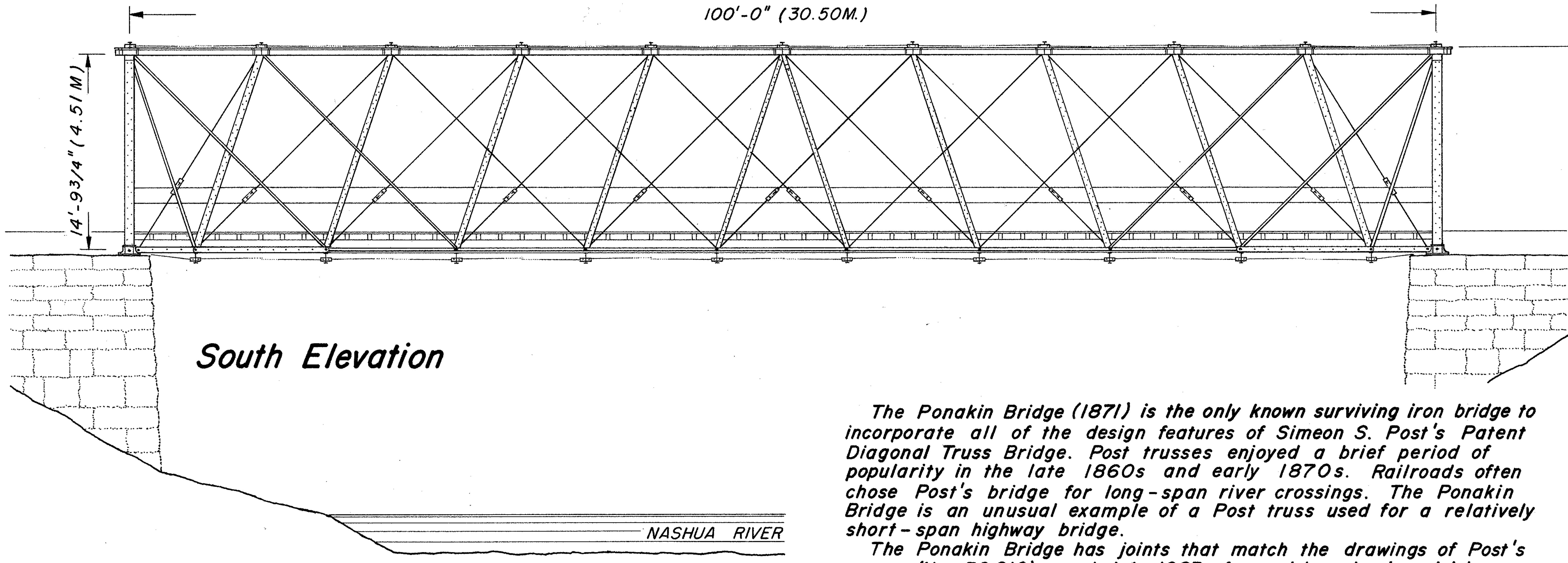
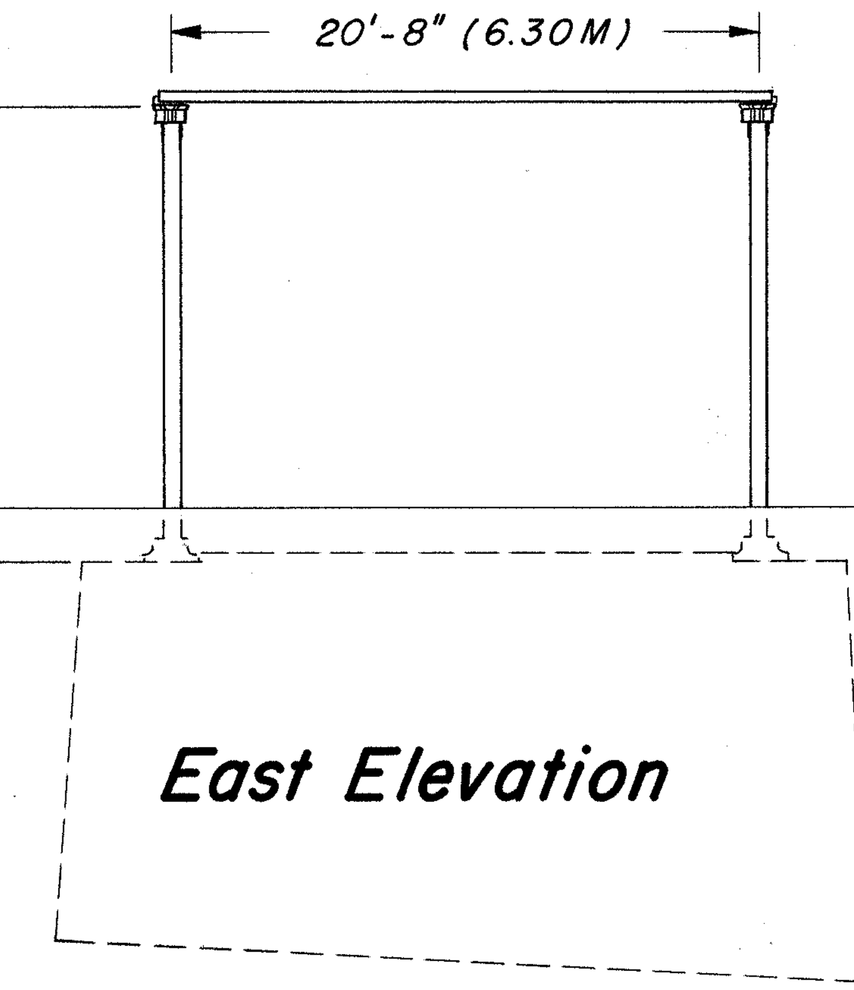
PONAKIN BRIDGE · 1871
LANCASTER, MASSACHUSETTS



South Elevation



East Elevation

Scale: 3/16" = 1'-0"

0 5 10 20 FEET

0 1 2 3 4 5 6 METERS 1:64

The Ponakin Bridge (1871) is the only known surviving iron bridge to incorporate all of the design features of Simeon S. Post's Patent Diagonal Truss Bridge. Post trusses enjoyed a brief period of popularity in the late 1860s and early 1870s. Railroads often chose Post's bridge for long-span river crossings. The Ponakin Bridge is an unusual example of a Post truss used for a relatively short-span highway bridge.

The Ponakin Bridge has joints that match the drawings of Post's patent (No. 38,910), granted in 1863. A special cast-iron joint box connects the top chord to the posts, struts, and braces; the bottom of the end posts are rounded and fit into cylindrical joints where they meet the bottom chord; and, a pin passes through a slot in the bottom chord to tie the end posts to the chord. Post claimed that these joints allowed the bridge to expand and contract without injury to its structure.

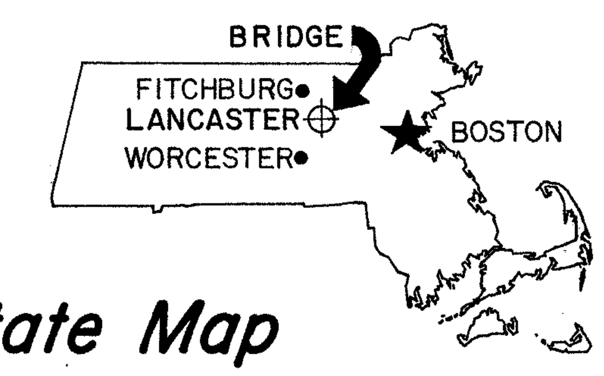
Although Post patented his joints, he never patented the unique combination of posts and diagonals that became the signature of his bridges. The Ponakin Bridge bears the Post truss's hallmark of cast-iron posts that incline towards the center of the bridge and double-intersecting, wrought-iron diagonals that incline toward the abutments. This through truss also has the characteristic upper and lower lateral bracing, and counters with adjustable turnbuckles.

