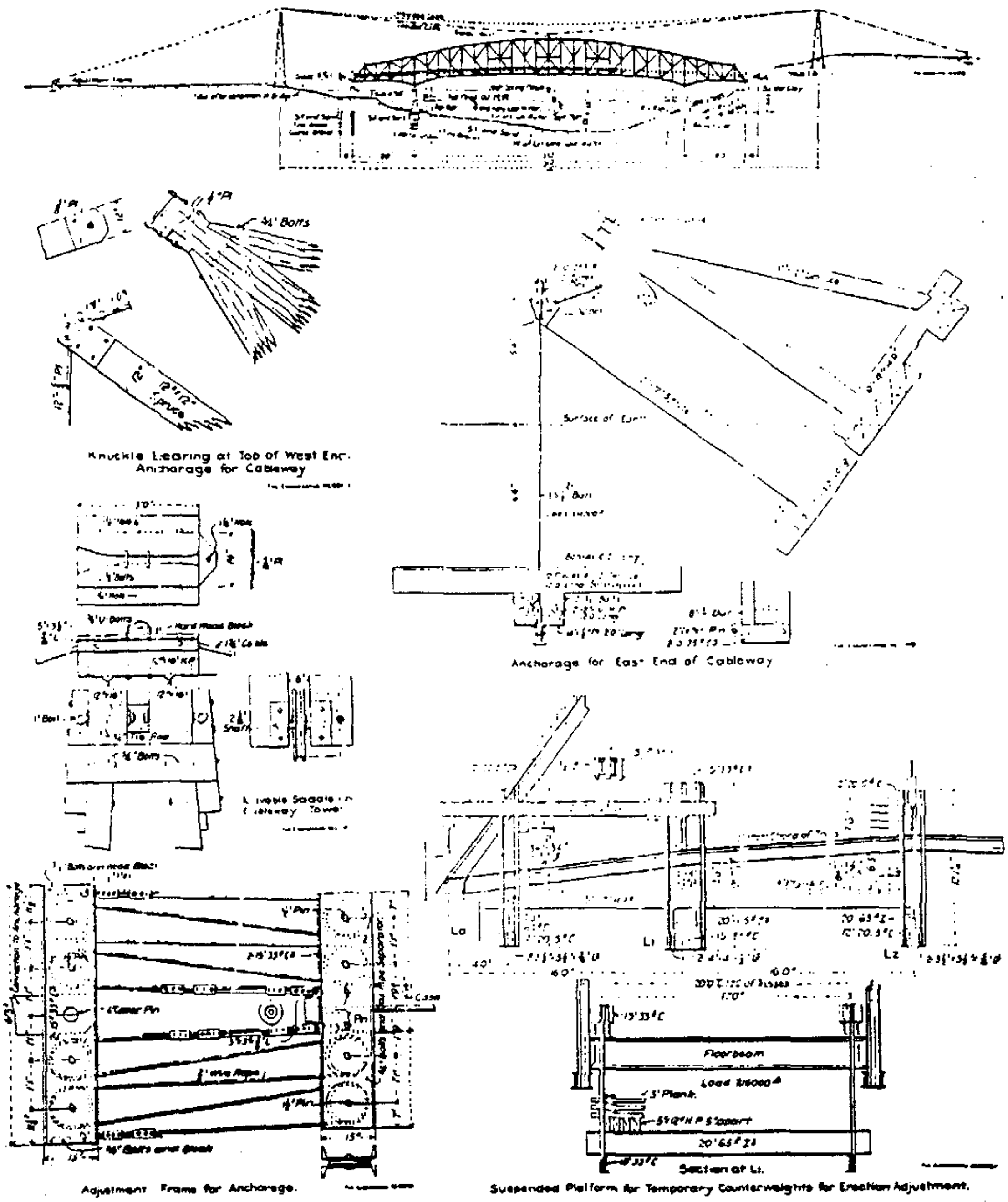


DIAGRAM OF APPARATUS USED IN THE ERECTION OF THE SCHELL MEMORIAL BRIDGE.

from one side to the other to put in place the corresponding panels.

When all but the three middle panels had been erected the gap at the center was partly closed on the afternoon of Aug. 28, 1904, by swinging in three lengths of lower chord on the south side, and suspending two of these lengths by iron rope guys from the ends of the upper chord. Measurements and levels were then taken with the result that there remained a gap in the lower chord at L_{11} of 4½ in., and that the top of the floor beam at L_{11} west was ... in. higher than the corresponding floorbeam at L_{11} east.

