Lower Plymouth Rock Bridge
Spanning Upper Iowa River
Kendallville vicinity
Winnishiek County
Iowa

HAER No. IA-18

HAER
IOWA,
96-KEND.V,
1-

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
Rocky Mountain Regional Office
National Park Service
Department of the Interior
P.O. Box 25287
Denver, Colorado 80537

HAER
IOWA,
96-KENDV,
1-

HISTORIC AMERICAN ENGINEERING RECORD

LOWER PLYMOUTH ROCK BRIDGE

Location:	Spanning the Upper Iowa River on unnumbered Winneshiek County road, 2.1 miles east of Kendallville; NW1/4, SW1/4, SE1/4, Section 35, Township 100 North, Range 10 West; Fremont Township, Winneshiek County, Iowa UTM: 15.581180.4809045
Quadrangle:	Bluffton, Iowa (7.5 minute series, 1981)
Date of Construction:	1877
Designer/Fabricator :	Wrought Iron Bridge Company, Canton, Ohio
Present Owner:	Winneshiek County, Iowa
Present Use:	Single-lane roadway bridge
Significance:	The Lower Plymouth Rock Bridge is one of the few intact examples remaining of what had once been the standard rural roadway bridge type of the 1870s in America: the bowstring arch-truss. This patented tubular arch design was marketed extensively throughout the United States and Canada by the Wrought Iron Bridge Company of Canton, Ohio, one of this country's most important 19th century iron bridge fabricators. The Lower Plymouth Rock Bridge is the oldest bowstring remaining in its original position in Winneshiek County.
Report Assembled by:	Clayton B. Fraser Principal, Fraserdesign Loveland Colorado January 1986

INTRODUCTION

The Historic American Engineering Record (HAER) documentation for the Freeport and Lower Plymouth Rock Bridges was conducted by Fraserdesign of Loveland, Colorado, under contract with Winneshiek County, Iowa. Winneshiek County has proposed the replacement of these two structures: the Lower Plymouth Rock Bridge (Project No. BROS-9096(8)) in early 1986 and the Freeport Bridge (Project No. BROS-9096(17)) in early 1987.

Some sections of the report have been expanded beyond the usual HAER format to serve specific needs. The coverage of Wrought Iron Bridge Company activities in Iowa, for instance, has been expanded to help the Iowa Department of Transportation identify and date similar bridges throughout the state. Similarly, Winneshiek County bridge history is discussed in extensive detail to provide a needed general history for the County Engineer's Office and answer questions regarding other extant structures in the county. Additionally, the volume of county records allows an unusual opportunity to provide a thorough coverage of county bridge building in the 1870s that is representative in the economics of bridge funding and contracting and novel in its focus upon one man and two bridge types. The Freeport and Lower Plymouth Rock bridges share many similarities in that they were funded by the same county, fabricated and erected by the same bridge manufacturer at about the same time, and using the same general design. Their detailing, however, differs in significant aspects, which the evolution of that design illustrate. (For more detailed information on the Lower Plymouth Rock Bridge, refer to HAER No. IA-18).

Field recording of the two bridges was undertaken in November 1985. The perspective-corrected photographs for both were processed and the three-sheet set of measured drawings for the Freeport Bridge (reductions of which are included in Appendix) was completed by year's end. Research and report preparation were conducted between November 1985 and January 1986, with this final report being completed in January 1986.

The research for this project has involved a variety of archival sources: the Winneshiek County Engineer's Office, Winneshiek County Clerk and Recorder, Luther College Library, Ohio State Historic Preservation Office, Ohio State University Library, Ohio Historical Society Library and the Denver Public Library. For their assistance in the research and support for the project, we would like to thank George Hanzlik, Winneshiek County Engineer; Dr. James Hippen of Luther College; David Cook of the Iowa Department of Transportation; David Simmons of the Ohio Historical Society; Eric DeLony of the Historic American Engineering Record in Washington; Greg Kendrick and Suzanne Evans of the National Park Service in Denver; and Dennis Gimmestad of the Minnesota Historical Society.

EARLY BRIDGE BUILDING IN WINNESHIEK COUNTY

Winneshiek County was formed by an act of the Iowa State Legislature on January 15, 1851. The first settlers had arrived in the region two years earlier and initial settlements had begun in several of the townships. From a population of 546 in 1850, the county grew dramatically to almost 13,500 in 1860, and totaled over 23,500 in 1870.[1] In 1852, Lincoln Township was settled and the town of Moneek was platted. Decorah and Frankville were surveyed and platted the following year, and Spillville was begun by the first Bohemian settlers in the county. Freeport and Calmar were platted in 1854, Ossian and Plymouth Rock a year later.[2] As other settlements formed and grew in the county, an impromptu network of overland roads and trails began to develop to link them, following the typical pattern of settlement and transportation.

Four rivers drain Winneshiek County. The Upper Iowa is the largest, entering the county from the northwest corner and meandering across to the eastern edge. The Turkey River cuts across the southwest corner of the county; the Yellow rises in the southeast. The Canoe, though termed a river, is little more than an enlarged stream. Additionally, the county is crisscrossed by a myriad of creeks, streams, runs, gullies, ravines and washes. Although they are numerous, none of these watercourses is very wide or deep and none would present any great technological difficulties in bridging. Nevertheless, they did impede travel over the region's growing system of wagon roads. Bridged crossings would be required if settlement was to continue.

Organized road and bridge building was the responsibility of the county government. The typical method of communication between the citizens and the elected officials was through road and bridge petitions, which requested specific construction or improvements. These petitions were considered by the county supervisors at their regularly scheduled meetings in Decorah, the county seat. In a sparsely populated region, however, with minimal government revenues, relatively few vehicular bridges were erected by Winneshiek County in the 1850s.

Beginning in 1860, county affairs were administered by a board of supervisors, composed of one member from each township. Ten years later, this board was replaced with a county commissioner system, with elected representatives, still termed supervisors, from each of three districts. These first members were Board Chairman M.S. Drury, G.C. Winship and A. Arneson. In 1872, the county was reapportioned into five districts, which each elected a representative.[3]

The board of supervisors responded to the deluge of urgent bridge construction petitions in the 1860s by authorizing many small-scale projects, but no long-span structures. In March 1870, for example, the board appropriated funds for several short-span structures around the county: a bridge across a ravine on a section-line road in Orleans Township ($10); a two-span timber stringer bridge across a creek in Orleans Township, with stone abutments and a timber pier ($55); two bridges on a slough in Lincoln Township ($60 for both); another bridge across a slough in Lincoln Township ($15); two bridges across a creek in Lincoln Township ($60 for both); a bridge in Madison Township ($25); and four or five bridges on the Decorah and Burr Springs Road ($75 for all).[4] For a relatively new county faced with a rapidly increasing number of rural roads and an acute shortage of funds, the construction of many small timber structures was the most practical short-term solution. Though inexpensive to build initially, most tended to be structurally suspect and required almost continuous maintenance to prevent their collapse. Moreover, the wider rivers would require more substantial crossings in the form of longer-span trusses or arches.

In 1870 the supervisors' primary concern was sheer volume and intensity of the bridge requests from around the county. The three beleaguered men sought some relief, if only temporary. On January 5, 1871, the board unanimously adopted the following resolution:

> WHEREAS, The Bridge Fund provided for by the tax levied amounts to only about $1500 after paying appropriations made; and some reform is therefore necessary in the manner of building and keeping in repair the bridges of the county; and
> WHEREAS, The Trustees of the several townships, under provisions of Sec. 2, of Chapter 100 of the laws of the 12th General Assembly, have the power to levy taxes for bridge purposes in their respective townships; therefore,
> RESOLVED, That hereafter this Board will not make any appropriations from the County or Bridge Funds for building or repairing bridges of less than 30 feet span; and we earnestly recommend that all bridges of less than 30 feet span are built with good stone arches where stone can be had at any reasonable prices, believing that such bridges will be much more substantial and economical; and this Board will in all cases determine the necessity for the bridge, and the length of span needed where the span is 30 feet or more; and G.C. Winship is hereby appointed a committee to receive petitions in vacation and examine and report upon the necessity and amount of appropriation and length of span needed in all such cases.[5]

The resolution was a rather transparent attempt by the board to shift the responsibility for bridge building to the individual townships. The supervisors must have realized that the measure could not be enforced over an extended period. A dubious piece of legislation at best, the resolution did, however, contain one kernel of foresight: the appointment of supervisor George Winship as the one-man bridge committee. It was a decision which would profoundly effect Winship's life and would have a far-reaching impact on the landscape of Winneshiek County.

Though not among the first pioneers to settle in the county, George C. Winship (1823-1898) was already a long-time resident in the area by 1871. He was born in Hartford, Connecticut, in August 1823. In September 1855, Winship moved to Winneshiek County from Ohio with his wife Charlotte and nine-year-old daughter, Emma. A second daughter, Minnie, was born on his farm six years later.[6] Winship began work in Decorah as a hired journeyman for the town's first blacksmith and later acquired a 40-acre farm a mile north of town.[7] By no means wealthy, he was nevertheless widely known and respected in the township.[8] The 1860 Census estimated the value of his real estate holdings at $5000 and his personal estate at $1000.[9] Ten years later his land had increased in value to $10,000 and his personal holdings to $1800, a total exceeded by only a dozen other men in the township.[10] A tall, thin man, Winship's stature was erect, his demeanor stern and forthright, though colored with a wry sense of humor. He had a rather drawn face with a sharp hawk-like nose, and even late in life carried a beard and full head of grey hair.

As the representative from the Decorah District, Winship had been one of the first three supervisors elected when the county adopted the county commissioner system in 1870.[11] In the most densely populated township in a county settled overwhelmingly by people with names such as Oleson, Hanson and Tollefson, Winship was an anomaly as an elected official in that he did not live in town and was not Scandinavian. He listed himself as a farmer to the census takers, and farming was his primary source of income. But his avocation - as the other supervisors would come to realize - was supervising county capitol improvement projects, particularly bridge construction.

Following his appointment as bridge committee, Winship began maintaining a journal, known as the bridge book. In this he recorded and mapped the numerous citizens' petitions for bridges and posted payments for bridge work.[12] The board had given him sole authority over county bridge matters, stating: "the bridge committee [is] authorized to draw warrants and to pay for work contracted for as fast as the work should be accepted by him and to make contracts for building or repairing bridges that may in his judgement be deemed indispensible."[13]

The first bridge that Winship authorized as bridge committee was Winneshiek County's largest and most costly bridge to date. Built by local stonemason P. Gallaher over Trout Run, two miles southeast of Decorah, the masonry structure consisted of five 12-foot arches supported by 4-1/2 foot solid masonry piers. It totaled 180 feet in length and 18 feet in width and cost $1596.72.[14] At the end of the year, Winship contracted for two other substantial masonry arches. The longer of these was the Bohemian Creek double-arch bridge in Sumner Township. Composed of almost 70 cords of stone and costing $1,438.27, it consisted of two 16-foot arches with a total length of 95 feet, including the wingwalls. Another two-span masonry arch was built over the Yellow River in Bloomfield Township for a total cost of $1455.[15]

Winship realized the limitations of masonry arches for crossings requiring long spans. Nevertheless, he preferred the arch in principle, calling it "the most handsome and utilitarian of bridges." When he would begin contracting for medium-span timber structures in 1871, these too would employ the arch. That year, Winship contracted with Sumner Township contractor Alva Tracy to erect a bridge over the Turkey River at Spillville for $1752.22. This was paid by warrants on the bridge fund and the poorhouse fund, "and no pains were spared to make a No. 1 bridge."[16] The following year, Tracy erected three bridges: the Bredeson Bridge over Trout Run in Glenwood Township ($1072.44), the Brandt Bridge ($1248.08), and Buck's Bridge over the Turkey River in Washington Township ($2009.46).[17] The combination spans that Tracy built were composed of timber arches and decks, with iron suspenders and floor structure.[18] Winship praised Tracy's invention, saying, "This bridge is built on an entirely different plan from any other bridge in northern Iowa. It is so strong that the heaviest loaded teams make no perceptible jar."[19]

Throughout 1871 and 1872, the supervisors were faced with two interrelated issues: the poor state of bridge construction in the county and charges from their constituency of unfair allocation of funds for bridge projects. The resolution of January 1871 had only exacerbated an already heated situation. Clearly, a more workable solution was needed. After considering the twin problems in its September 5, 1872 meeting, the now five-member board adopted another resolution:

> WHEREAS, It is found that citizens of the several townships of the county are unable, for want of means, to build the necessary small bridges in their townships, and,
> WHEREAS, The townships have contributed alike towards the bridge funds of the county; therefore,
> RESOLVED, That this Board will build, in each township, one arch bridge, of not over 16 feet span, as soon as the state of the funds will permit, and that the bridge committee is hereby authorized to locate such bridges, and to contract for the building of the same as fast as the same can be built consistent with the state of the funds.[20]

It was an imaginative plan, designed to benefit all twenty townships equitably and set the standard for sound bridge building in the county. Because it stipulated stone construction for the bridges, the supervisors' program would benefit local contractors and quarry operators, rather than send the appropriations to out-of-state bridge companies.[21] To fund this ambitious program, the board engaged in a bit of administrative legerdemain. The county had traditionally allotted no more than a 3 mill levy for bridge construction and was unwilling to raise the levy to accommodate the growing need for upgrading of the roads and bridges. Rather than increase the appropriation for bridges, the supervisors withdrew money from the poorhouse fund whenever the cost of bridge projects exceeded the amount budgeted in a particular year. Good for travelers in Winneshiek County; bad for the indigent.