The Watson Manufacturing Company of Paterson, New Jersey built the 100-foot long, 20-foot wide, single-span Ponakin Bridge. The firm held the license for Post's patented trusses, and Andrew J. Post, Simon S. Post's son, worked for the bridge manufacturer. The company probably built most of the iron Post trusses erected in this country.

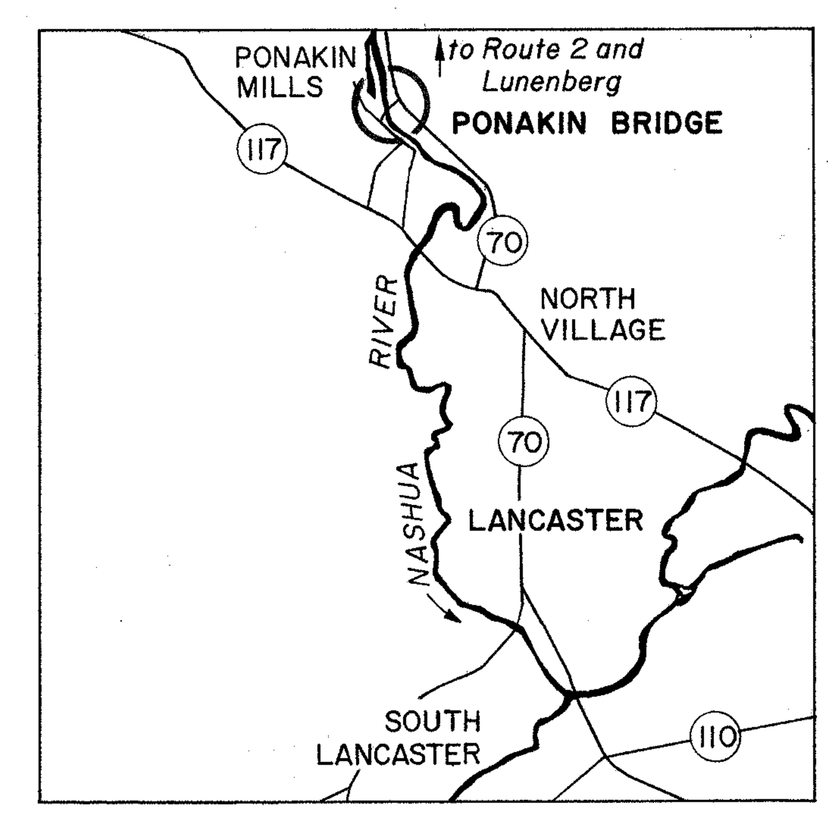
The Ponakin Bridge replaced a series of wooden bridges that had crossed the North Nashua River at the village of Ponakin since the eighteenth century. The new iron truss served a small cotton textile village on the west bank until the factory closed in the early 1930s. The Ponakin Road remained the major thoroughfare between Lancaster and Lunenberg until 1965 when Route 117 bypassed the bridge. In 1978 the town closed the Ponakin Bridge after engineers discovered structural weaknesses.

The Ponakin Bridge has not been significantly altered, although it has sustained some damage; the lower chord has buckled. Fewer than five Post-type trusses are known to survive in the United States. In 1979 the National Register of Historic Places listed the Ponakin Bridge.

The Massachusetts Historic Bridge Project is part of the Historic American Engineering Record (HAER) a long-range program to document historicaly significant engineering and industrial sites in the United States. The National Park Service U.S. Department of the Interior administers the HAER program. The Massachusetts Department of Public Works, Jane F. Garvey, Commissioner, George R. Turner, Jr., Chief Engineer, and Stephen J. Roper, Historic Bridge Specialist; and the Historic American Engineering Record (HABS/HAER), Dr. Robert J. Kapsch, Director, co-sponsored the Massachusetts Historic Bridge Project with the cooperation of the Massachusetts Historical Commission, Elsa Fitzgerald, Acting Exec. Dir. The field team under the direction of Eric DeLony, Chief and Principal Architect, HAER, consisted of Daniel L. Schodek, professor of architectural technology (Harvard University), field supervisor, Patricia Reese (Boston Architectural Center), Gary Kleinschmidt (Harvard University), Chris Payne (Columbia University), Morgan Fleisig (Harvard University), Mark Rowan (Catholic University of America), and Rudolf Sosef (Technical University of Delft, the Netherlands, US/ICOMOS), architectural technicians; Lola Bennett (University of Vermont), Patrick Harshbarger (University of Delaware/Hagley Museum and Library), and John Healey (University of Birmingham, England, US/ICOMOS), historians; and Marty Stupich (Massachusetts College of Art), photographer.



State Map



Local Map

UTM 19.279250.4705490

Based on U.S.G.S. 7.5 x 15 min. series topographic map, Hudson Quadrangle, 1980 (edited 1988).

Scale: 1:16250

0 .5 1 1.5 MILES

0 .5 1 2 3KM.

HISTORIC AMERICAN ENGINEERING RECORD MA-13

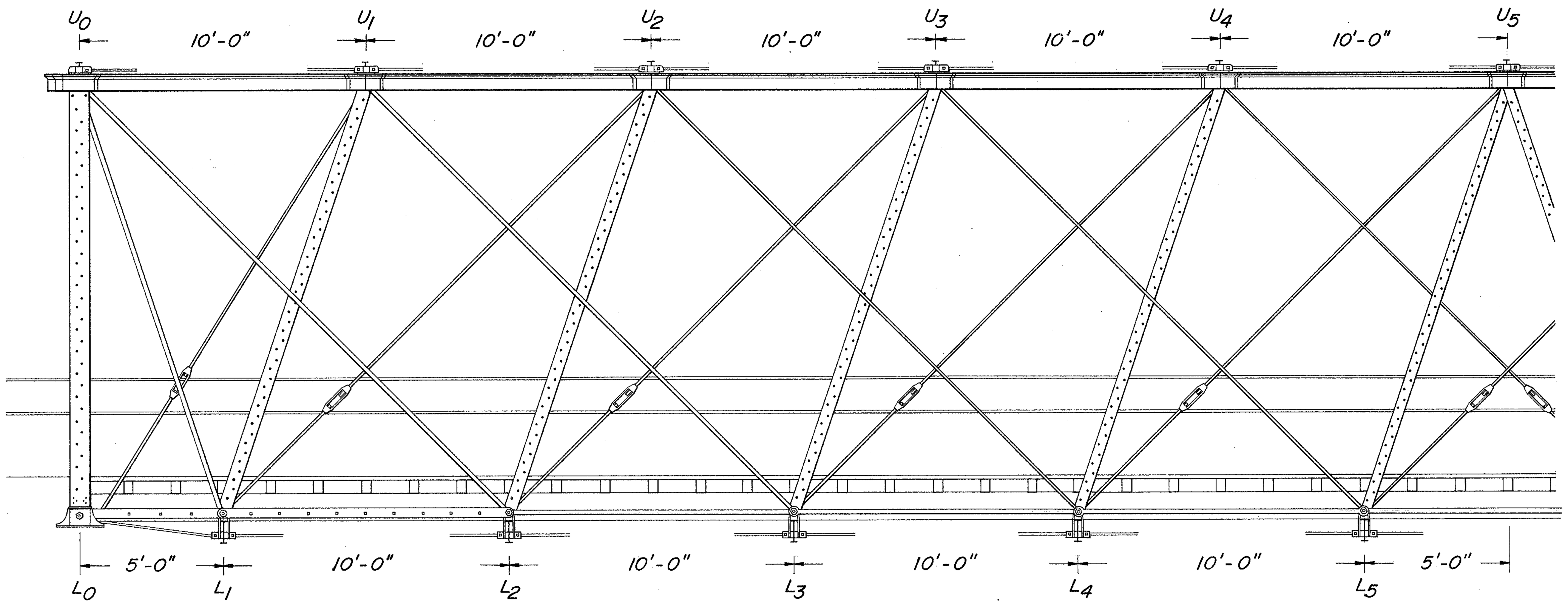
SHEET 1 of 6

PONAKIN BRIDGE - 1871
Spanning the North Nashua River on Ponakin Road
LANCASTER WORCESTER COUNTY MASSACHUSETTS