Between this date and Sept. 3 the remaining parts of the trusses were erected and levels were taken, showing an elevation at L_{11} west ¾ in. higher than at L_{11} east. On the afternoon of Sept. 3 the lower chords were drawn together, closing the gaps in these members, but leaving a gap in the upper chord of 2½ in. A part of the earth counterweight was then removed, bringing a slight stress on the anchor bars which were then slackened off so as to raise the shore ends and lower the outer ends of the cantilevers, thus closing the gap in the upper chord. Levels taken on Sept. 8, after the closure had been made (and when there was probably a slight compression in the upper chord and tension in the lower chord) show a fair correspondence in level of the two sides of the bridge.

A further deflection of ¾ in. at the center of the bridge was measured on Sept. 19, after the counterweights had been entirely removed and the flooring, except two panels of 16 ft. at each end, was in place. All of the above results are shown on the diagram. The counterweights consisted of sand and earth ballast in wooden bins supported upon steel beams suspended from the floorbeams at L_2, L_3 and L_4 by temporary steel hangers, as shown by the detail, the total weight of each being about 105 net tons.

The cantilevers were erected (not including riveting) at a maximum speed of one double panel of 32 ft. in 18 hours, by a gang of six erectors, two men on shore to select and deliver material, and one man to operate the hoisting engine.

The riveting was done by four gangs of four men each, including heaters. Three of these gangs used air hammers, the fourth gang driving by hand hammers throughout. The compressed air for riveting hammers was carried across the river in a pipe suspended from the trusses, unsuccessful attempts having been made to float this pipe.

The cableway was arranged in a special manner, and the towers, saddles and anchorages were designed and constructed by the contractors to provide for the special requirements of the work. The cable was a 1¾-in. crucible steel rope with a rated strength of 96 tons. It had a total length of 1,200 ft. and a clear span of 700 ft. The anchorages were about 1,160 ft. apart and were both fixed points, but the cable was supported on the tops of the towers on saddles having a transverse movement of 20 ft. The height of the cable was sufficient to give clearance for the hoisting tackle above the highest portion of the upper chord, and the transverse adjustment on the towers enabled it, when shifted, to command all portions of the superstructure. It was designed to have a maximum working stress, including that from its own weight, of 64,000 lb.

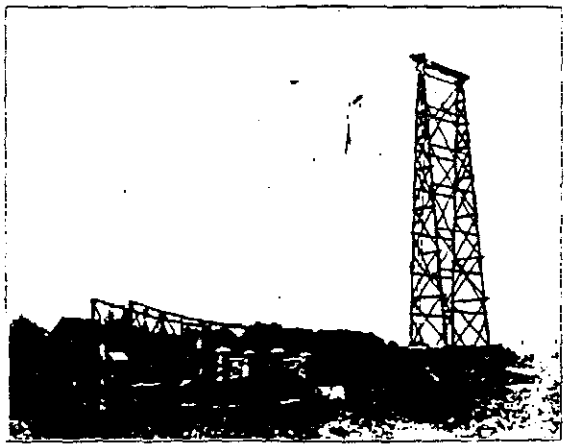
Each anchorage consisted of a timber platform buried about 7 ft. underground and connected with the end of the cable by vertical steel bars and a strut in the direction of the resultant of the stresses in the cable and the vertical anchor bars, the strut being composed of three pieces of timber arranged in fan shape with the spread ends down and bearing on the earth through an inclined timber platform. At the east end the cable was coned into a cylindrical cast-iron block which bore upon a riveted steel angle block upon the upper end of the inclined strut. The vertical anchor bars were a pair of 8x⅝-in. bars with reinforced ends, pin-connected between the webs of pairs of short horizontal channels at top and bottom. The bottom channels supported the centers of a pair of 12x16-in. horizontal timbers, 12 ft. long, which were bolted together and braced the anchorage platform, buried in the ground. The west cable was fitted with a clevis eye which engaged a pin through the bent and reinforced end of a single 12x¾-in. vertical suspension plate 14 ft. long, with top and bottom connections to the inclined strut and anchorage platform, as shown in the detail. The inclined strut was the same as at the east end, except that the cap differed as shown. The vertical anchor at the west end was connected to the short channels below the anchorage platform by a single 4-in. pin.

The timber towers for the cableway were of different heights, owing to the profile of the ground. The west tower was about 100 ft. high and had its base on nearly level ground, but at the site of the east tower the bank had a considerable slope both longitudinally and transversely, and a pit having an average depth of about 12 ft. was dug in order to level the base of this tower, which was then about 75 ft. high from its base.