Stone suitable for building the arches was readily available throughout the region. The central part of the county is floored primarily by Trenton limestone, which gradually changes to galena in the southwest corner. Several extensive quarries located in the county separated and cut this stone. Near Decorah, pure high-grade limestone of a light grey color was quarried. Additionally, quarry operators mined sandstone in the eastern part of the county and magnesia on Canoe Creek six miles north of Decorah.[22] Given the abundance of materials, the masonry arch seemed a logical and economical choice for small-scale crossings. By the end of the year, Winship had made arrangements to construct several masonry arches throughout the county.

More importantly, by the end of 1872, he had begun preparations for the county's first iron bridges. Winship contracted with local stonemasons for construction of the stone abutments for three iron bridges: one over the Turkey River at Fort Atkinson, and two in Lincoln Township near the Daubersmith Brothers' Mill the Butz Mill west of Ridgeway.[23]

These latter structures, called the Daubersmith and Butz Bridges, or simply the Daubersmith Bridge, may have been a single two-span bridge or two single-span bridges close together; the records are unclear. It was erected in 1873 for a total cost of $5621.24 - by far the most expensive bridge built in the county. The structure entailed over 108 cords of stone for the abutments and wingwalls, 38,688 feet of 12"x12" timber for the driven piles and two iron superstructures - 60 and 70 feet long.[24]

For the abutments, Winship contracted with stonemason Peter Reis. Reis first encountered quicksand on the riverbank, necessitating a change in the foundations. Then he encountered difficulty in procuring suitably sized stone. Finally, he encountered difficulty in moving the stone across an adjacent parcel of land. "A gentleman with stubbornness extraordinarily developed, refused to let us pass across a little corner of his land," Winship told the board, "although we offered him $50 for the privilege, and agreed to level down all ruts and sow the track to grass seed... I wish the gentleman well, but I think he has more than his share of pure mulishness."[25] Before he would accept the masonry work, Winship exacted a twenty-five year guarantee for the bridge abutments from the contractor.[26]

For the superstructure, Winship followed the typical bridge contract solicitation and award process of the period, which he would also use when contracting for all subsequent iron spans. He instructed the county clerk to advertise for competitive bids, giving the span length and location of the proposed bridge. With their cost proposals, the regional bridge companies were required to submit design proposals, including plans, specifications and design load tables. Winship then reviewed the proposals comparatively with the board of supervisors. Given his propensity for areh bridges, it is not surprising that he and the supervisors chose a bowstring arch-truss for the Daubersmith

Bridge. In April 1873, after inspecting an iron arch in adjacent Howard County, the board instructed Winship to purchase the Wrought Iron Tubular Arch Bridge, manufactured by the Ohio Bridge Company of Cleveland, Ohio, for this and two other bridges.[27] For some unrecorded reason, he awarded the superstructure contract to the Wrought Iron Bridge Company of Canton, Ohio.[28]

The other iron bridge built in 1873, for which foundations had been laid the year before, was the Fort Atkinson Bridge over the Turkey River. This span was an 84-foot bowstring arch-truss supported by stone abutments. The total cost of the bridge was $3,101.50. Like the Daubersmith Bridge, the substructure for the Fort Atkinson Bridge was built by local contractors. The superstructure was fabricated and installed by the Wrought Iron Bridge Company under a single contract with the Daubersmith Bridge.[29]

Construction of a third iron span, the Gillece [Gilliece; Gillence] Bridge, in Bluffton Township was begun late in 1873. By year's end the work was almost completed. A stonemason named Dwyer built the massive masonry abutments, which, according to Winship, were "by far the best job of masonry in the county, so noted by all who have seen it."[30] The abutments and 95-foot wing-walls consumed almost 212 cords of limestone and 17,898 feet of timber and plank. The 104-foot bowstring superstructure was produced by the Wrought Iron Bridge Company.[31]

For all four of Winneshiek County's first iron bridges, George Winship had contracted with Wrought Iron. The total amount paid by Winneshiek County to the Canton-based company in 1873 was $7,198.00: far more any previous year's total expenditure for bridges.[32] In his annual bridge report to the board, Winship defended the high cost of these first iron bridges, saying, "No money has been needlessly expended, but unforeseen expenses, to a large amount, have been incurred. At each of our four iron bridges, where we expected and looked for rock or hard pan foundations, we struck quagmires of quicksand, which cost us sixty four thousand, three hundred and thirty eight feet of timber and plank for foundation, besides the expense incident thereto, for transportation, framing, sinking, &c, &c."[33]

The following year saw five more iron bridges erected in what would prove to be the most extensive single-year construction program undertaken by the county in the 1860s, 70s and 80s. The Goddard Bridge over Plum Creek in Washington Township was a 34-foot structure costing $1205.51 ($459 of which was paid for the superstructure). The Stich Bridge in Pleasant Township cost $2236.34 ($1080 for the superstructure). The Upper Plymouth Bridge in Fremont Township was a 130-foot bowstring arch-truss erected over the Upper Iowa River for $4770.77 ($3570.00 for the superstructure). The Drake Bridge in Glenwood Township, another 130-foot bowstring over the Upper Iowa, cost $6155.61 ($3607.50 for the superstructure). The most expensive among these was the Decorah Bridge, a medium-span iron structure built for $7994.89 ($3941.50 for the superstructure).[34] Because of its location within a relatively heavily trafficked urban area and the requirement for a wide roadway, the supervisors chose a medium-span through truss for the superstructure, instead of a bowstring, a bridge type thought more suitable for rural farm-to-market roads. The Decorah Bridge was manufactured by King and Son of Topeka, Kansas.[35] The others were manufactured by the Wrought Iron Bridge Company.

In the four years since his appointment as bridge committee, George Winship had accelerated the rate of bridge construction significantly. By the end of 1874, Winneshiek County had built one five-arch, two double-arch and thirteen single-arch masonry bridges. Additionally, the county had contracted for its first iron bridges.[36] All but one of these nine spans had been fabricated by the Wrought Iron Bridge Company.

WROUGHT IRON BRIDGE COMPANY

In its extensive dealings with the Wrought Iron Bridge Company, Winneshiek County was simply following a regional trend. As this county and hundreds of others in the Midwest contracted with the Ohio-based bridge company in the 1870s, Wrought Iron quickly became one of the largest bridge fabricators in America. And its president, David Hammond, distinguished himself as one of the country's most prolific bridge innovators.

Born September 12, 1830, on a farm in Plain Township, Ohio, David A. Hammond had moved to Canton, Ohio, at the age of eighteen. There he served as an apprentice carpenter to William Prince, a locally prominent builder. By 1860, Hammond had formed his own construction company and was building, among other things, several small-scale timber roadway bridges. With John Laird, owner of a local foundary, and Washington R. Reeves, a local metal worker, he developed a combination bridge in which he substituted iron for wood on some of the tension members and connection details. Hammond patented this design, the first in what would be a long series of bridge patents issued to him. In 1862, Hammond was contracted to build an iron bridge over the Middle Branch of Nimishillen Creek in Canton, for $1200. "It was strictly a wrought-iron bridge," stated The American Pictorial Monthly, "made out of bars and bolts." Hammond and Reeves built the 60-foot bridge - their first all-metal span - in an 18'x 30' blacksmith shop using a one-horse power drill.[37]

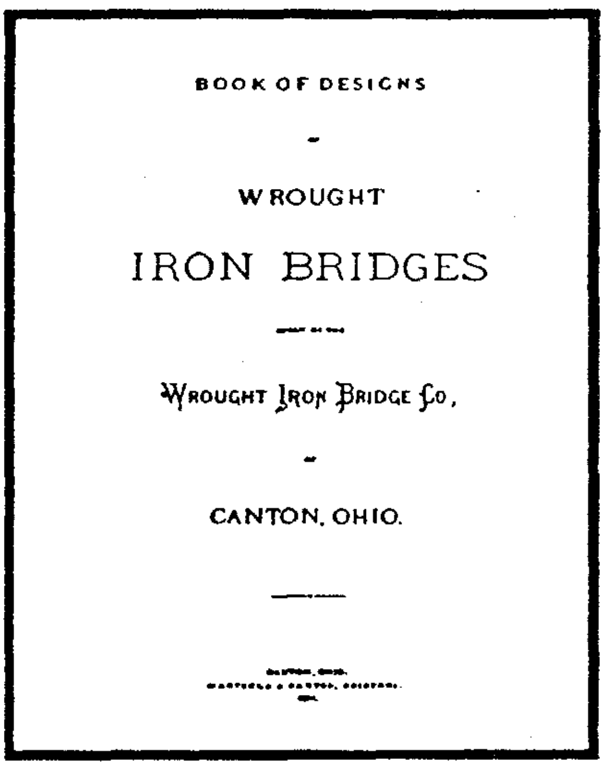
In 1864, Hammond and Reeves formed a partnership to engage in bridge work and general contracting. That year they jointly patented their first bowstring arch-truss design (described in more detail later) and built a small fabricating plant on the Fort Wayne Railroad near the West Branch of Nimishillen Creek. Not satisfied with the small-scale construction undertaken by his partnership with Reeves, Hammond formed the Wrought Iron Bridge Company in 1865 and for the next four years operated both bridge companies from the same facility. As Wrought Iron increased its construction activity, the cramped facilities suffered under the strain. [38]

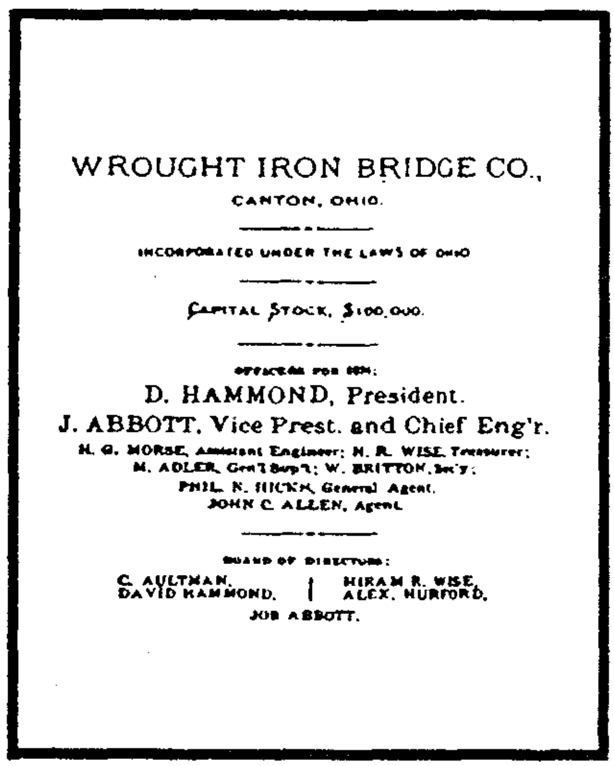
In 1870, Hammond and Reeves dissolved their partnership and Reeves returned to metalworking. Hammond continued to expand his bridge fabrication enterprise. In January 1871, the Wrought Iron Bridge Company was incorporated with an initial capitalization of $106,000.[39] The first officers were Hammond, Reeves and Michael Adler. Later joining Hammond on the board of directors were C. Aultman, Hiram H. Wise, Alexander Hurford and Job Abbott, a patent attorney turned bridge engineer. The company built a new fabricating plant at East Ninth and Saxton Streets, opposite the passenger station of the Fort Wayne Railroad, increasing his production capacity tremendously. Hammond's success throughout the 1870s was phenomenal. In 1871, the company sold 100 bridges worth $200,000. The following year sales had doubled to $400,000, and by 1873 production had increased to a half million dollars.[40] By August 1877, the Wrought Iron Bridge Company employed three hundred men, working around-the-clock to produce the 12,000 feet of iron bridges then under contract.[41] Like most bridge fabricators of the time, Wrought Iron cut and assembled the members for its iron bridges, but did not manufacture the wrought iron. An 1880 account describes the company's operation:

> The material they use in construction of bridges is specifically manufactured for them under the most rigid specifications, as to tensile strength and quality, and is critically tested on its arrival at the shops. Their bridges are built on scientific principals, approved by long and thorough experience, and the utmost caution is excercised in their erection. In all the work they have executed, there has not been a single case of failure or accident, under protracted usage for road travel or excessively trying tests. Such an exceptional record is certainly worth of consideration. Their facilities for accurate and reliable work are unequaled by those of any similar establishment, and enable them to complete contracts with great dispatch.[42]

The Wrought Iron Bridge Company marketed its bridges through the traditional means of solicitation and advertising. The company opened branch offices in several midwestern states from which it fielded general agents. Essentially traveling salesmen, these agents visited with city and county officials in their territories, explaining the company's bridge designs and presenting proposals for competitive bid lettings. The company advertised in national and regional trade periodicals such as Isaac Potter's County Roads (shown in Figure 8). Additionally, it circulated illustrated pamphlets which showed representative examples of its work. In 1874, Wrought Iron printed its "Book of Designs" (shown in Figure 1). This served both as an advertisement for the company and as a pattern book of standardized bridge designs that the company manufactured. The fronticepiece of this illustrated pamphlet tries to dispel the lingering questions regarding the safety and economy of iron and clearly demonstrates who the targeted customers were:

> To County Commissioners and Others:
>
> The large amount of money annually required for the construction and maintenance or railroad and highway bridges, calls for the most careful investigation by all those interested in public economy, as to what means are necessary to reduce this cost of manufacture, and naturally leads to inquiries as to whether iron bridge building will contribute to this result; whether iron bridges have been sufficiently tested to render their adoption no longer an experiment, but a certain success; whether cast or wrought iron should be adopted for bridge work; whether wrought iron, if adopted, will be effected by corrosion or other causes; what the proper capacity of an iron bridge should be; what are the best plans for iron bridges, and what is the best mode of obtaining an iron bridge of proper construction.[43]





[44]

Figure 1

As indicated by the Book of Designs, the primary superstructural type marketed by the Wrought Iron Bridge Company in the 1870s was the bowstring arch-truss made up of wrought and cast iron components. The bowstring was the most commonly erected all-metal bridge of the 1870s, due in large part to Wrought Iron and its main competitor, the King Bridge and Manufacturing Company of Cleveland, Ohio. The first and second largest bridge manufacturers in the country during the decade, both companies fabricated standardized versions of their own patented bowstring designs.