MASSACHUSETTS HISTORIC BRIDGE PROJECT
NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

DELINEATED BY: PAT REESE, 1990

Elevation

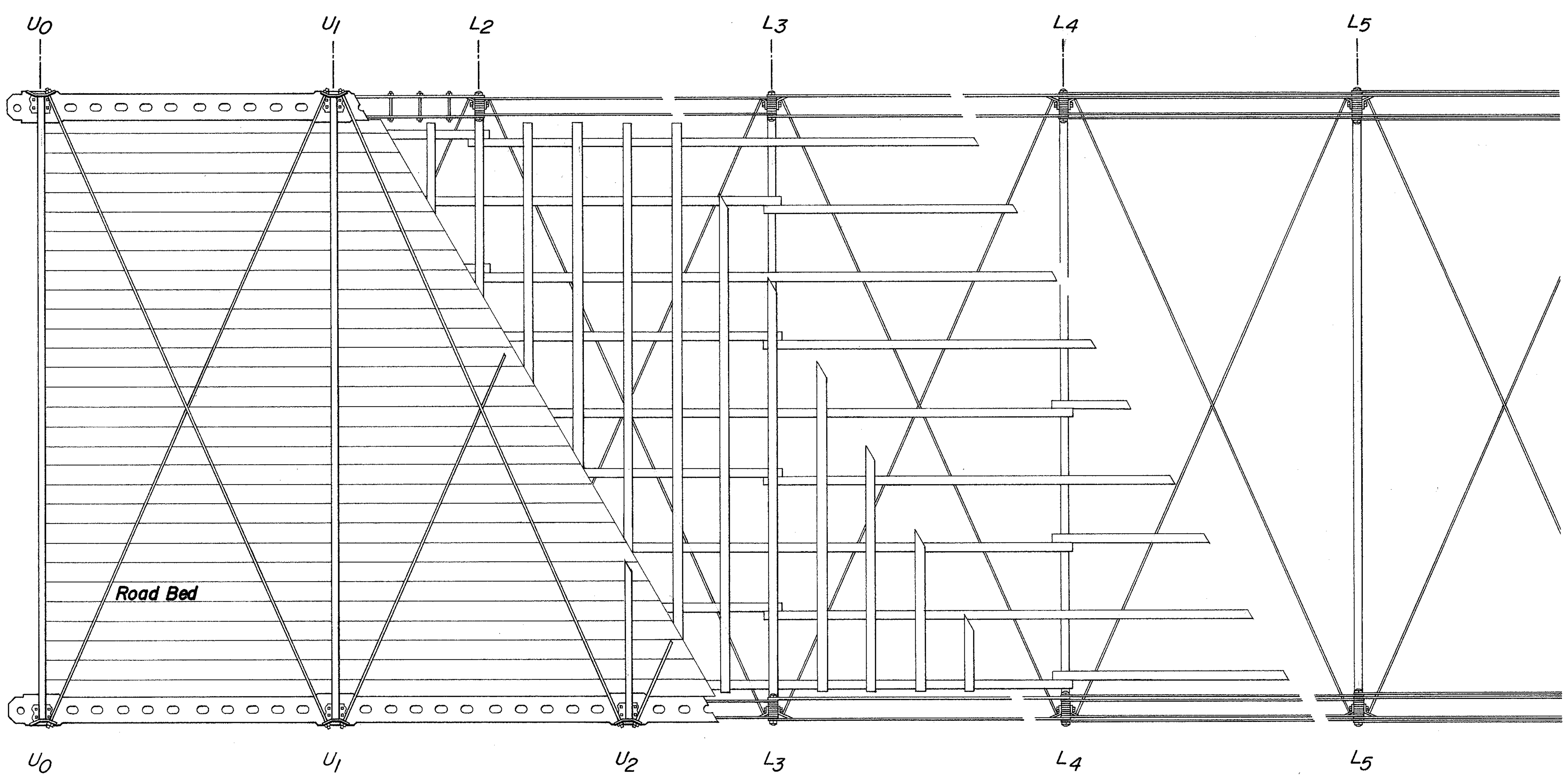


scale 3/8" = 1'-0"

0 1 2 4 6 FEET

0 1 2 METERS

Plan



50'-0" (15.24 M.)

Table of Member Sections

Scale: 1-1/2" = 1'-0"

0 1 2 FEET

0 10 20 30 40 50 CENTIMETERS 1:8

Upper Lateral Strut — 4"; 2 3/4"

Upper Lateral Rod — 3/4" ø

Upper Chord — 6 1/4"; 8"

Post U_0L_0 ($U_{10}L_{11}$) — 1/4"; 1/4" Plate typ.; 2"; 1/4"; 7 3/4"; 7 3/4"

Main Diagonals U_0L_1, U_0L_2, U_1L_3 (U_9L_8, $U_{10}L_9$, $U_{10}L_{10}$) — 1/2"; 2"

Post U_1L_1 (U_9L_{10}) — 3/16" typ.; 5 7/8"; 1 1/2"; 4 1/2" typ.

Main Diagonals U_2L_4, U_3L_5 (U_7L_6, U_8L_7) — 1/2"; 1"

Post U_2L_2, U_3L_3 (U_7L_8, U_8L_9) — 5"; 1 1/8"

Counters U_1L_0, U_2L_1 (U_8L_{10}, U_9L_{11}) — 1" ø

Post U_4L_4, U_5L_5 (U_5L_6, U_6L_7) — 4 1/2"; 1"

Counters U_3L_2, U_4L_3, U_5L_4, U_4L_6 (U_6L_5, U_5L_7, U_6L_8, U_7L_9) — 7/8" ø

Lower Chord

1/2"	4"	L_0L_1 ($L_{10}L_{11}$)
1/2"	4"	L_1L_2 (L_9L_{10})
5/8"	2"	L_2L_3 (L_8L_9)
1"	2"	L_3L_4 (L_7L_8)
1/2" typ.	2"	L_4L_5 (L_6L_7)
5/8" typ.	2"	L_4L_5

Floor Beam — 9"

Lower Lateral Rods — 3/4" ø

DELINEATED BY: Rudolf J.A. Sosef, 1990; Albert N. Debnam, 1991

MASSACHUSETTS HISTORIC BRIDGE PROJECT

NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

PONAKIN BRIDGE — 1871

Spanning the North Nashua River on Ponakin Road

LANCASTER WORCESTER COUNTY MASSACHUSETTS

SHEET 2 of 6

HISTORIC AMERICAN ENGINEERING RECORD MA-13

Scale: 1/4" = 1'-0" (Isometric)