Each tower consisted of two transverse bents 20 ft. wide on centers and about 15 ft. apart longitudinally at the foot, and 2 ft. apart at the top. Each bent was made with two 8x8-in. posts connected by horizontal struts averaging about 12 ft. apart with X-bracing in double panels. The 12x12-in. sills were seated on four 12x12-in. sleepers, 23 ft. long. The caps of the towers overhung the main posts and were guyed by lateral and back guys of wire rope attached to eye-bolts passing through them near the ends. These caps carried a pair of rails about 18 in. apart, on which the cable saddle was seated. This saddle consisted of a solid timber block with a wide steel base-plate projecting on both sides and on one end to furnish connections for the traversing rope and for a backstay rope. The sides of the block were protected by channels bolted to them, and a longitudinal groove was cut in each block to receive the cable, which was locked in position by a cap piece fastened over it by U-bolts. The saddle was moved along the caps, when it became necessary to shift the cable, by wire ropes attached to each side and led over sheaves at the ends, and thence down to hand tackles.

Close to the west anchorage an adjustment for the cable was provided by interposing a sheave frame made of a pair of transverse steel beams, one of which was connected to the cable and the other to the top of the vertical anchor bar, each beam consisting of a pair of 15-in. channels, back to back, with a space sufficient for four sheaves between each pair. These sheaves were rove with two ⅞-in. steel wire ropes so as to correspond to a ten-part tackle. One end of each rope was fastened to the beam at the anchor end, and the other end, after engaging four sheaves, was clamped to a short rope connected to the opposite beam. Beyond the clamp the main rope passed down to a hand tackle by which it could be adjusted.

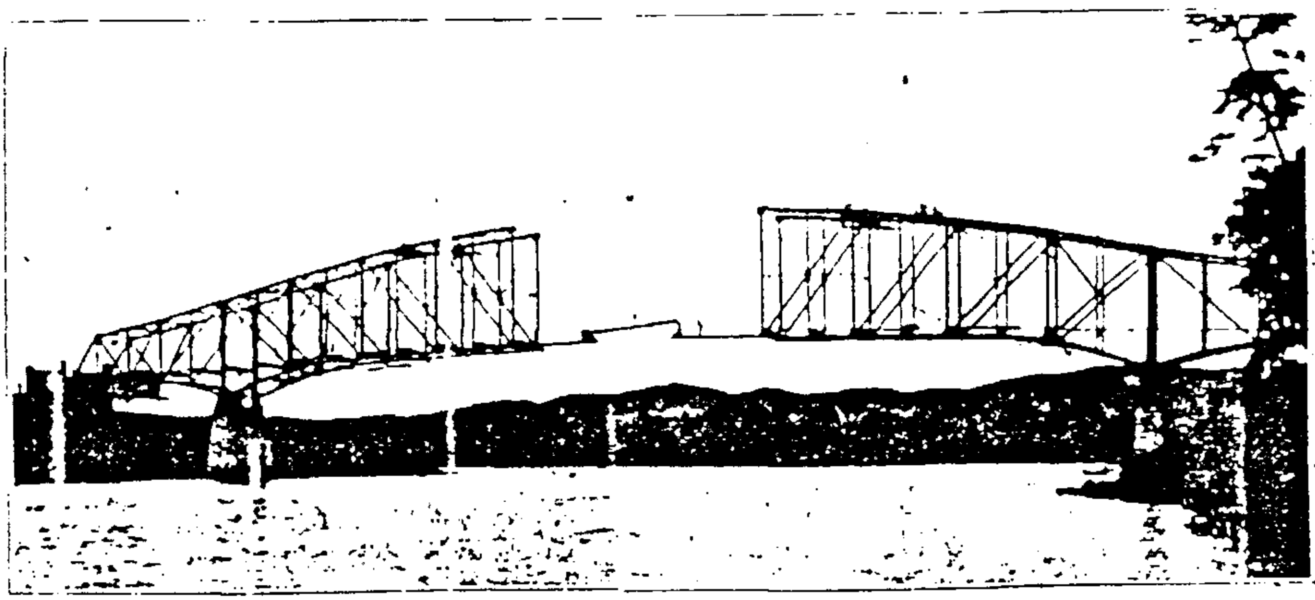
In operation, if it was necessary to shorten or lengthen the main cable while in service, a strain was put on the two tackles connected to



Cableway Tower with Traveling Saddle.

the adjustment device and the clamps between the short ropes and the tackle ropes were loosened. The tackles were then slacked off or set up, as the case might be, and when the distance between the beams had been sufficiently changed the clamps were then screwed up and the tackles released, leaving the adjustment device fixed with the required dimensions.

Mr. Edward S. Shaw, of Boston, was the designer and superintending engineer of this bridge. The New England Structural Co., of Boston and Everett, Mass., was the contractor for the superstructure; Mr. W. H. Douglass was chief engineer, and Mr. E. N. Pike chief draughtsman of this company. Messrs. Ellis & Duwell, of Woburn, Mass., were the contractors for the substructure.



Cantilever Erection with Cableway, Schell Memorial Bridge.

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34. Woburn 200th Anniversary.

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