By altering the configuration of the primary arches and suspenders on its bridges, Wrought Iron was able to produce a series of bowstrings covering a range of span lengths from 50 to 350 feet. The shortest bowstring was what Wrought Iron termed a Column Arch Bridge (shown in Figure 2). This bridge, according to the company, "was specially designed for country bridges of moderate spans, and has proved to be remarkably well adapted to such purpose; its moderate cost, great strength and stiffness and neat and ornamental appearance making it much superior to any other arch bridge for short spans."[45] The column arch bridge, intended for spans between 50 and 120 feet, employed a cylindrical wrought iron arch made up of four flanged quarter round segments riveted together. It was a pony configuration - Wrought Iron's only pony arch - with no overhead lateral bracing.

For span lengths ranging from 80 to 140 feet, Wrought Iron designed a Column and Channel, or Column and Thimble, Arch Bridge (shown in Figure 3). The primary arches consisted of four riveted quarter round sections, with two channels inserted on the horizontal axis. "Although designed especially for large spans," the Book of Designs stated, "we have succeeded in adapting it in the most perfect manner, as is attested by the very large number of spans erected by us within the [80-140-foot] limits."[46] By varying the size of the column and channel members, the company could vary the size of the arches from 8-1/2" to 11-1/2" deep and from 11-1/2" to 15-1/2" wide.

Wrought Iron's Column, Plate and Channel Arch Bridge (shown in Figure 4) was designed for spans ranging from 140 to 180 feet. The arches were configured much like the column and channel bridge, with a stiffening wrought iron diaphragm inserted between the quarter round sections. Intended for the span range most commonly specified in county bridge construction, the column, plate and channel arch was Wrought Iron's most popular bridge type.

For longer span bridges, Wrought Iron marketed two other types of bowstrings: the Column, Plate and Channel Arch Bridge (shown in Figures 5 and 6) and the Double Column and Channel Arch Bridge (shown in Figure 7). Although outlined in the Book of Designs, these last two bridge types were rarely erected. The longest column and channel bridge known to have been constructed was a a double-265-foot span bridge built ca. 1874 in Foxburg, Pennsylvania.[47] No double column and channel bridges are known to have been fabricated.

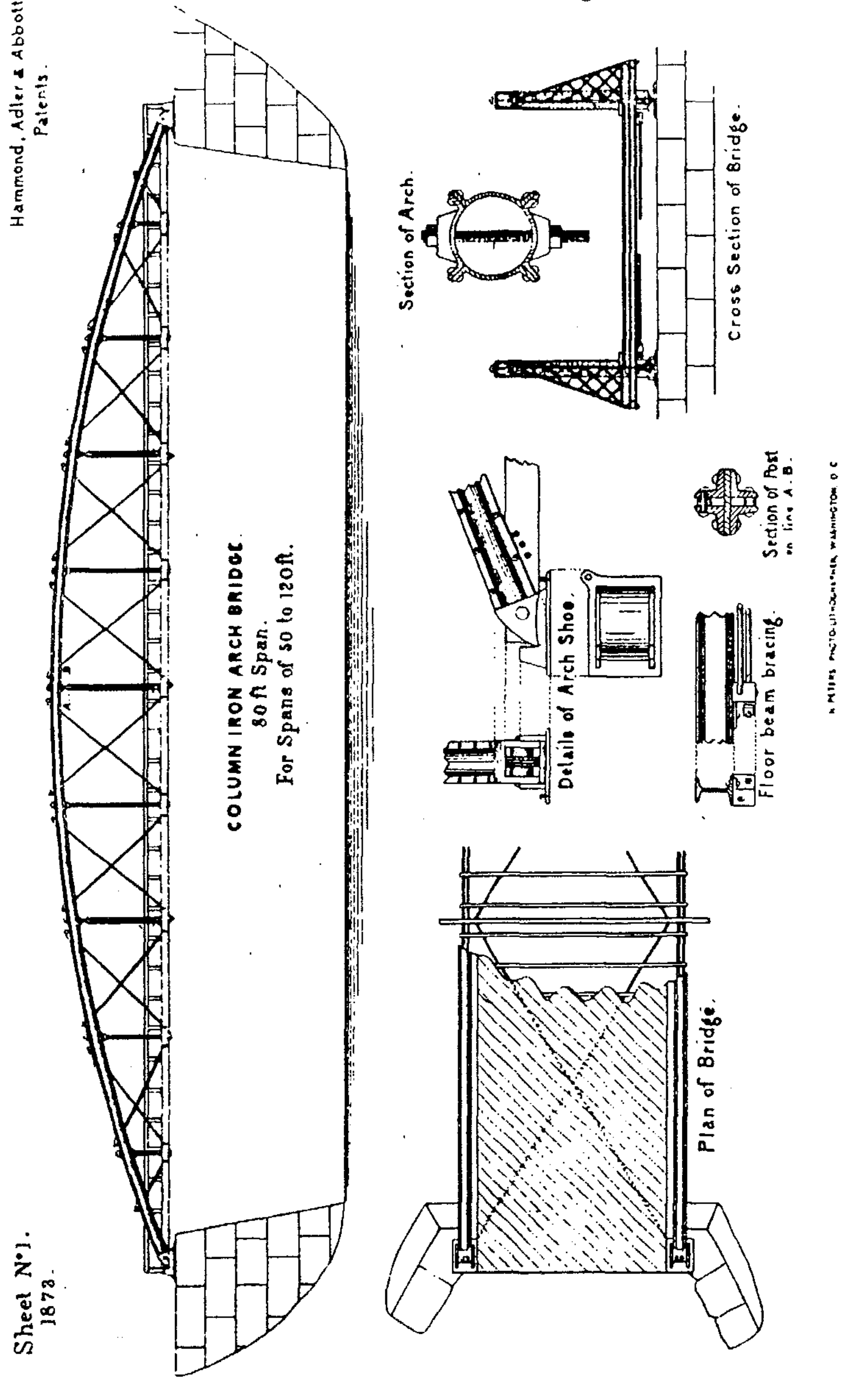

Hammond, Adler & Abbott's
Patents.
COLUMN IRON ARCH BRIDGE.
80 ft Span.
For Spans of 50 to 120 ft.
Section of Arch.
Cross Section of Bridge.
Details of Arch Shoe.
Section of Post
on line A.B.
Floor beam bracing.
Plan of Bridge.
Sheet No 1.
1873.

Figure 2

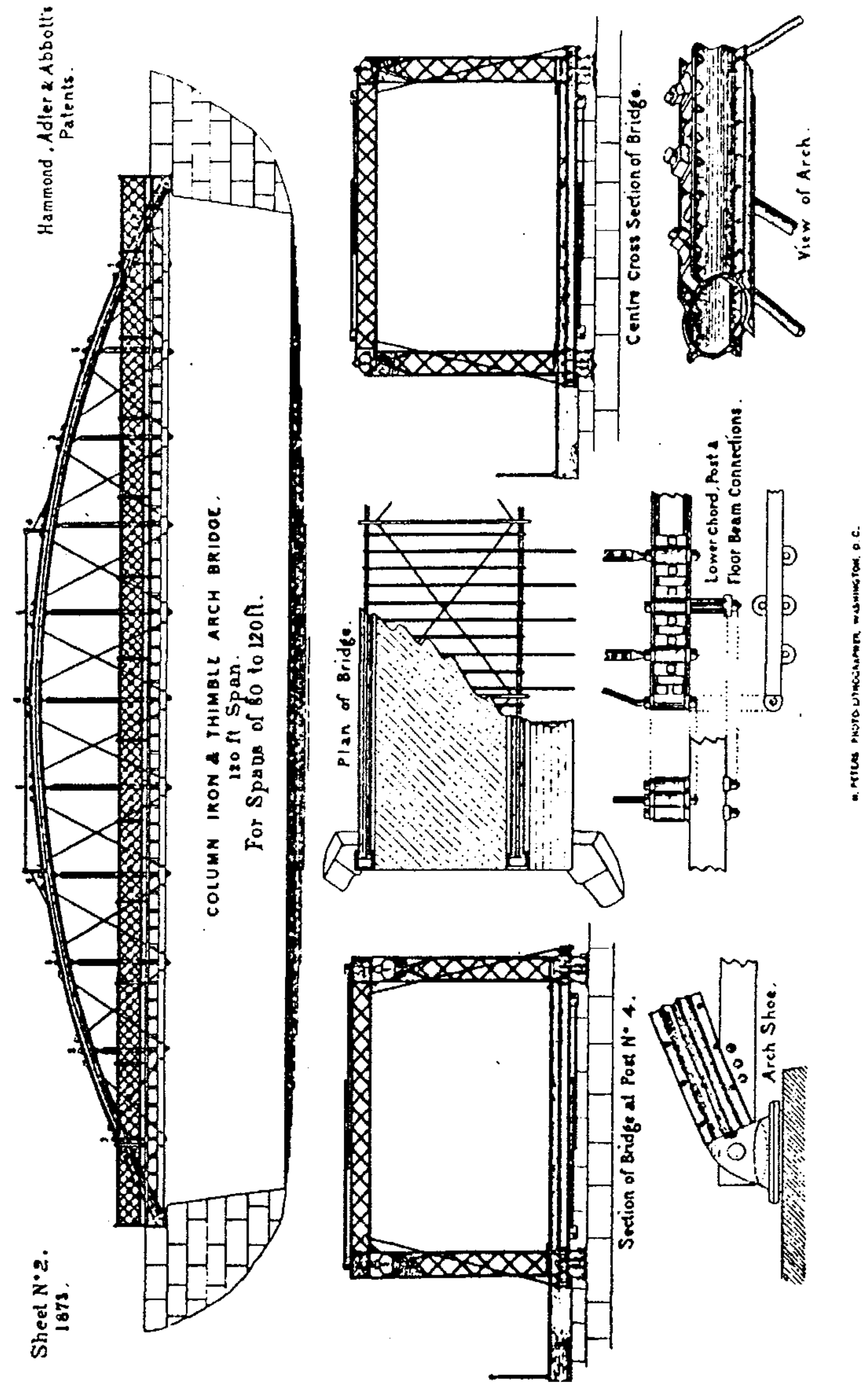

Hammond, Adler & Abbott's Patents.
COLUMN IRON & THIMBLE ARCH BRIDGE.
120 ft Span.
For Spans of 80 to 120 ft.
Sheet No 2.
1873.
Centre Cross Section of Bridge.
View of Arch.
Plan of Bridge.
Lower Chord, Post & Floor Beam Connections.
Section of Bridge at Post No 4.
Arch Shoe.