0 5 10 FEET

0 1 2 3 METERS 1:48

Connections of Upper Chord U4 Typical

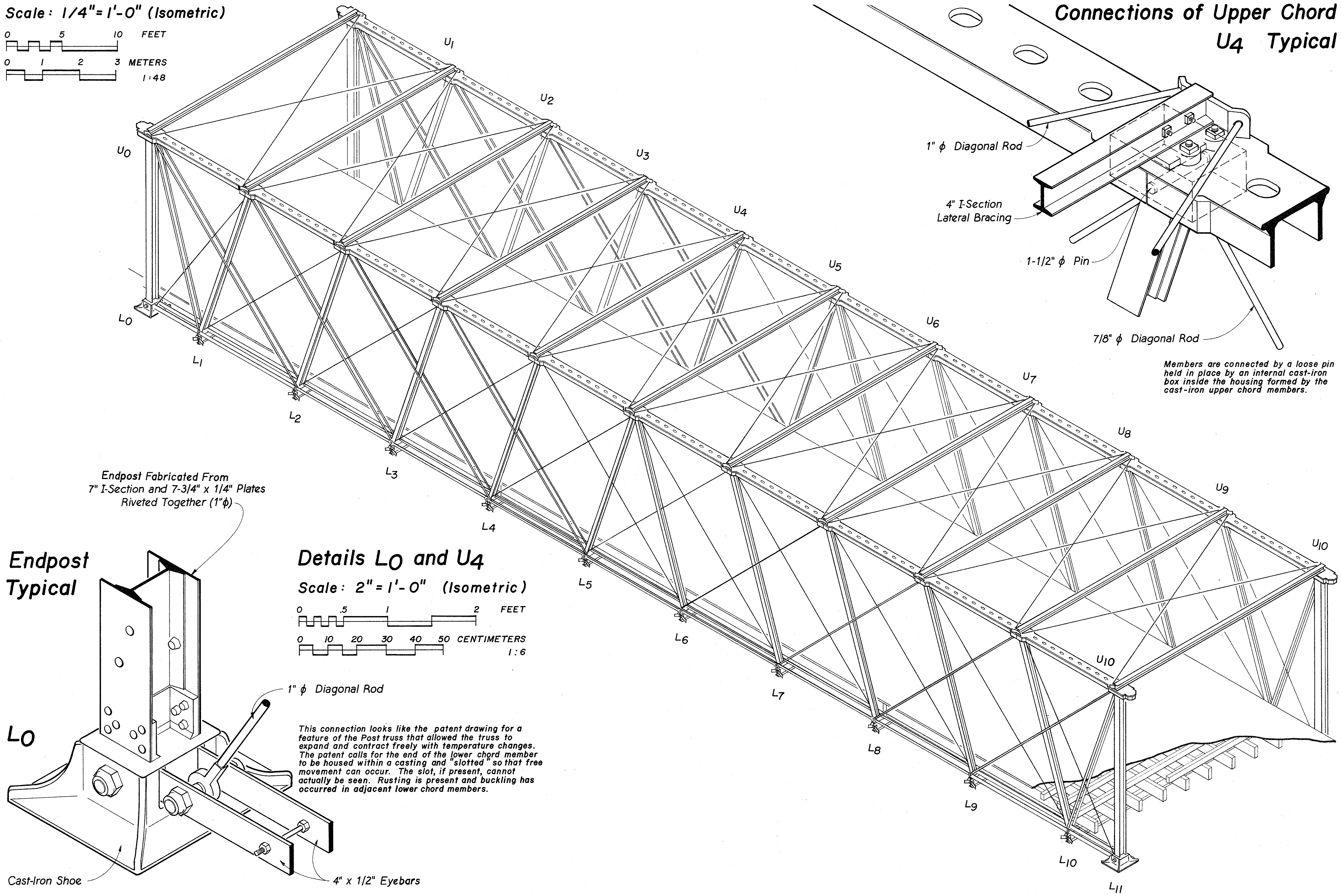
Endpost Typical

Details L0 and U4

Scale: 2" = 1'-0" (Isometric)

0 .5 1 2 FEET

0 10 20 30 40 50 CENTIMETERS 1:6



Members are connected by a loose pin held in place by an internal cast-iron box inside the housing formed by the cast-iron upper chord members.

This connection looks like the patent drawing for a feature of the Post truss that allowed the truss to expand and contract freely with temperature changes. The patent calls for the end of the lower chord member to be housed within a casting and "slotted" so that free movement can occur. The slot, if present, cannot actually be seen. Rusting is present and buckling has occurred in adjacent lower chord members.

DELINEATED BY: PAT REESE, 1990

MASSACHUSETTS HISTORIC BRIDGE PROJECT
NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

LANCASTER

PONAKIN BRIDGE — 1871
Spanning the North Nashua River on Ponakin Road
WORCESTER COUNTY

MASSACHUSETTS

SHEET 3 of 6

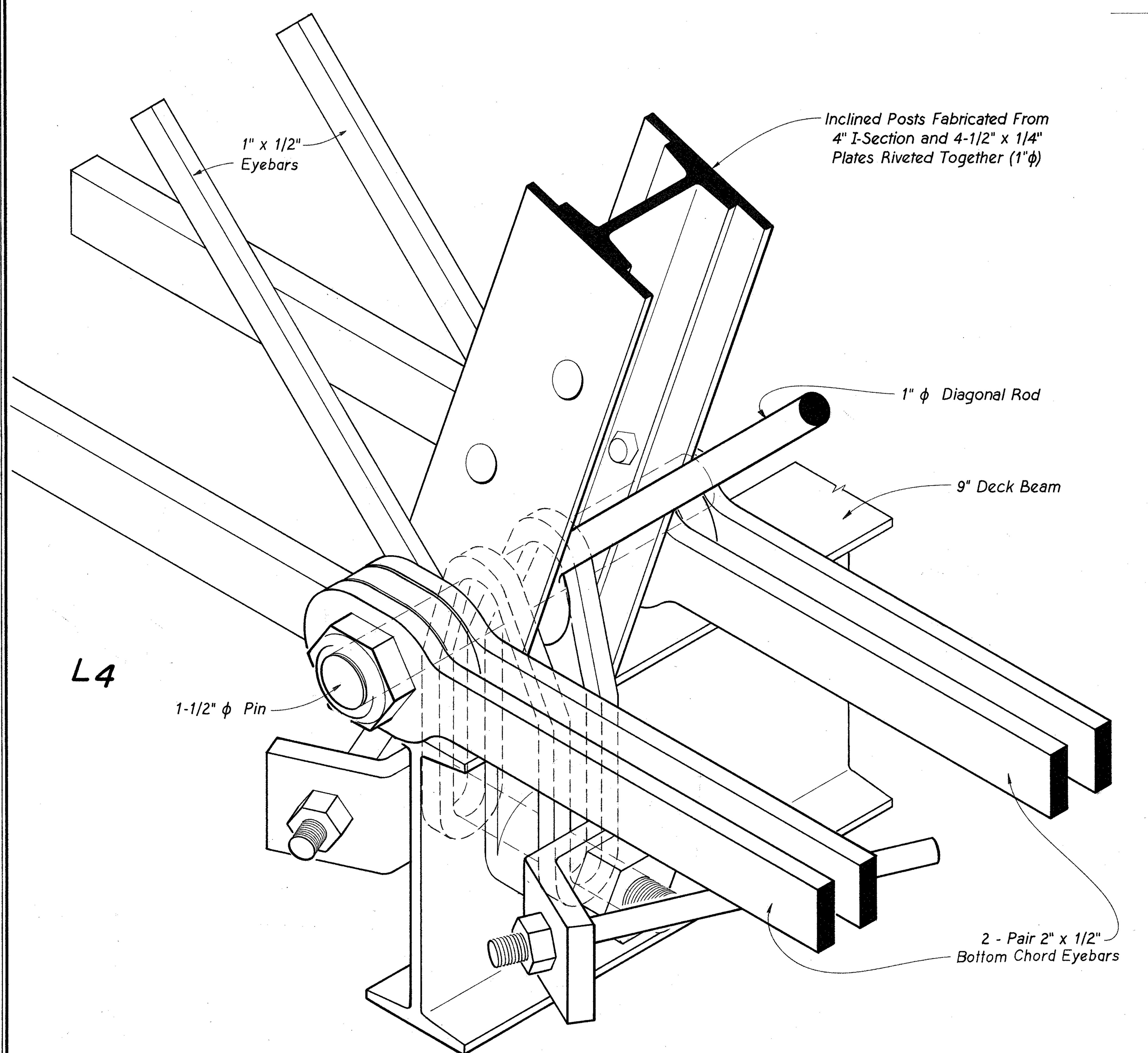
HISTORIC AMERICAN ENGINEERING RECORD MA-13

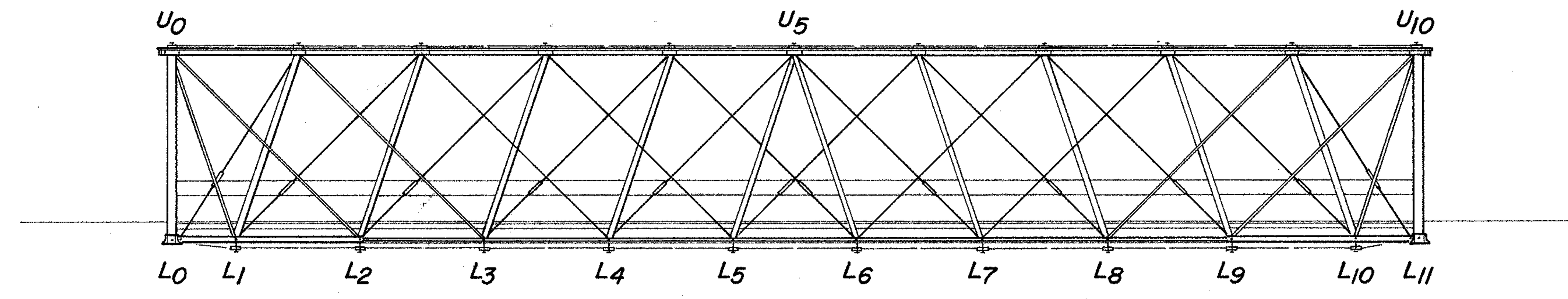
Connections of Lower Chord

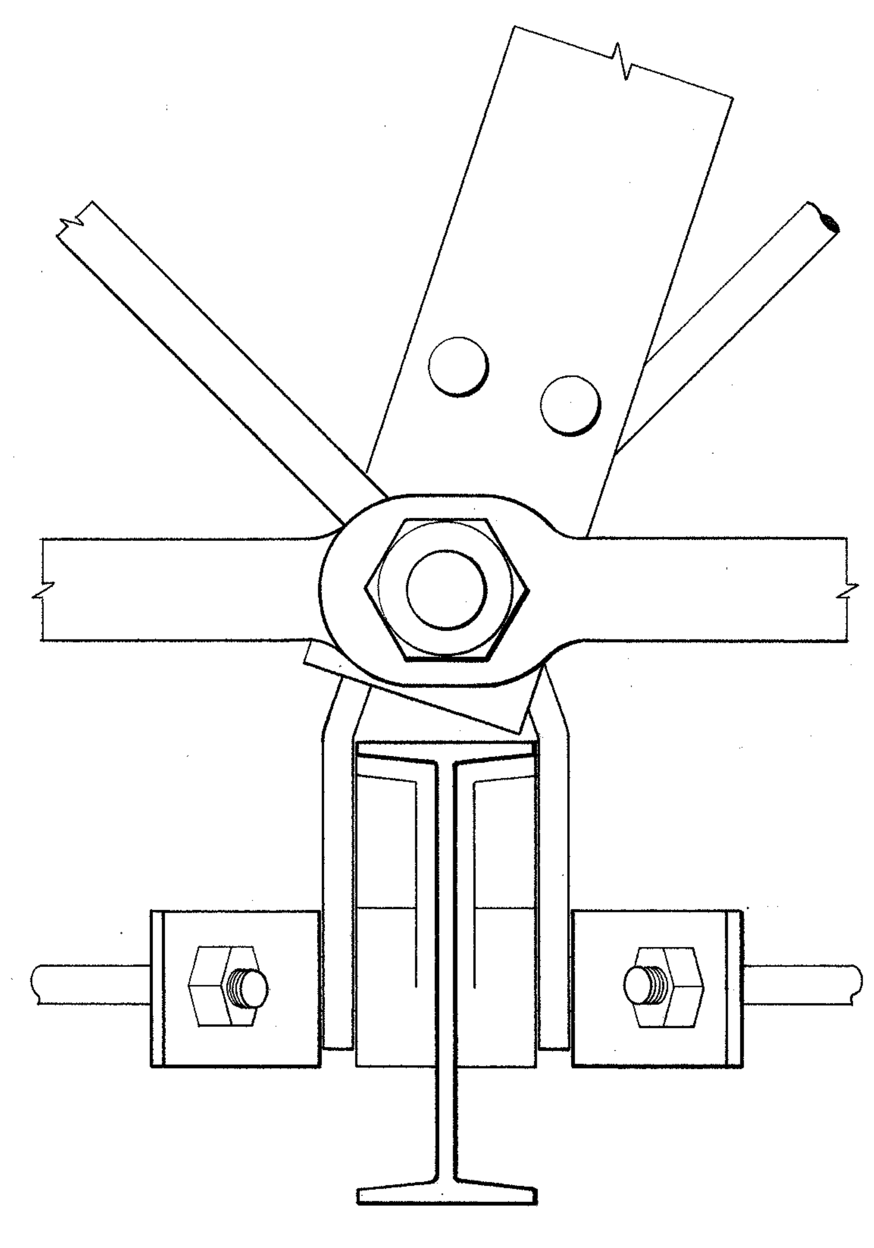
Scale: 6" = 1'-0" (Isometric)

0 1 2 3 4 5 6 9 12 INCHES

0 5 10 15 20 30 CENTIMETERS 1:2





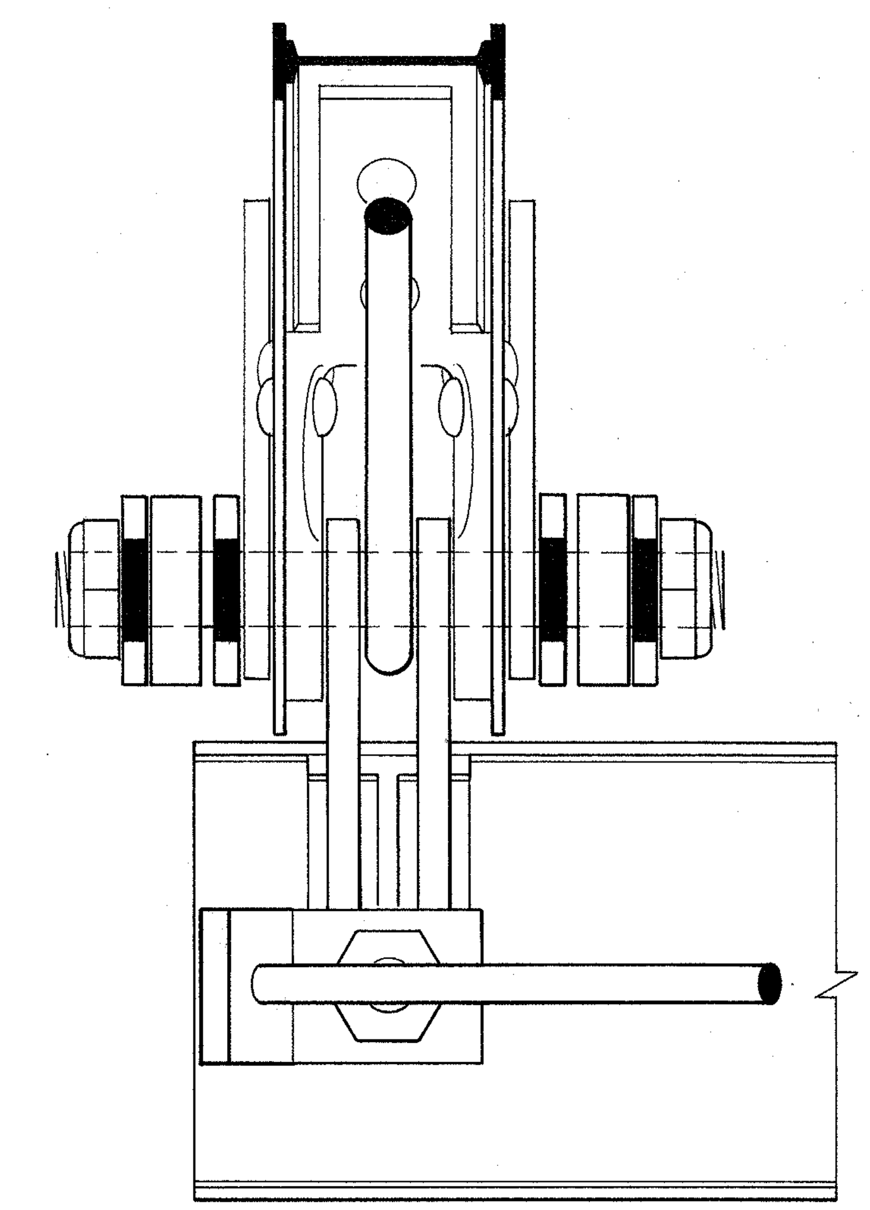


Elevation L4

Scale: 4" = 1'-0"