Figure 3

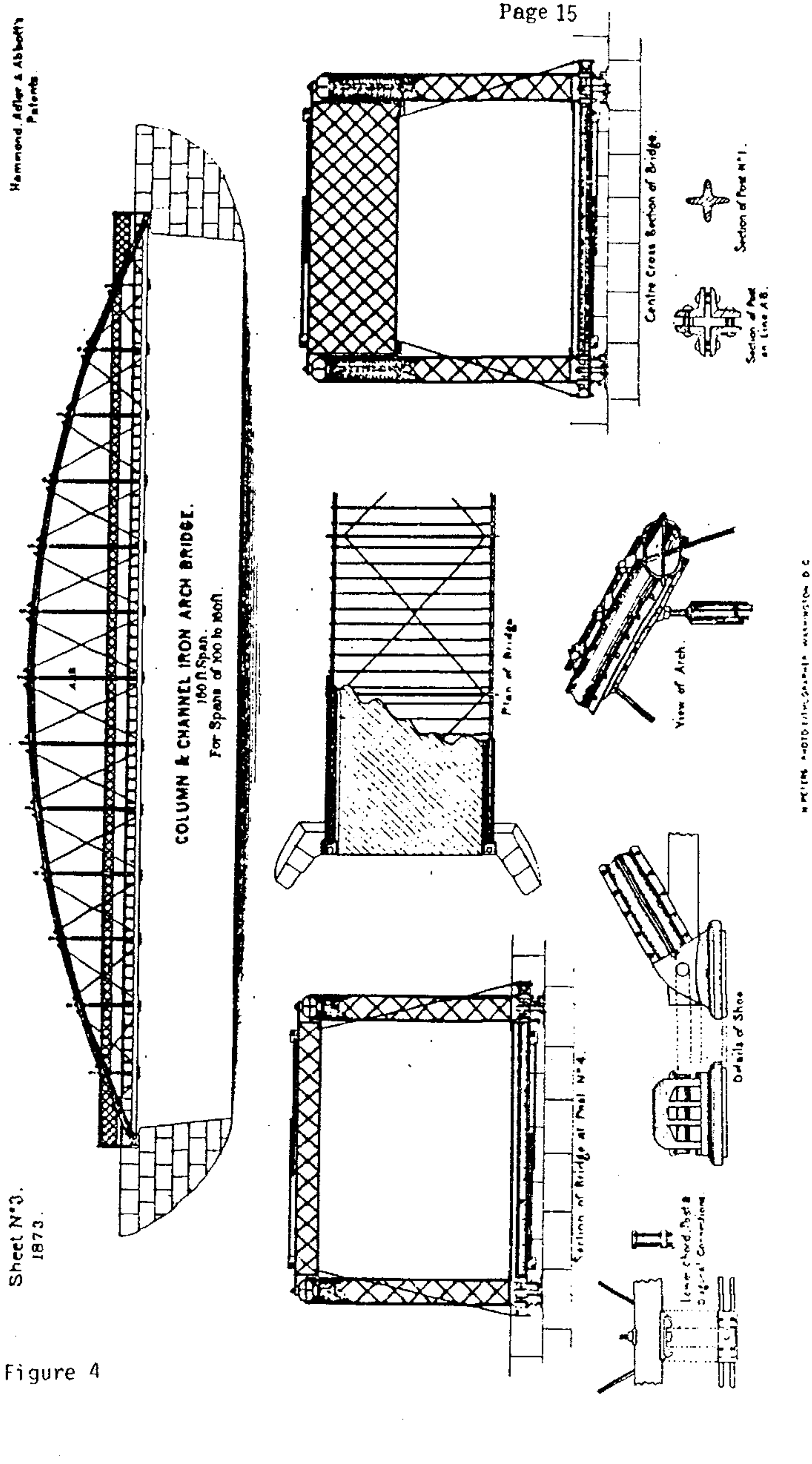

Hammond, Adler & Abbott's Patents
COLUMN & CHANNEL IRON ARCH BRIDGE.
160 ft Span.
For Spans of 100 to 160ft.
Centre Cross Section of Bridge.
Section of Post N°1.
Section of Post on Line AB.
Plan of Bridge.
View of Arch.
Details of Shoe.
Section of Bridge at Post N°4.
Sheet N°3.
1873.

Figure 4

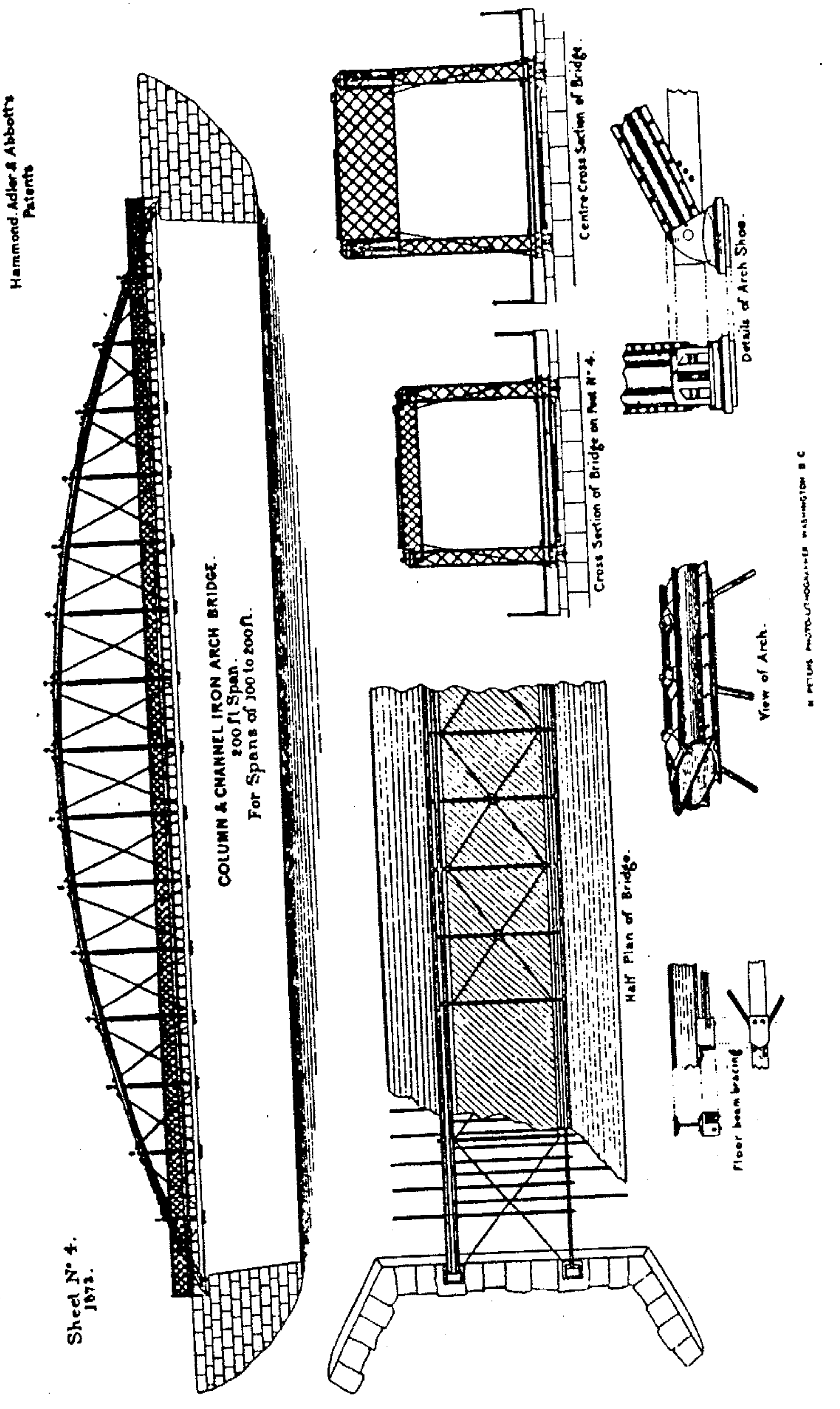

Hammond. Adler & Abbott's Patents
COLUMN & CHANNEL IRON ARCH BRIDGE.
200 ft Span.
For Spans of 100 to 200ft.
Sheet No 4.
1872.
Centre Cross Section of Bridge.
Cross Section of Bridge on Post No 4.
Details of Arch Shoe.
View of Arch.
Half Plan of Bridge.
Floor beam bracing

Figure 5

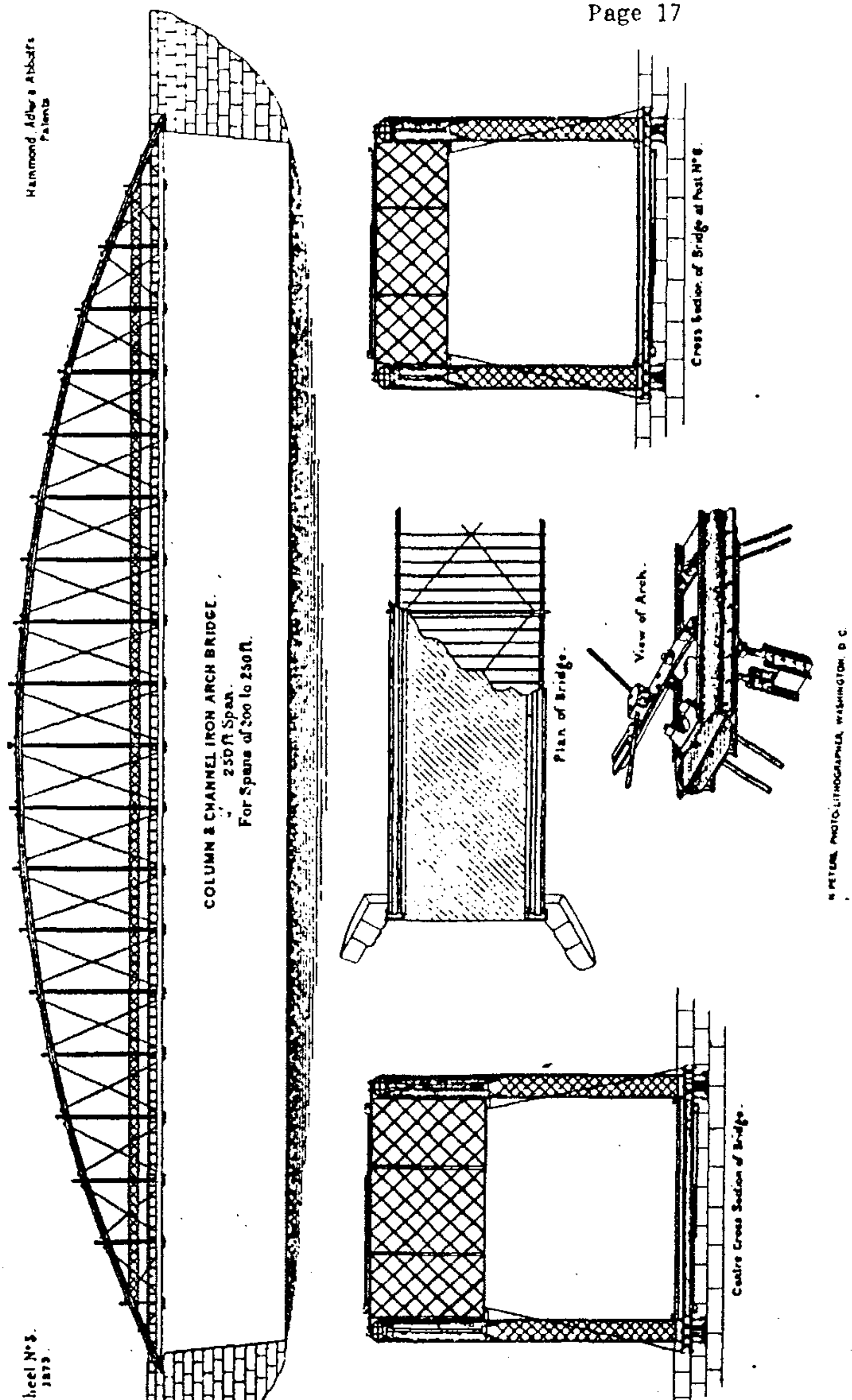

Hammond, Adler & Abbott's Patents
COLUMN & CHANNEL IRON ARCH BRIDGE.
250 ft Span.
For Spans of 200 to 250 ft.
Sheet No. 3.
Cross Section of Bridge at Post No. 8.
Plan of Bridge.
View of Arch.
Centre Cross Section of Bridge.
N. PETERS, PHOTO-LITHOGRAPHER, WASHINGTON, D.C.