0 1 2 3 4 5 6 9 12 INCHES

0 10 20 30 CENTIMETERS 1:3



Section L4

DELINEATED BY: PAT REESE, 1990

MASSACHUSETTS HISTORIC BRIDGE PROJECT
NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

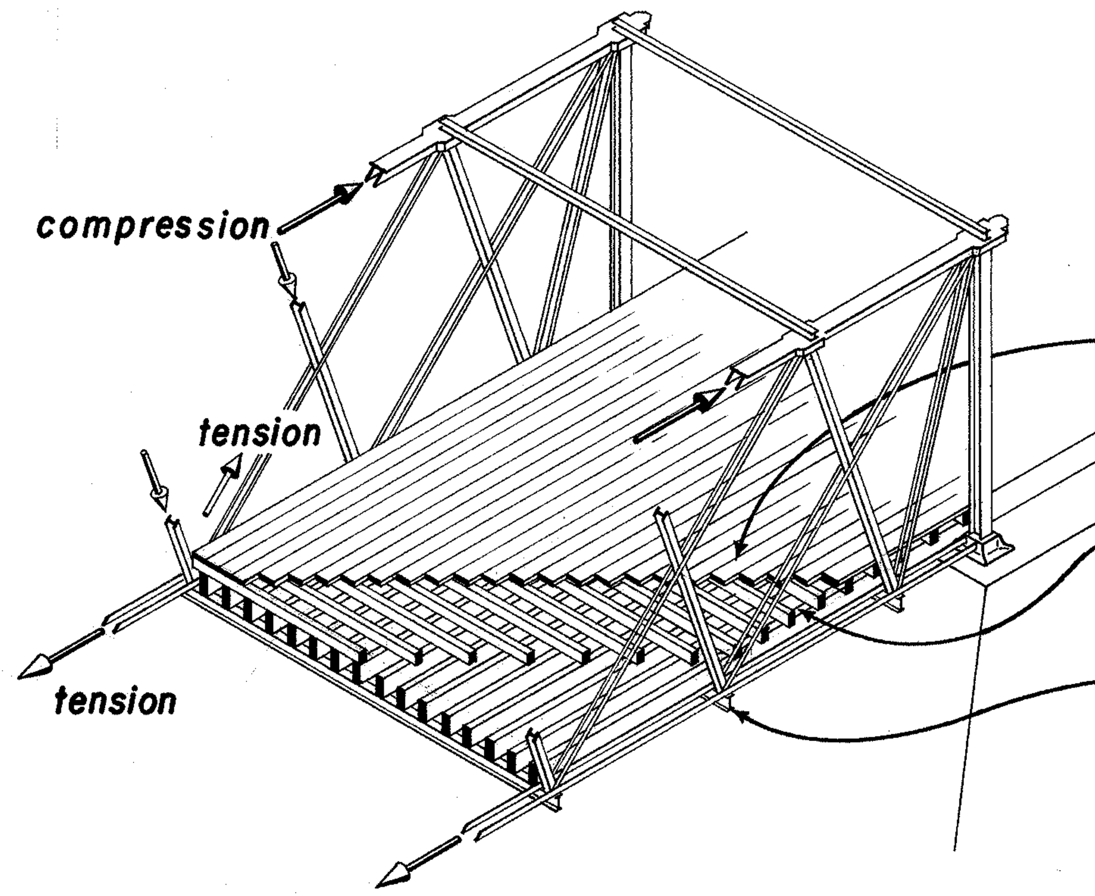
PONAKIN BRIDGE - 1871
Spanning the North Nashua River on Ponakin Road
LANCASTER WORCESTER COUNTY MASSACHUSETTS

SHEET 4 of 6

HISTORIC AMERICAN ENGINEERING RECORD
MA-13

TRIM LINE

STRUCTURAL BEHAVIOR OF POST TRUSSES



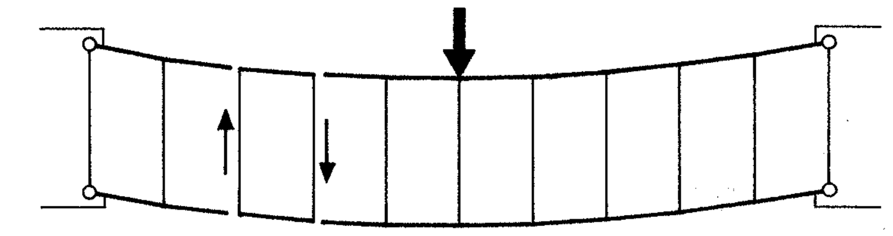
Live loads from vehicles or pedestrians are carried by the decking to the timber beams.

Timber beams carry loads to the wrought-iron transverse beams.

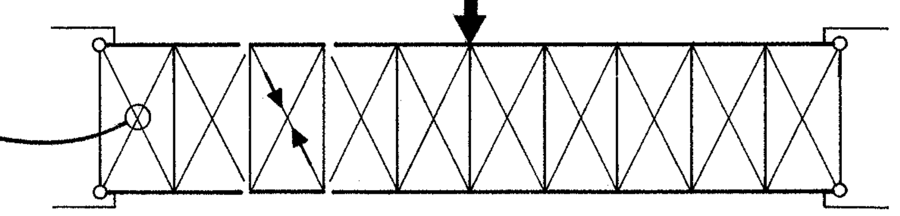
Transverse wrought-iron beams carry loads to the truss joints.

Trusses carry all loads to the supports. Tension or compression forces are consequently induced in truss members. The member configuration shown is entirely characteristic of other Post trusses.