Figure 6

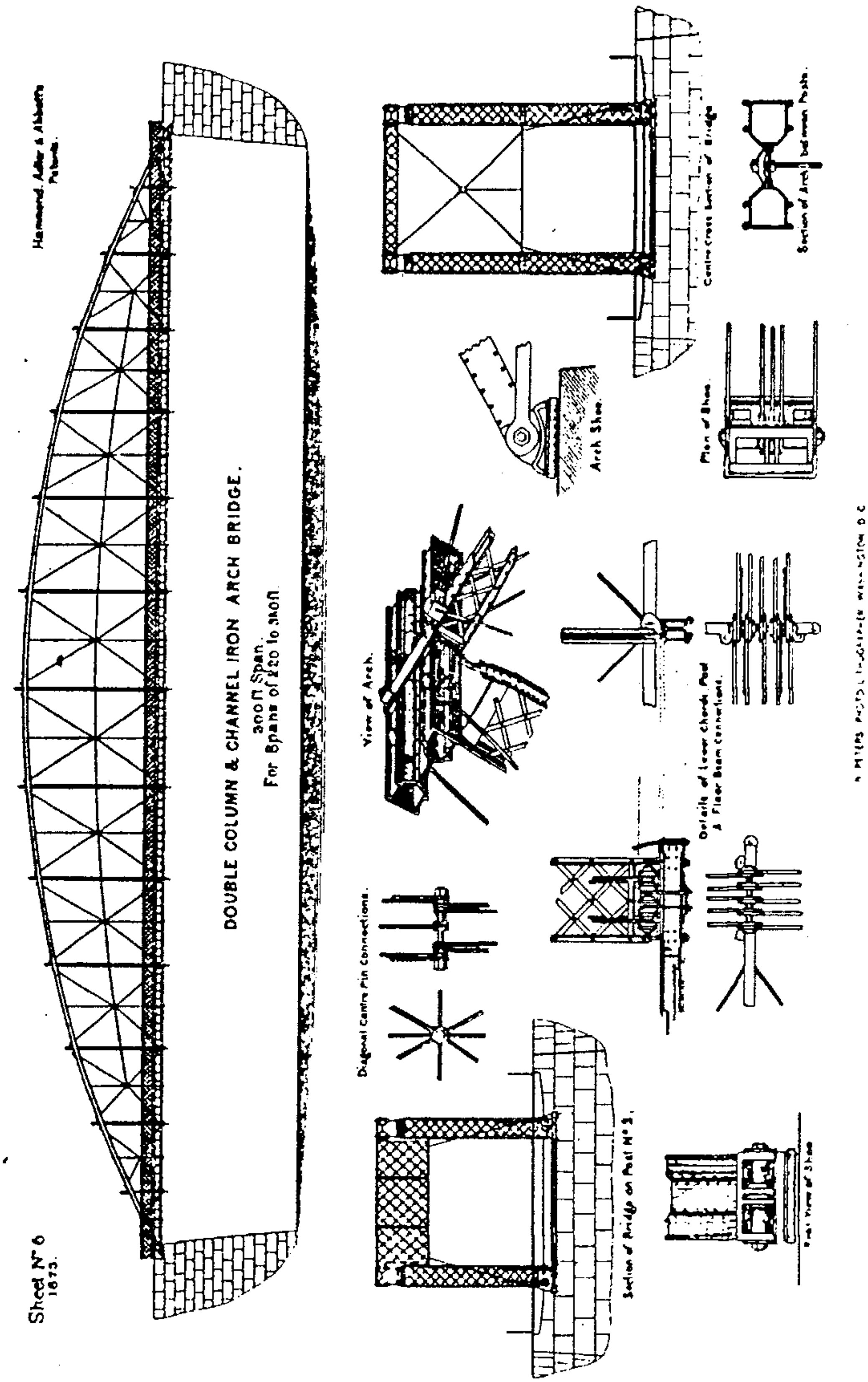

DOUBLE COLUMN & CHANNEL IRON ARCH BRIDGE.
300ft Span.
For Spans of 220 to 360ft
Sheet No 6
1873.
View of Arch.
Arch Shoe.
Plan of Shoe.
Diagonal Centre Pin Connections.
Section of Bridge on Post No 3.
End View of Shoe

Figure 7

WROUGHT IRON BRIDGE CO.

Iron and Steel

BRIDGES, VIADUCTS,

GIRDERS, TURN-TABLES,

Power-Houses, Electric-Light Stations,

STEEL AND IRON ROOFS.

COMMUNICATE WITH NEAREST OFFICE.

Canton, OHIO. 136 Liberty Street, NEW YORK CITY. 1309 Monadnock Building, CHICAGO, ILL.
New York Life Building, Kansas City, Mo.

As the Wrought Iron Bridge Company marketed these bowstring configurations extensively around the country, other bridge fabricators were also erecting and patenting their own bowstrings bridges. Squire Whipple patented his "Iron Bowstring Bridge" in 1841 (Patent No. 2064; 24 April 1841).[48] Like most successful inventions, his bridge design spawned numerous other variations, most of which deviated from his patent just enough to avoid infringement. Over the next thirty-five years, dozens of patents were issued for improvements on Whipple's design. These included such configurations as the triangular wrought iron tubular arch patented by Cincinnati inventor Thomas Moseley (Patent No. 16,572; 3 February 1857), the square wrought iron tubular arch patented by Cleveland inventor Zenas King (Patent No. 33,384; 3 February 1861) and the parallel plate arch patented by Wilmington, Ohio, inventors Johnathan and Zimbi Wall (Patent No. 148,010; 24 February 1874).[49] In his 1874 Book of Designs, Hammond gives a brief history of the early development of iron bridge fabrication:

> The building of highway iron bridges, begun by Whipple in 1846-'50, was carried on to a limited extent until 1861. Moseley [of Moseley and Company, Cincinnati] patented a wrought-iron arch bridge in 1857, and erected several spans in 1858 to 1861; King and Frees [later King Iron Bridge and Manufacturing Company, Cleveland] began building wrought-iron bridges in 1859-'60, and Hammond and Reeves [later, the Wrought Iron Bridge Company, Canton] began building wrought-iron bridges in 1864-66. Wrought iron bridge work for highway purposes has made rapid progress from that date to the present time, almost supplanting cast iron, as was the case

> with railway bridges, and forcing the public to concede its superiority over wood or cast iron, whenever they were brought into comparison. Starting from New York in 1845, iron highway bridges have grown in public favor until they are now found in almost every State in the Union, and even those States, such as Maine, New Hampshire and Michigan, whose facilities for building wooden bridges are unrivalled, are abandoning wooden for iron bridges.[50]

Most of the bowstring patent activity centered in New York - Whipple's home state - and Ohio, among whose inventors David Hammond was the most active. In the 1860s and 1870s, he and his colleagues at Wrought Iron produced more than sixteen different bridge designs.[51] During this period, they were by far the most prolific bridge innovators in Ohio, and on a national level were surpassed by only the venerable Captain James Eads in bridge patents issued. Whipple may have invented the bowstring, but no other inventor in 19th Century America did as much as David Hammond to perfect the form.

Hammond's first bridge, patented with Reeves in 1864 (Patent No. 43,202; 21 June 1864), featured an inverted U-shaped arch made up of three flat iron bars clamped together at regular intervals.[52] His second patent, issued in 1866 (Patent No. 56,043; 3 July 1866), showed an arch composed of two I-beams - termed double-T irons - covered by an iron plate. "The nature of my invention," he stated in the specification, "consists in the novel construction of a wrought-iron arch of double-T iron and novel clamping pieces, and also in the combination of a covering piece which excludes moisture, and also serves to prevent any lateral movement of the arch... whereby I obtain an arch of great strength and simplicity with a comparatively small weight and cost of construction."[53] The accompanying drawing shows a pony configuration, with suspenders improbably oriented perpendicular to the arch, rather than vertical. The arch was evidently intended only for short-span roadway applications. Hammond continued to refine his arch designs and filed revised specifications and drawings for both with the patent office in 1867 and 1869.[54]

In 1869, he patented yet another arch design (Patent No. 86,538; 2 February 1869), presented as an improvement to his 1864 patent, "said improvements consisting, first, in the use of channel or L-iron for the arch-pieces, in the place of the plate-iron there shown, by the use of which we are enabled to firmly rivet the arch-pieces and covering piece together, instead of depending wholly on the clamping-bolts, clamping-pieces and suspension-rods and bracing for the binding of said pieces together, as is the case in our previous patent, whereby we greatly increase the resistance of our arch to any horizontal deflection, and thus greatly increase its strength."[55]

With each patent application, Hammond refined his bowstring design. His fourth bridge patent, issued in April 1870, delineated for the first time the tubular arch configuration which would later become the trademark for the Wrought Iron Bridge Company. In this patent (Patent No. 102,392; 26 April 1870), Hammond described three Phoenix-tube wrought iron arches roughly equivalent to his later column arch, column and channel arch and column, plate and channel arch. The result, Hammond asserted in the specification was "a tubular arch of great strength and stiffness, which admits of a very economical distribution and proportion of material to any required case of construction." [56]

Clumsy though it looked, this was the direct predecessor to Hammond's fifth and final arch bridge patent. Issued in February 1873, this patent (Patent No. 135,802; 11 February 1873) was the basis upon which the Wrought Iron Bridge Company fabricated thousands of bowstring bridges across North America in the 1870s. The specifications described a series of bowstring arch-truss designs which used Phoenix tubes for the primary arches. Although his preceding patent specifications and accompanying illustrations were relatively brief, Hammond describes in lengthy and painstaking detail every aspect of this series of bridges. Significantly, this patent was the first to delineate an extremely long-span (up to 350 feet) bowstring through design.

One particular technological issue that Hammond and the others sought to address with their patents was the inherent lateral instability of the bowstring arch-truss. "It is well known to bridge constructors," Hammond stated in 1873, "that the principal defect in the practical working of bow-string girders as heretofore constructed, especially in long spans, has been their want of stiffness to resist the action of a rolling load." [57] Live loads placed on the bridge deck are transferred to the floor beams and then to the verticals, which are suspended from the primary arches. The tensile force of the suspenders tends twist the compression arches sideways, especially if the load is applied with any eccentricity from the neutral axis of the arch. This is countered in most arch patents by the installation of overhead struts to tie the two primary arches together and make a rigid structure. The arch's curved configuration, however, makes placement of these struts impossible in the outer panels, necessitating an extremely rigid arch construction to overcome the twisting action. For all but his short-span arches, Hammond specified tubular arches that were stronger laterally than they were axially. For his longest spans (between 220 and 360 feet), he actually doubled the tubes and connected them with a continuous solid web to create an immensely rigid frame. [58]

The counties and municipalities of Iowa were among the best customers of the Wrought Iron Bridge Company. The period of extensive rural road and bridge construction in the state during the 1870s coincided with Wrought Iron's ascendance in the industry, combining to create a booming market for the bridge company's regional sales representatives. Winneshiek County's almost exclusive relationship with Wrought Iron may have been an extreme case. (Other bridge companies such as the King Iron Bridge Company of Cleveland also marketed heavily in eastern Iowa during this period, and bridge superstructure contracts were let primarily on the basis of cost, not company.) Nevertheless, the

Wrought Iron Bridge Company was extremely active in the region. In 1874, Wrought Iron listed several of its recently erected bowstrings in Iowa. Winneshiek County bridges are indicated by an asterisk:

Sidney	85-foot span;	12-foot roadway	Column Arch
Shenandoah	42-foot span;	12-foot roadway	"
Hall's Mill	90-foot span;	16-foot roadway	"
Columbus Junction	95-foot span;	16-foot roadway	"
Watson's Ford	75-foot span;	12-foot roadway	"
*Fort Atkinson	84-foot span;	16-foot roadway	"
Ridgeway	70-foot span;	16-foot roadway	"
Red Oak Junction	100-foot span;	18-foot roadway	"
Orford	113-foot span;	14-foot roadway	Column and Channel Arch
Chelsea	140-foot span;	14-foot roadway	"
Quasketon	125-foot span;	16-foot roadway	"
Fairbanks	145-foot span;	16-foot roadway	"
Nora Springs	120,125-foot spans;	16-foot roadway	"
Independence	(2)145-foot spans;	18-foot roadway	"
Cedar Falls	(3)115-foot spans;	16-foot roadway	"
Keosauqua	(4)151-foot spans;	16-foot roadway	"
Cedar Rapids	(6)120-foot spans;	18-foot roadway	"
Watsell's Ford	140-foot span;	16-foot roadway	"
*Decorah (Gillece)	104-foot span;	16-foot roadway	"
Nora Springs	115-foot span;	16-foot roadway	"
Springville	153-foot span;	16-foot roadway	"
Palo	85-foot span;	16-foot roadway	"
Marshalltown	100-foot span;	16-foot roadway	"
*Decorah (Plymouth)	130-foot span;	15-foot roadway	"
*Decorah (Drake)	130-foot span;	17-foot roadway	" [59]

In 1877, the company built a six-span iron bridge, with a total length of 960 feet, at Columbus Junction in Louisa County. This was Iowa's longest highway bridge to date.[60] As Winneshiek and other counties continued to purchase arch and truss superstructures from Wrought Iron, the aggregate length of the firm's spans in the state accumulated. By 1885, David Hammond's company had installed 21,600 feet of bridges in Iowa: almost equaling the total output by the company across the country in its first nine years. Only New York, Ohio, Indiana and Illinois had purchased more structures from Wrought Iron.[61]

That year, David Hammond's bridges could be found in 41 of the state's 99 counties.[62] Although these were distributed in all areas of Iowa except the northwest corner, Wrought Iron's strength clearly lay in the eastern part of the state. Over 70% of the counties in which Wrought Iron's bridges had been installed were east of Des Moines, and almost 60% were east of Waterloo. One particular stronghold for the company was the northeast tier of counties.

Winneshiek, Howard, Chickasaw, Floyd, Mitchell, Fayette, Clayton, Buchanon, Delaware and Dubuque Counties had all bought bridge superstructures from Wrought Iron in the 1870s and 80s. Allamakee County remained the only holdout.[63] Iowa's list of Wrought Iron's bridges in 1885 included the following structures (Winneshiek County bridges indicated by an asterisk):

Shell Rock, Butler County	(3) 85-foot spans;	17-foot roadway
Mitchell, Mitchell County	(2)128-foot spans;	16-foot roadway
Osage, Mitchell County	(2)240-foot spans;	16-foot roadway
*Decorah, Winneshiek County (Twin)	(2)116-foot spans;	16-foot roadway
Black Hawk County	(3)150-foot spans;	16-foot roadway
Center Grove, Dubuque County	96-foot span;	16-foot roadway
Waterloo, Black Hawk County	155-foot span;	16-foot roadway
*Decorah, Winneshiek County (Bluffton)	116-foot span;	16-foot roadway
Webster City, Hamilton County	150-foot span;	16-foot roadway
Palo, Linn County	(2)165-foot spans;	16-foot roadway
Paris, Linn County	160-foot span;	16-foot roadway
Ivanhoe, Linn County	(2)130-foot spans;	16-foot roadway
Stone City, Jones County	115, 117-foot spans;	16-foot roadway
Rochester, Cedar County	(4)151-foot spans;	16-foot roadway
Pine Mills, Muscatine County	96-foot span;	16-foot roadway
Jackson, Adair County	84-foot span;	16-foot roadway
Rockford, Floyd County	260-foot span;	16-foot roadway
Fremont County	102-foot span;	14-foot roadway[64]

Despite its frequent expansion of facilities, Wrought Iron's tremendous workload in the mid-1870s caused the company occasionally to fall behind on its fabrication schedule. This in turn created problems for the customers as contracted bridges waited for completion. Winneshiek County experienced such delivery problems with the Wrought Iron Bridge Company in 1875. "Owing to the failure of the Iron Bridge Co's. in fulfilling their contracts on time," George Winship complained in January 1876, "We are compelled to postpone grading and finishing our abutment walls until spring on a number of bridges. In fact there are but two of our Iron bridges erected in 1875 that is [sic] entirely completed."[65]

Since its formation in 1871, George Winship had not only chaired the bridge committee for Winneshiek County, he constituted it completely. But with the duties of being a one-man committee came the inevitable complaints from a disgruntled constituency. In an 1875 presentation to the board he defended himself against his critics, saying: "In making contracts and superintending the bridge work for the past year, I am not aware that I have assumed any authority not delegated me by the Board. I have endeavored to carry out your orders to the best of my ability, and although I may have been the most abused man in Winneshiek County, I am conscious that no duty has been imposed upon me that is not performed."[66]

In April 1876, the board again nominated George Winship to be the bridge committee, as he had throughout the preceding five years. The pressure and criticism that had mounted over the preceding years finally overcame his interest in bridges, however, and this time he refused. "Thanking you for your preference," he stated, "I, at the same time, positively decline to act as committee on Bridges, and ask as a personal favor that the motion be withdrawn, as forcing the office upon me without my consent will involve my resignation."[67] Taken aback, the other board members promptly withdrew the motion and offered the following extemporaneous resolution:

> Resolved, that we express to G.C. Winship our appreciation of his long and efficient service as bridge committee. The management of the details of our bridge matters by him during his terms of service as such committee has been marked by prudence, honesty and efficiency, and we hereby tender him our thanks for such service and express our regret at his refusal to longer serve in such capacity.[68]

In Winship's place, three members of the board - supervisors Brittain, Morton and Callender - formed the new bridge committee, to serve until the following January.

Despite his abrupt resignation, Winship remained active in county bridge matters as a supervisor. In January 1877, he was elected chairman of the board. With only a $1917.49 balance in the bridge fund, the county began the new year as it had years past: chronically short of money. Winship directed the bridge committee in April to build and repair only those bridges that were absolutely necessary, but "in no case are they to exceed the amount of bridge revenues for the current year."[69] The self-imposed moratorium would not last long, however, as urgent petitions for road and bridge improvements continued to come in from around the county. One of these petitions presented that month was from G.V. Punteney requesting a replacement bridge for the timber structure over the Upper Iowa River at Plymouth Rock, in Fremont Township.

Fremont Township forms the northwesternmost division within Winneshiek County. Covering twenty-eight square miles, the area is characterized by undulating hills, overlaid with dense hardwood forests, with steeper bluffs found in the central part. The Upper Iowa River meanders through the center of the township, as described by a 1905 Atlas of Winneshiek County:

> The Upper Iowa River runs southeasterly through the township, entering near the northwest corner of Section 7, and pursuing a winding course to the southeast, leaving the township on the south line of Section 35 and returning at near the southeast corner of Section 36. The river is clear, rapid, and in its winding descent affords numerous favorable mill sites. The banks are skirted by forests of a great variety of deciduous trees, except here and there where the land has been cleared for farming purposes. Here and there upon the bluffs on the eastern and northern side of the stream are clusters and large groves of pine, spruce and cedar, some of it having been utilized in the early days of settlement for building purposes.[70]

Settlement in Fremont Township coincided with the rest of the county in the early 1850s. The region's economy was typically based upon subsistence agriculture. Wheat was the primary cash crop. Throughout much of the 1850s, the market for the this was McGregor, Iowa, but by the late 1860s two water-powered mills had been built along the river within the township. One of these was constructed in 1868 in a nascent settlement called Twin Springs by S.G. Kendall, an 1860 immigrant to Iowa from Mississippi. The settlement's name was immediately changed to Kendallville, as Kendall's mill formed the nucleus for what would become the largest community in the township. The other mill spawned a settlement which would become known as Plymouth Rock.[71]

Plymouth Rock was a small crossroads community in the southeast corner of the township, located along the Upper Iowa River on the road between the larger towns of Bluffton and Kendallville. The unincorporated community had begun as early as 1852, when the river was dammed for a mill site. The following year, before the land was surveyed for the official section line delineation, Selden Carter constructed a sawmill along the west bank of the Upper Iowa, alongside the diversion dam. When Carter's Mill was later closed and dismantled, a flour mill was erected on the sawmill site by Mattock, Kelly and others. Mattock and Kelly subsequently sold their interest in the property to the Bean Brothers, with S.G. Kendall holding partial interest. The Beans operated the mill profitably for several years before closing in insolvency after the wheat crop failed in successive seasons. G.V. Punteney acquired the mill and was operating it successfully in 1877.[72]

In September 1855, a small town was platted and several houses built beside the mill on the relatively level west bank of the river. Fifteen lots laid out within two elongated blocks initially constituted the settlement. These were oriented toward two north-south streets named Main and River. East-west Ford Street formed the southern boundary. In the late 1870s, the population of the settlement hovered around thirty. During that time a half dozen residences, a small frame schoolhouse and a general store operated by L. Wanless constituted Plymouth Rock. The small community was bounded on three sides by a half-mile bend in the river, and by 1877 the Upper Iowa had been bridged in two locations near Plymouth Rock along the east-west Kendallville-Bluffton Road. The Upper Plymouth Rock Bridge crossed the river along about one-half mile west of the community. The Lower Plymouth Rock Bridge crossed the river on the south side of town, at the end of Ford Street. As the instigator of the petition for a new bridge at the Lower Plymouth Rock crossing, Punteney would benefit greatly by the erection of a substantial new structure at this location.

An important crossing at the northwest corner of the county, the first bridge over the Upper Iowa at Plymouth Rock had been built as early as 1866. In January of that year one hundred voters signed a petition asking the county to appropriate $2,000 for a new bridge. The board responded by laying the matter over to the next meeting, saying: "In view of the late appropriation for a bridge near that point [at Kendallville], and the present state of the bridge fund, we beg leave to refer the petition back to the House, suggesting it might be well to appoint 1 or 3 members of this Board Commissioners to examine said location and report at the next meeting of the Board."[75] Apparently the bridge was completed that year.

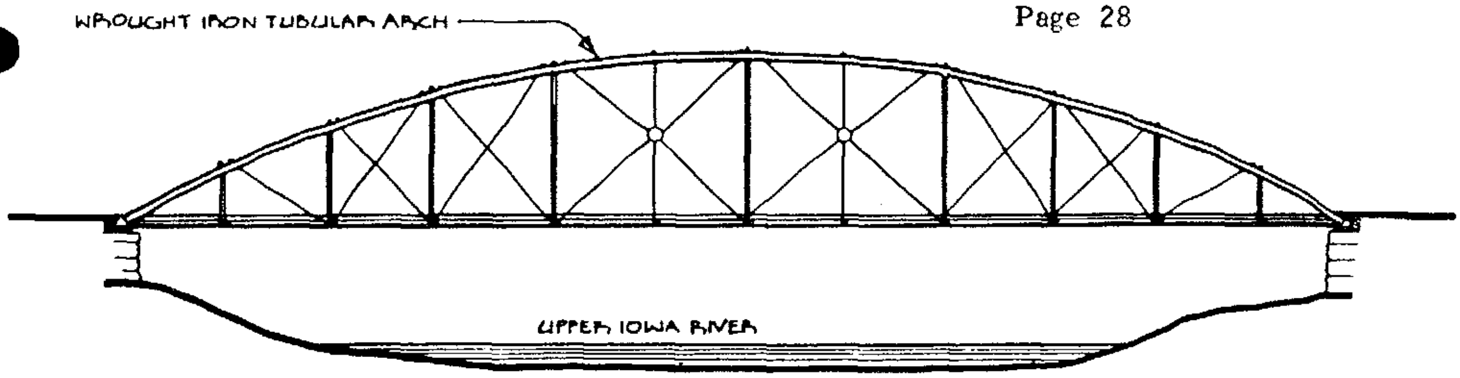
The Lower Plymouth Rock Bridge suffered from the same structural drawbacks as the dozens of other small-span timber bridges in the county: it required frequent repair to the deck and the substructure to keep it serviceable. In late 1872, another citizens' petition presented to the board requested that a replacement bridge be built. The board would commit only to a substructural renovation of the bridge and directed the bridge committee (George Winship) to procure materials to build icebreakers on the piers and abutments as soon as practical. These were installed early the next year, costing $42.10 for timber, iron, stone and labor. The county made more repairs in 1874. No major repairs were made to the bridge in 1875 and 1876. Repairs in early 1877 had cost the county $15.00.[76]

By the spring of 1877, the Lower Plymouth Rock Bridge had deteriorated to an unsafe condition. In response to Punteney's urgent petition in April, the three-man bridge committee inspected it and the Old Mission Bridge over the Turkey River in Washington Township. Both structures were among the oldest and most heavily trafficked crossings in the county. Both required either extensive repair or replacement. The committee opted for the latter, directing the county clerk to issue advertisements and solicit competitive proposals from several regional bridge companies for the two spans. Typically, the clerk specified only the locations and span length for the proposed structures and required each individual bridge contractor to provide the design of the superstructure with its cost proposal. The construction for each bridge would be let in two separate contracts entailing superstructural and substructural work. The county's minimal specifications for the Old Mission Bridge called for a 74-foot span; the Lower Plymouth Bridge would span 130 feet.[77]

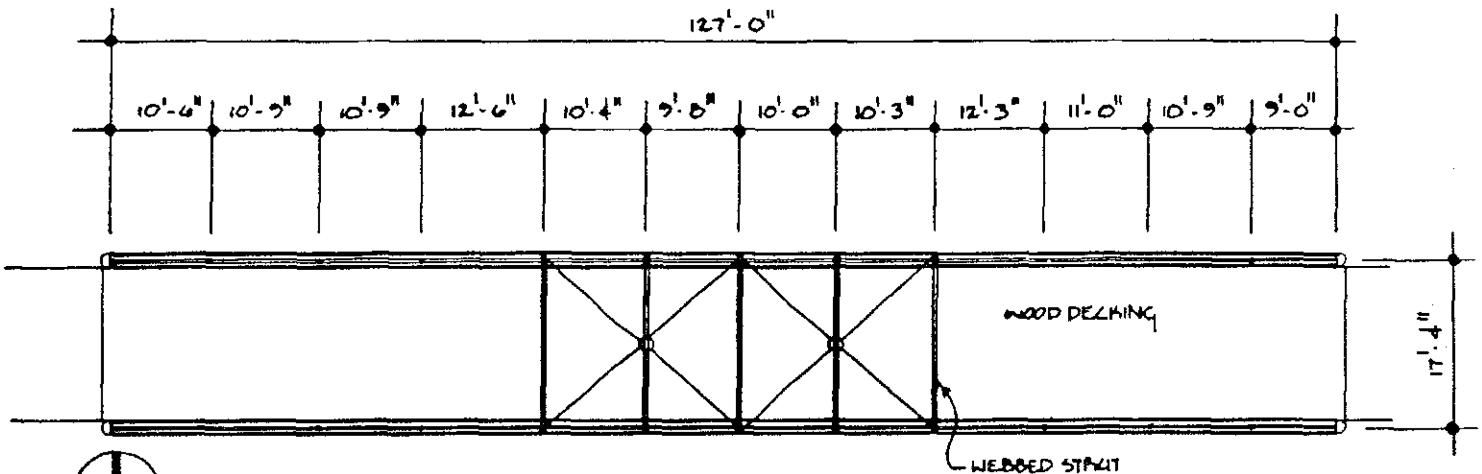
On the afternoon of Thursday, June 15, board chairman George Winship and board members P. Morton, H. Giesen, T. Callender and O.W. Ellingson met to consider the plans and specifications submitted by several bridge companies for the two bridges. Although the men spent the entire afternoon discussing the proposals, they could not arrive at a decision. The board reconvened the following morning to review the proposals again. Before noon they had awarded the construction contracts for the superstructures of the two bridges to the Wrought Iron Bridge Company, an unsurprising decision in light of the county's past relationship with the Canton-based bridge fabricator. With bids of $2600 for the Lower Plymouth Bridge and $1091.50 for Old Mission, the Wrought Iron regional sales representative had proposed his company's patented bowstring arch-truss for both spans, similar to those his company had erected elsewhere in the county. The Old Mission Bridge would be a "Column Iron Arch Bridge," Wrought Iron's shortest and only pony-type bowstring span configuration. The Lower Plymouth Bridge would be a "Column, Plate and Channel Arch Bridge" - Wrought Iron's most commonly fabricated arch type - designed for spans ranging from 140 to 180 feet.[78]

The Lower Plymouth Rock Bridge (Winneshiek County Bridge #154) features standardized Wrought Iron Bridge Company configuration and detailing, straight from the company's current book of designs. With a span length of 128 feet and an overall length of 130 feet, it is subdivided into twelve unequal panels, ranging in width from 9'8" to 12'6". The roadway width is nominally 16 feet (actually 15'8"), with a vertical roadway clearance of 12'8". The arches are 17'4" high, from bearing end to midspan. Despite mass production of the wrought iron components, the bridge contains noticeable variations in panel width and vertical height dimensions. (See Figure 9).