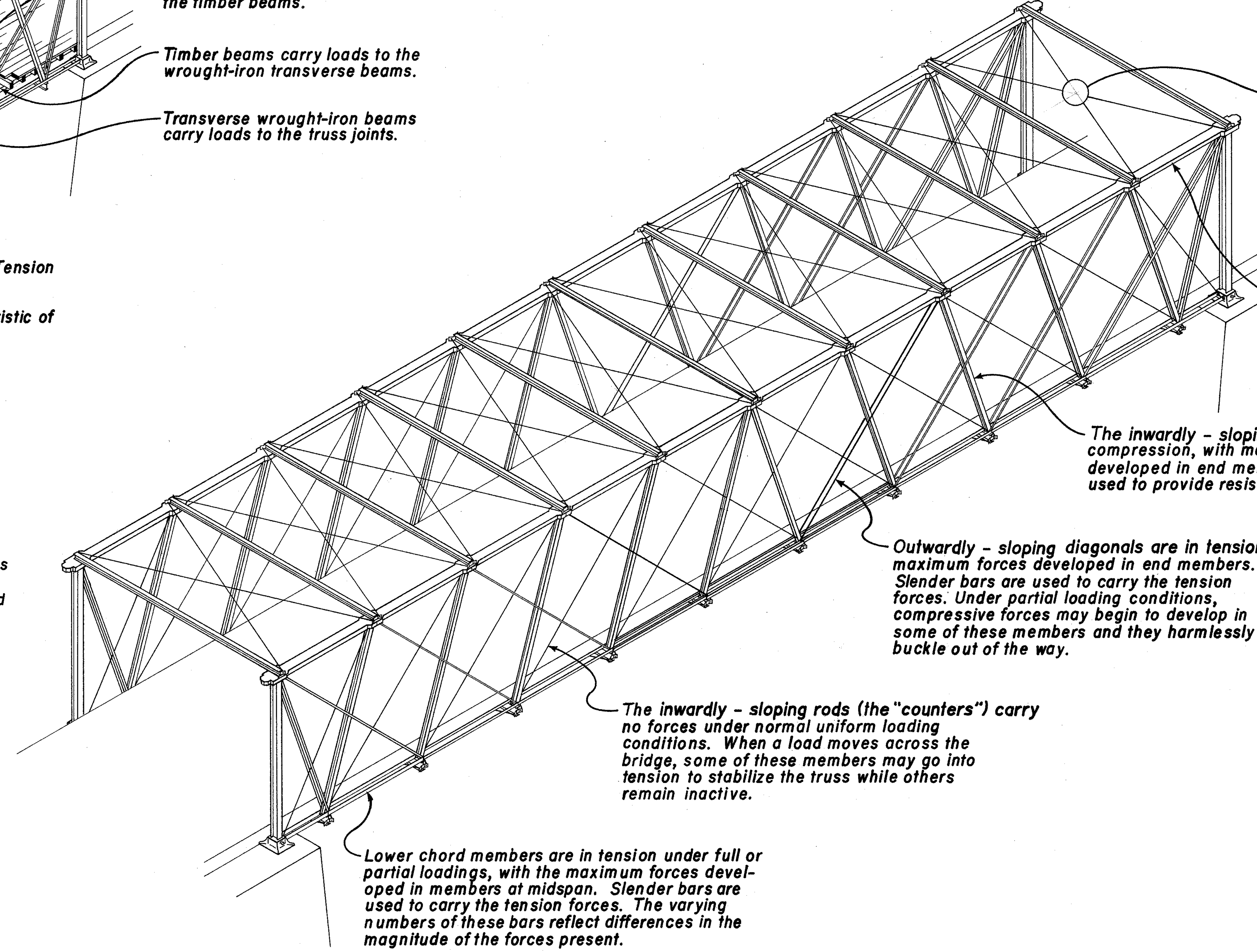
The crossed diagonals in the planes of the top and bottom chords prevent the bridge from deflecting sideways due to wind (or other laterally acting forces) as well as helping to prevent torsional deformations.



Deflection without crossed diagonals



Diagonals stiffen structure



Top chord members are in compression under full or partial loadings, with maximum forces normally developed in members at midspan. Rigid members are used to provide resistance to buckling.

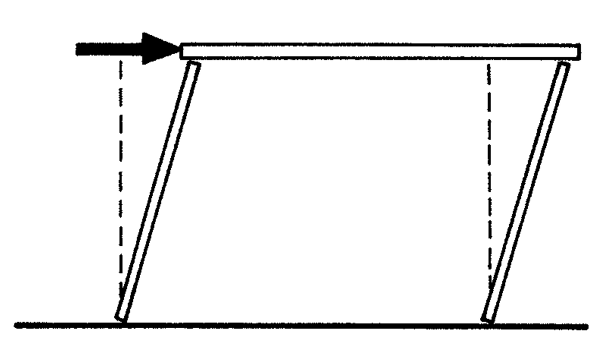
The inwardly - sloping diagonals are in compression, with maximum forces normally developed in end members. Rigid members are used to provide resistance to buckling.

Outwardly - sloping diagonals are in tension, with maximum forces developed in end members. Slender bars are used to carry the tension forces. Under partial loading conditions, compressive forces may begin to develop in some of these members and they harmlessly buckle out of the way.

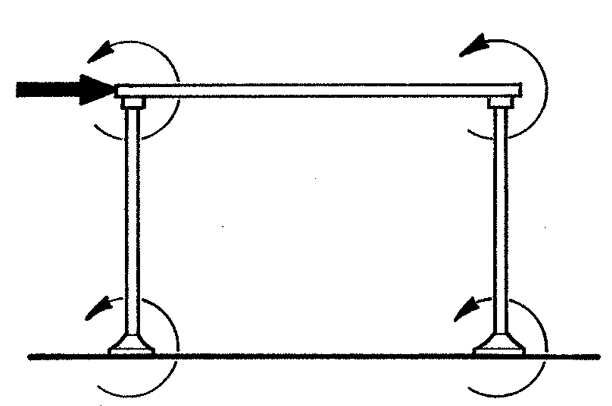
The inwardly - sloping rods (the "counters") carry no forces under normal uniform loading conditions. When a load moves across the bridge, some of these members may go into tension to stabilize the truss while others remain inactive.

Lower chord members are in tension under full or partial loadings, with the maximum forces developed in members at midspan. Slender bars are used to carry the tension forces. The varying numbers of these bars reflect differences in the magnitude of the forces present.

The rigid portals at both ends, along with the stiffening provided by the upper cross members at panel points, prevent the bridge from racking sideways due to wind or other laterally acting forces.

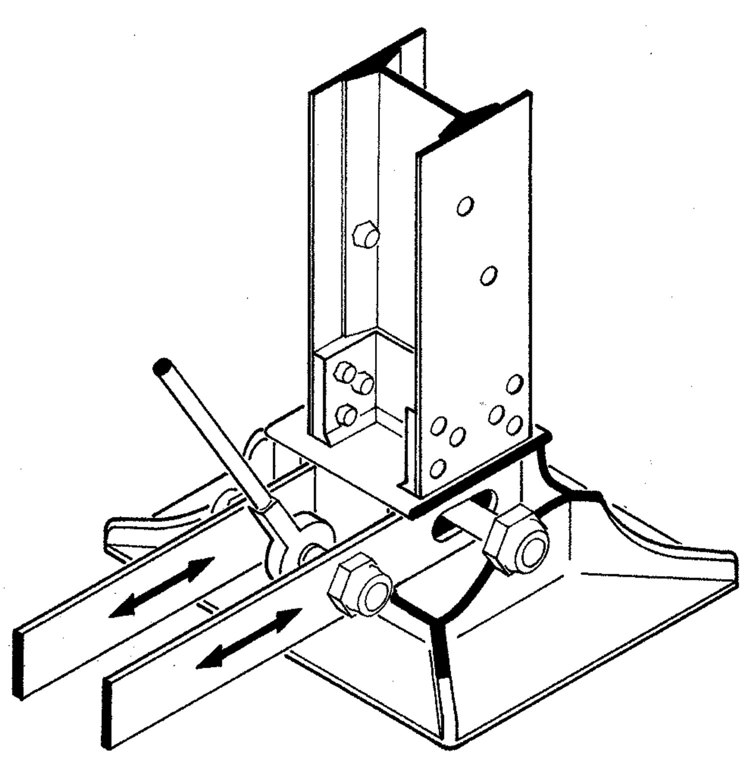


Possible racking



Rigid frame action

Patent drawings for Post trusses show an abutment connection housing a slotted lower chord end which would allow free thermal expansion and contraction to occur.