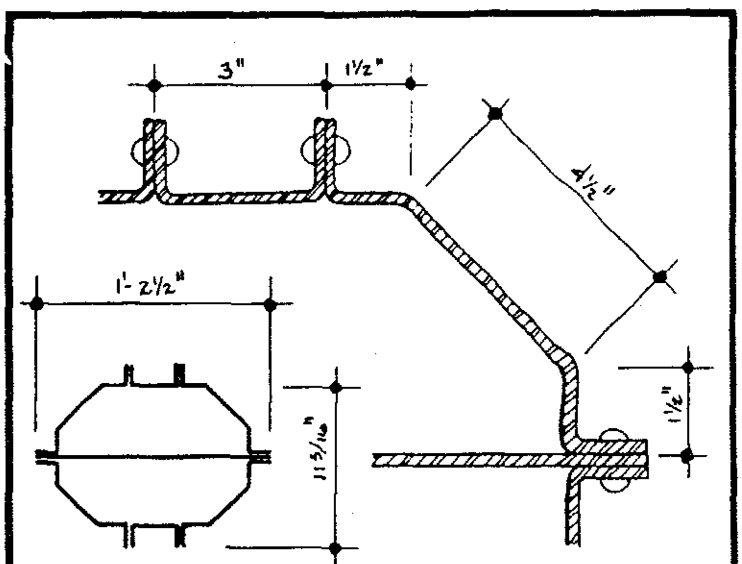
The most distinctive features of the bridge are its two primary arches. Like all of Wrought Iron Bridge Company's bowstrings of the 1870s, these employ a patented, Phoenix built-up construction, composed of several wrought iron components riveted into an octagonal tube. "The arches of this bridge," the company stated in its 1874 brochure, "are composed of four column segments and two channel bars, riveted together with six rows of rivets, and between the upper and lower halves of the arch at its ends, there are riveted plates of iron of the full width of the arch." The corner column segments are made of 1/4" wrought iron plate, formed into 5-5/8" quarter round sections. The two 1/4" iron channels measure 3"x 1-3/4". The continuous stiffening diaphragm



SOUTH ELEVATION SCALE: 1/4" = 1'-0"



PLAN SCALE: 1" = 20'-0"



ARCH DETAILS NOT TO SCALE

HAER No. IA-18

LOWER PLYMOUTH ROCK BRIDGE

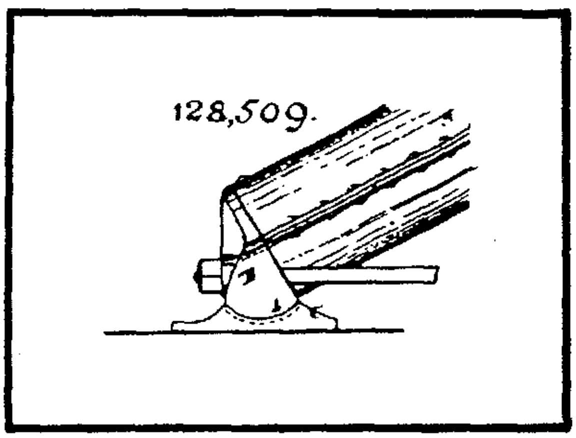
WINNESHIEK COUNTY IOWA

CLAYTON B. FRASER JANUARY 1986

Figure 9

is also made of 1/4" wrought iron plate. With an overall width of 14-1/2" and a height of 11-5/16", the arch possesses greater lateral than axial strength. This reveals the Achilles' heel of the bowstring arch-truss: poor lateral stability of the primary arches, particularly in the outer panels, where struts cannot be installed. "The great lateral stiffness of the arch will be evident from examining the cross section," the company stated in its Book of Designs, "and the addition of the middle plate at the ends of the arches gives just the proper increase of cross section and lateral stiffness to make the ends of the arch as stiff as the central portion, which is held against lateral bending by the overhead lateral trussing." [79]

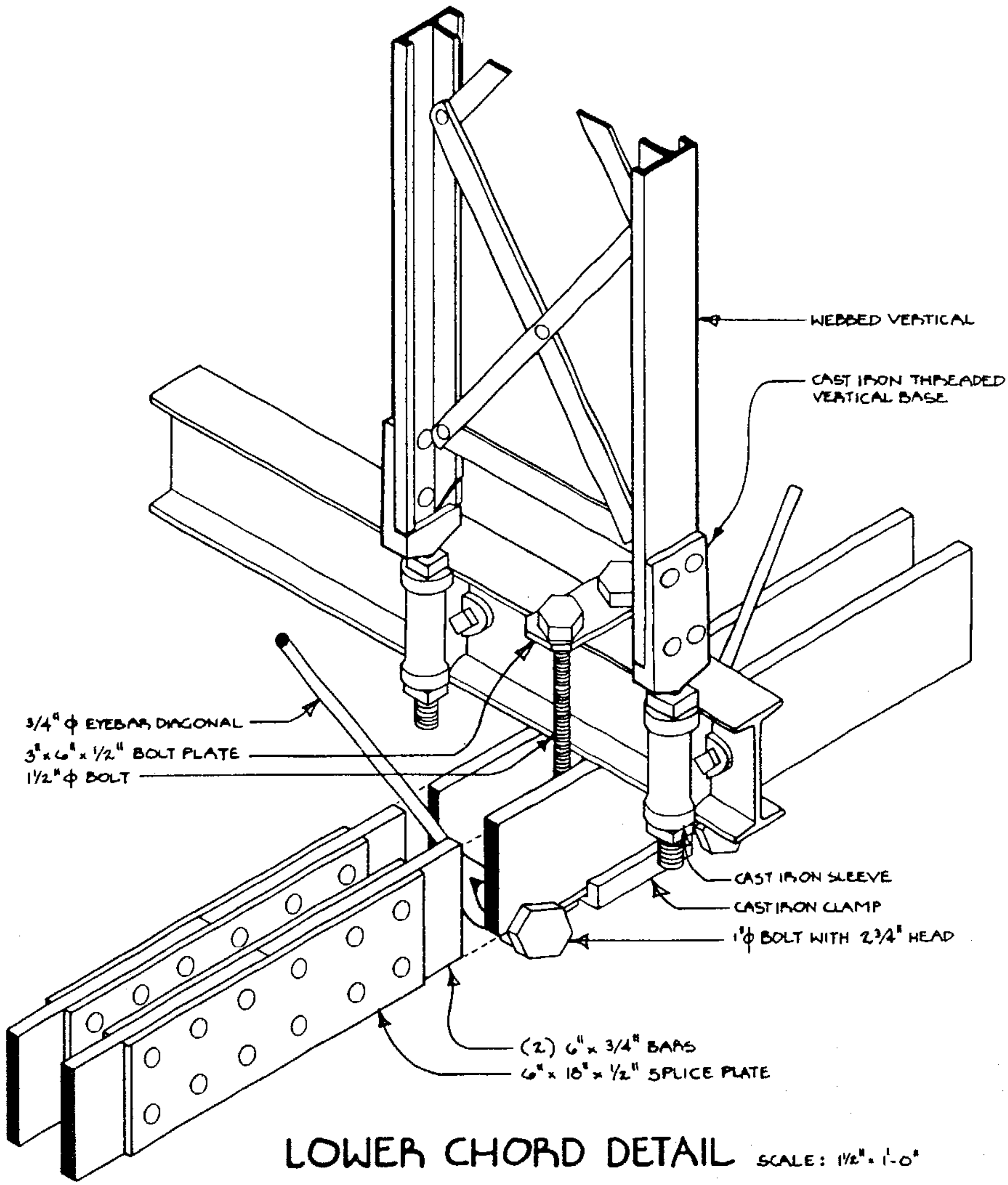
At the four bridge bearing points, the arch ends are fitted to heavy cast iron skewbacks, similar to those patented in 1872 by William B. Rezner of the Cleveland-based Ohio Bridge Company (Patent No. 128,509; 2 July 1872, shown in Figure 10). These skewbacks have curved lower edges which nest on the curved upper surfaces of cast iron bearing shoes. The shoes are fixed by anchor bolts to the stone abutments on both sides of the bridge. Expansion and contraction of the arches is compensated for by the sliding of the curved skewbacks over the base shoes.



[80]

Figure 10

The lower chords of the bridge consist of two parallel, rectangular 6"x 3/4" bars spaced 2-3/4" apart. These extend continuously through the panel point connections with the floor beams and verticals (shown in Figure 11). The 25'6" long bars are spliced in four locations along the bridge's length using riveted overlaps. The bar ends at the corner bearing shoes have been forged and threaded to accept a hexagonal end nut. These ends pass through slots in the arch skewbacks and are bolted to elliptical castings, which slide as the skewback tilts during expansion and contraction of the arches.



LOWER CHORD DETAIL SCALE: 1 1/2" = 1'-0"

HAER No. IA-18

LOWER PLYMOUTH ROCK BRIDGE

WINNESHIEK COUNTY IOWA

CLAYTON B. FRASER JANUARY 1986

Figure 11

Two types of vertical suspenders are used on alternating panel points of the bridge. The first, what Wrought Iron termed an angle crusher, consists of four 1-1/2"x 1-1/2"x 1/2" angles tied with spacer rivets into a cruciform shape. The other, a lattice column, consists of two 3-1/2"x 1-3/4"x 1/4" tee-shapes with 1-1/4"x 1/4" wrought iron webbing riveted between. These wrought iron tees feature pronounced fillets and small returns on the flanges, like serifs on a T. Their web has been formed asymmetrically with respect to the flange, which allows the moment of inertia to coincide with the exact centerline of the assembled column. This column type is a derivation of a wrought iron post configuration patented by David Hammond in 1876 (Patent No. 184,521; 21 November 1876). Titled an "Improvement in Wrought Iron Posts," Hammond's patent detailed the of the wrought iron asymmetrical tees, which were to be used in lieu of paired iron angles.[81]

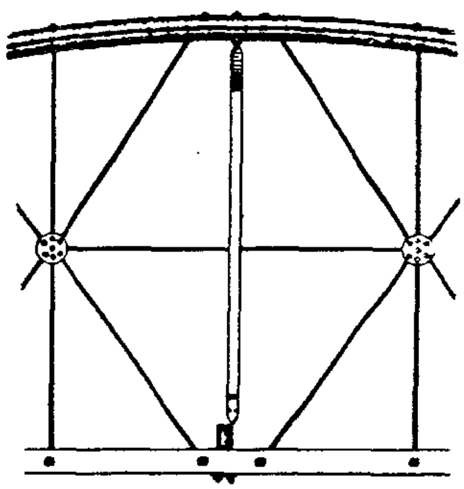
Cast iron caps are riveted to both types of verticals to attach them to the tubular arches. The threaded shaft of each of these caps passes through a hexagonal nut and a cast iron skewback on the arch bottom, through a hole drilled in the arch and through another skewback and two more hexagonal nuts on the upper face of the arch. Similar threaded castings are riveted to the ends of the tees on the bottoms of the lattice columns. These are bolted to castings, which in turn are bolted alongside the webs of the floor beams.

An 1874 Wrought Iron Bridge Company brochure described its patented method of arch bracing:

> The Straight Lattice Brace Posts are used in spans of 100 ft. and over, and are secured to the arches as before shown [using threaded caps through cast iron skewbacks], while the bolts at their lower end run through thimbles on the sides of the brace beams, where they are secured by jam nuts. The brace beams are fastened to the chords by a bolt at each side passing through a cross plate above the beam, and down between the chords with washer and nut below, and the Side Tension Rod runs from a thimble at the end of brace beam across the post to the Top Lattice Girder, so that the Brace Post acts as a rigid lattice girder between the brace beam and arch, and also forms a crushing post to act with the side rods against side motion, both features being patented by us and used only in our bridges, and forming the most perfect system of side bracing ever used on an arch bridge.[82]

Each 3/4" diameter eyebar diagonal is connected at the lower chords by two forged straps. These 1" wide iron straps are secured between the bottom of the lower chord eyebars and the floor beams by bolted cast iron clamps. "As [the diagonals'] size is such in this length of span," the company stated, "as to make it impracticable to properly secure them to the chords by a through bolt, without wasting the chord section, this connection is made by our combined Wrought Hitch Plate, whieh consists of a wrought iron plate having its ends slotted and turned over, like the ends of a strap hinge."[83] In their upper connection with the arch, the diagonal braces have been inserted through slots cut in the arch bottom, passed through cast iron skewbacks on the top surface of the arch and threaded into hexagonal nuts, like the verticals.