(Conjectural drawing)

DELINEATED BY: JOHN LEEKE, 1991

MASSACHUSETTS HISTORIC BRIDGE PROJECT
NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

LANCASTER

PONAKIN BRIDGE — 1871
Spanning the North Nashua River on Ponakin Road
WORCESTER COUNTY

MASSACHUSETTS

SHEET 5 of 6

HISTORIC AMERICAN ENGINEERING RECORD
MA—13

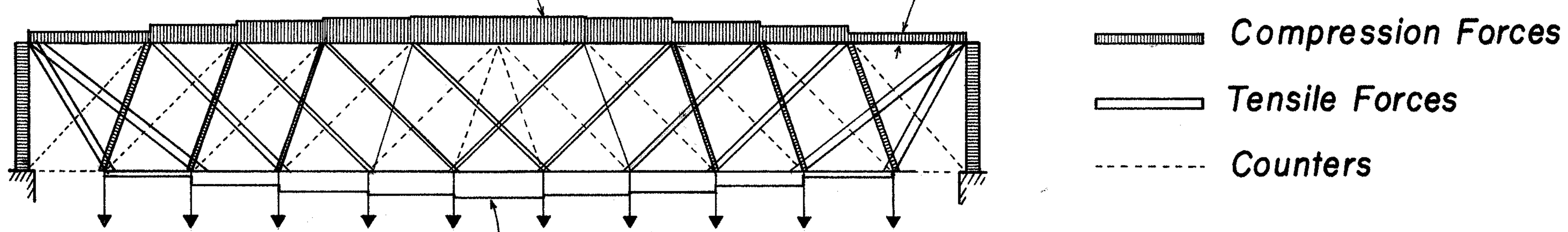
TRIM LINE

TRIM LINE

FORCES IN TRUSS MEMBERS: FULL LOADING CONDITION

Loadings on the bridge include both "Dead Loads" and "Live Loads". Dead loads include the self-weights of the trusses, beams, and decking, and are always present. Live loads reflect the weights of vehicles and pedestrians and may or may not be present (the bridge may be only partially loaded with live loads as a vehicle moves across a bridge). A full loading condition with the maximum live and dead loading present is shown.

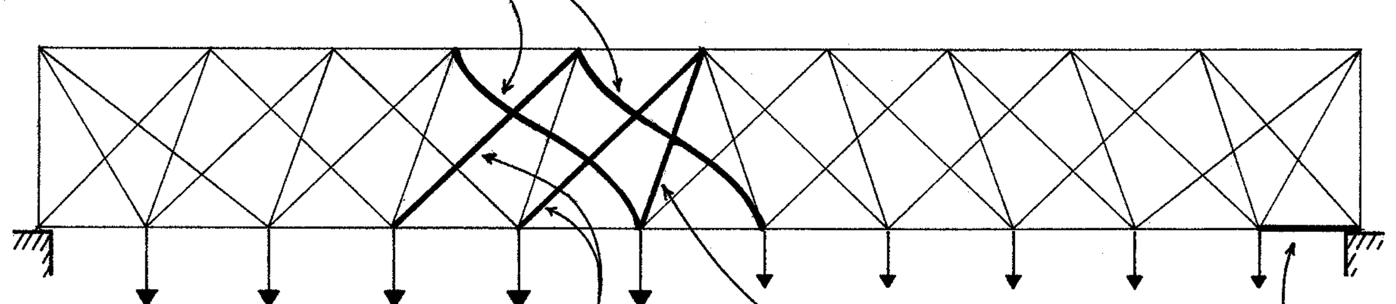
When a truss is loaded, tension or compression forces of varying magnitudes are developed in different truss members. These forces could be accurately predicted by 19th century engineers through a variety of analytical methods based on a mathematical understanding of the equilibrium of different joints in the truss, and subsequently used to determine the size and shape of truss members.



TRUSS MEMBERS: OTHER LOADING CONDITIONS

When vehicles or other loads move across the bridge (creating a nonuniform loading condition), the force types and magnitudes present in truss members changes. Only one of many possible partial loading conditions that could exist is shown below.

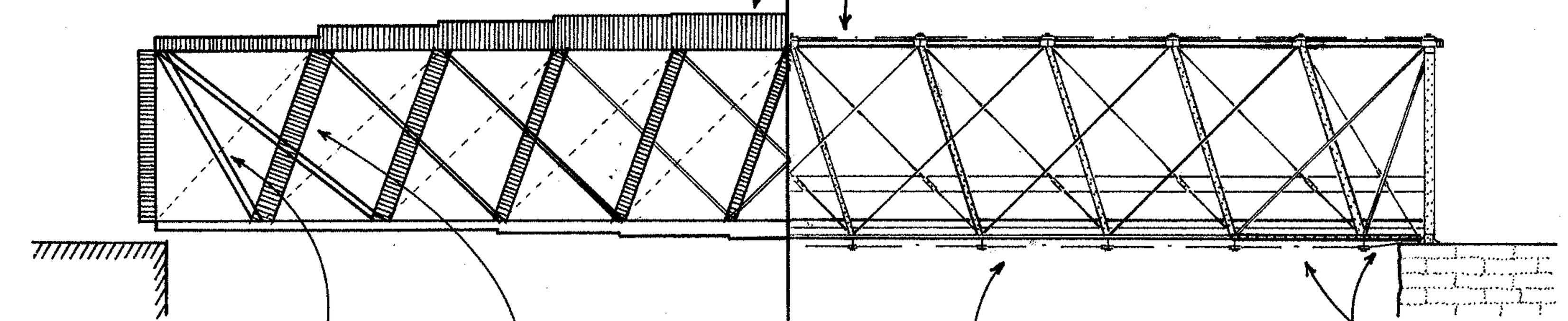
Stress-reversals may occur in some truss members. Compression forces may begin to develop in slender diagonal members designed primarily to carry tension forces only (these members buckle harmlessly out of the way as long as counters are present which go into tension and stabilize the truss). In some loading conditions, minor compression forces can develop in the lower chord members adjacent to the end supports (e.g., due to the braking action of vehicles, longitudinal earthquake or wind forces, or a failure of the expansion joint).



MEMBER DESIGN

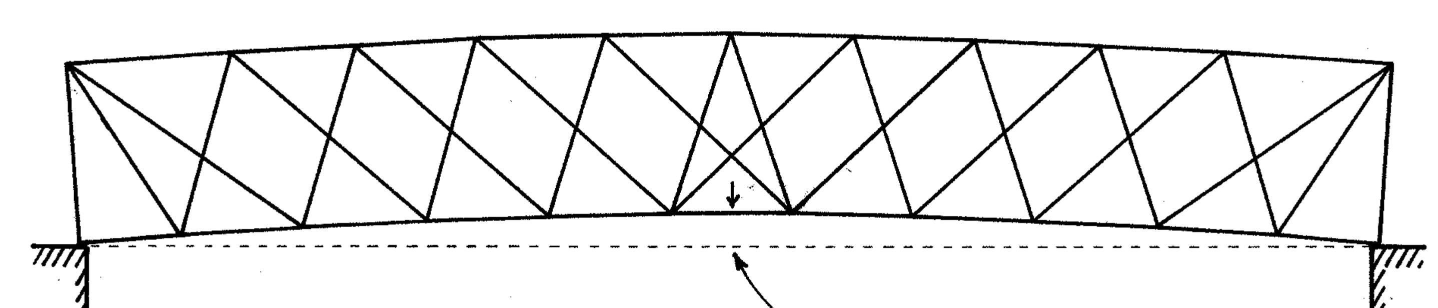
Members in the Ponakin Bridge have been sized and shaped in direct response to the nature and type of forces present. Members that have been designed to resist tension forces only are usually relatively slender and have small cross-sections. Members that have been designed to resist compression, and are hence susceptable to buckling, are always larger and stiffer.

There are small but obvious size differences in many of the truss members used in the Ponakin Bridge. These size differences reflect the variation in type and magnitude of forces in the truss as described to the left. These variations are diagrammed below and noted in detail in the Table of Member Sections (Sheet 2 of 6). Some variations, however, are associated with partial loading conditions described in the lower left figure.



CAMBER

Excessive downward deflections were often problematic in 19th century bridges. The Ponakin Bridge was apparently designed with an upward camber to counteract these adverse deflections. The bridge tends to level out when subjected to a downward load. Levels taken on the bridge indicate that an upward camber still exists.



DELINEATED BY: Rudolf J.A. Sosef, 1990; Albert N. Debnam, 1991

MASSACHUSETTS HISTORIC BRIDGE PROJECT
NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

PONAKIN BRIDGE — 1871
Spanning the North Nashua River on Ponakin Road
LANCASTER WORCESTER COUNTY MASSACHUSETTS

SHEET 6 of 6

HISTORIC AMERICAN ENGINEERING RECORD
MA-13

TRIM LINE