184,490. METALLIC ARCH-BRIDGES. Job Abbott, Canton, Ohio, assignor to Wrought Iron Bridge Company, same place. (Filed Aug. 19, 1876.)



1. The connection of the diagonal ties in a panel of a bow-string arch-bridge with each other, and with the arch and chord of said bridge at their intersection, substantially as and for the purpose specified.
2. The attachment of the center of an arch-post with the connection of the diagonal ties at their intersection, substantially as and for the purpose specified.

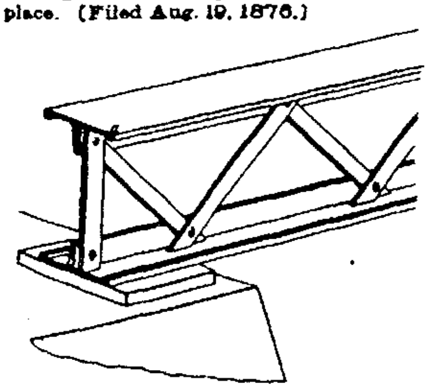
[84]

Figure 12

The diagonal ties connect with the upper and lower chords in each panel, forming the distinctive x-pattern on the web. They span two panels on either side of midspan and are connected at their centers by forged eyes sandwiched between octagonal cast iron connector plates. This configuration and method of connection was protected by a patent granted to Job Abbott and assigned to the Wrought Iron Bridge Company in 1876 (Patent No.184,490; 21 November 1876, shown in Figure 12). The feature, as Abbott described in his patent specification, was designed "to obviate the difficulty experienced in constructing long-span arch-bridges, of getting the diagonal ties to lie at or near the proper angle, to secure stiffness and economy without making the panels of too great length, as well as to effect a saving of material by reducing the number of posts required." [85]

The struts which stiffen the arches overhead were similarly covered by patent granted in 1876 to David Hammond (Patent No. 184,522; 21 November 1876, shown in Figure 13). Hammond's patent, titled an "Improvement in Wrought-Iron Girders," delineated a beam with asymmetrical tees for the upper and lower flanges and wrought iron webbing between. The struts for the Lower Plymouth Bridge feature the upper flange tee, but had a more conventional double-angle lower flange. The struts at most panel points have the height of a single web intersection. The midspan strut, with greater clearance over the roadway, features a deeper web. The upper lateral bracing consists of 3/4" diameter rods, connected with forged eyes to the columns at the outsides and with threaded ends bolted to a circular connector ring in the centers.

184,522. Wrought-Iron Girders. David Hammond, Canton, Ohio, assignor to Wrought Iron Bridge Company, same place. (Filed Aug. 19, 1876.)



A wrought-iron girder having an upper T-head made with flat top and ribs on its under edges, in combination with a plate or lattice-web and T or angle lower head, substantially as and for the purpose specified.

[86]

Figure 13

The floor structure of the bridge is, as Wrought Iron emphasized, "wholly of iron, and entirely independent of all wood work, consisting of rolled I beams placed at the brace posts, and united by lateral tie rods under the floor, the whole forming a rigid lateral iron truss extending between the chords the full length of the bridge, and preventing any lateral motion in the floor or bridge at chord level." [87] The floor beams are single-piece wrought iron I-beams, with 3-1/4" flange widths, 6-1/4" overall height and 3/8" flange and web thickness. The lower lateral bracing consists of 1" square bars, with forged eyebar ends bolted to the floor beams.

The Wrought Iron Bridge Company fabricated, shipped and assembled the superstructures for the Old Mission and Lower Plymouth Bridges in 1877. The company supplied all of the ironwork, including the bearing shoes and floor beams. Winneshiek County contracted locally for the masonry abutments and for the oak stringers, mud sills, decking and wearing planks. Masonry work for the two bridges had begun soon after the letting of the contracts in June. Several courses of stone were added to the existing abutments of the Old Mission Bridge to increase the high water clearance beneath the new superstructure (the second raising of the bridge; the first occurred in 1872). Stonemasons reconstructed the coursed limestone abutments for the Lower Plymouth Bridge entirely to accept the new long-span arch-truss. The soil on the east riverbank here consisted of a stiff yellow clay subsoil with a thick overlayment of black loam topsoil. On the other side of the river, the soil had a similar structure, though the topsoil carried slightly more sand and fine gravel.[88] Under these favorable subsurface conditions, the contractors drove heavy timber piles as substructure for the stone abutments and wingwalls.

Grading for the Lower Plymouth Bridge was provided by residents on both sides, and by late autumn the structure was open to regular traffic. In the absence of evidence otherwise, it is assumed that the construction progressed without major incident. Total cost of the Old Mission Bridge was $1139.99 - $1091.50 for the iron superstructure and $47.50 for raising the abutment walls. A longer structure which required a new masonry substructure, the Plymouth Rock Bridge had cost substantially more. The $4173.56 total construction cost breaks down as follows: $2600 to the Wrought Iron Bridge Company for fabrication and installation of the iron superstructure; $1462.50 for the 112.25 cords of stone and masonry used for the abutment and wingwalls; $81.90 for 2,340 feet of oak wearing plank; and $29.16 for sawing, boring and hauling bridge decking.[89]

Despite its tentative beginning, 1877 had proved to be an expensive year for bridge building in Winneshiek County. This was due largely to the high cost of the Lower Plymouth Rock Bridge. In the third and fourth quarters alone, the board of supervisors had approved warrants for $7,296.14 on bridge construction and maintenance, comprising almost a third of the total budget. The Old Mission Bridge had cost $1139; the Plymouth Rock Bridge, $4173.56. The Larsen Bridge, a 44-foot timber/iron combination truss on masonry abutments, was built in Highland Township at a total cost of $1529.59.[90] Additionally, several small-span timber and stone bridges were erected throughout the county and existing bridges replanked or reshored. Finally, after five years the pro rata arch bridge program was substantially completed.[91]

BRIDGE BUILDING IN WINNESHIEK COUNTY AFTER 1877

By the end of 1877, with his arch bridge program completed, George Winship had grown tired of his responsibility as county supervisor. During the 1870s, he had spent as much as a third of his time supervising bridge construction around the county and and wished to return to full-time farming. In January 1878, at the age of 53, he retired from the board of supervisors against the protests of the other board members. Noting his retirement, the Decorah Republican stated, "For a number of years he has been the guiding spirit in [the board's] deliberations, and wielded the most influence."[92] The newspaper continued with an unprecedented testimonial:

> In losing his services, the county loses much. Every member who has been associated with him will testify to the unfailing courtesy, and the rigid integrity which he has given to his duties. If he has made mistakes - and we are sure they are but a few - he has been always ready to acknowledge and correct them. At times he has been violently assailed, but he has always promptly and ably defended himself; and time has proved that he has served the county wisely, capably and honestly. His most important service has been that of bridge committeeman. It is on this account he has been most vemently [sic] assailed. Time shows this fact; when he began his service, there was hardly a decent bridge in the whole county. The superstructures were rotten, and the abutments flimsy shams. To-day, the county may well be proud of her numerous iron and stone bridges. We do not know how many they number, but they can be found all over the county; and whenever found, a good job is to be seen. This has been accomplished, too, without increasing the tax for bridge purposes, a single mill... Of course, Mr. Winship is to be credited with only a part of this work. His associates saw and approved his methods, and backed him in his plans. They have their share of the credit, but they cheerfully accord him with the greatest, as the master spirit. The record of his work is seen in these enduring works, and we think, that, as he retires from public service, this recognition of his labors are due.[93]

Winship's departure from the board immediately precipitated a couple of changes in the way the county handled bridge matters. The three-man bridge committee, appointed the year before, was expanded to include the entire board of supervisors - A.W. Brownell, T. Callender, O.W. Ellingson, P. Morton and B.E. Jewell. Jewell would chair the committee. Additionally, the board empowered the county auditor "to issue warrants on the bridge fund in payment for bridge construction and maintenance on the written order of the chairman of the bridge committee."[94] This was a responsibility which George Winship had assumed during his term as the bridge committee.

It is evident the board intended that bridge building would proceed in 1878 as it had through the previous year, with most of the effort directed toward replacement of several of the earliest timber structures by more substantial iron spans. The first such replacement project was initiated at the first meeting of the new year, on January 8. That morning the supervisors traveled northeast of Decorah to ascertain the condition of the existing Freeport Bridge over the Upper Iowa River. Back in town that afternoon, they directed that an iron bridge be erected on the site of the existing timber structure "at as earliest date as consistent."[95] The Wrought Iron Bridge Company erected the 160-foot bowstring arch-truss (Winneshiek County Bridge #69) later that year.

Of the eleven new spans erected by Winneshiek County in 1878, Freeport Bridge was easily the most costly. Other iron bridges contracted for by the county commissioners that year were the Iverson Bridge in Canoe Township (33' span; $705), Pine Creek Bridge in Bluffton Township (35' span; $980.50), Cuppernill Bridge in Orleans Township (39' span; $705), Snyder Bridge (50' span; $1313.68) and the Springwater Bridge in Canoe Township (80' span; $1890.05). Additionally, the county built five small-scale wood bridges, ranging in span length from 20 to 40 feet and in cost from $331.54 to $563.85. The bridge expenditure for the second half of 1878 exceeded $14,400, typically constituting the largest line item in the board of supervisors' budget.[96]

Bridge construction dropped precipitously for Winneshiek County in 1879. That year the supervisors contracted for only one iron structure, the Spillville Bridge in Calmar Township, a 100-foot bowstring arch-truss.[97] By 1880, Winneshiek County had erected a total of thirty-two iron bridges on the county roads, sixteen or more stone arch bridges, three Tracy "composition" bridges (made of iron girders and lower chords, with wooden arches) and numerous small-scale wooden spans. Remarkably, these had all been built in the nine years since George Winship had organized the county's bridge program. "The iron and stone bridges are erected with a view to permanency," the 1880 Winneshiek County Almanac stated. "The abutments for the former are invariably massive, and the superstructure of superior workmanship."[98]

Of the stone arch bridges, one, over Trout Run, two miles southeast of Decorah, was composed of five arches. Two were double arch bridges, the remainder single arches. The aggregate cost for nine of these structures was $9,230.15. Among the most expensive iron structures were: the Decorah Bridge (span length unknown (1874); $7,994.39); the Gillece Bridge in Bluffton Township (104' arch span (1873-74); $6,961.46); the Drake Bridge in Glenwood Township (130' arch span (1874); $6,155.61); the Daubersmith Bridge in Lincoln Township (70' and 60' arch spans (1873); $5,621.24); the Freeport Bridge (160' arch span (1878); $5,549.03); the Upper Plymouth Rock Bridge (130' span (1874); $4,770.77); the Lower Plymouth Rock Bridge (130' arch span (1877); $4,173.56); the Turkey River Bridge at Fort Atkinson (84' arch span (1873); $3,101.50); and the Spillville Bridge (100' arch span (1879); $2868.80).[99]

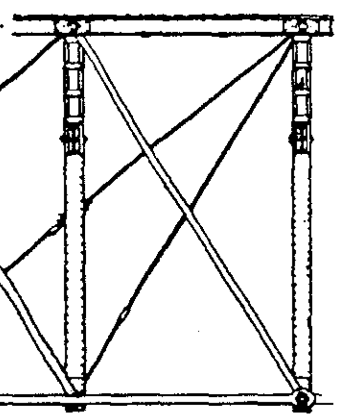
In 1880, Winneshiek County contracted with the Wrought Iron Bridge Company for two medium-span iron bridge superstructures. The first, used for the Sawrence Bridge in Jackson Township, was an 84-foot bowstring arch-truss, erected for a total cost of $2519.35. The other was a 116-foot-span Pratt through truss replacement structure for the Bluffton Bridge, placed over the Upper Iowa River on existing abutments for $2831.23.[100]

184,590. Truss-Bridges. David Hammond, Henry G. Morse, and Job Abbott, Canton, Ohio. (Filed Aug. 19, 1876.)

1. A pin-connection truss having the posts held longitudinally at the center by diagonal ties run through and secured by jam nuts and washers in the posts, substantially as and for the purpose specified.

2. The combination, with a truss-post, of a diagonal tie having sleeve-nut adjustment, and with one screw end for said sleeve-nut secured by jam-nuts and oblique washers in said post, substantially as and for the purpose specified.

184,590.



3. A truss-girder having the main diagonal ties run across one panel, and the counter-ties run across two panels, and secured to the posts at the center, substantially as and for the purpose specified.

4. A truss-post for partial-deck spans, having the section below the floor-beams greater than the section above said beams, substantially as and for the purpose specified.

5. The construction of the lower chords of a truss-girder in pairs, running over two or more panels, with intermediate bars to take up the strains from intermediate diagonal ties, substantially as and for the purpose specified.

6. The within-described corner-connection for box-chord trusses, formed by fitting the end post under the chord end, and uniting the same by inside plates, bearing-plates, and corner-pin, substantially as and for the purpose specified.

[101]

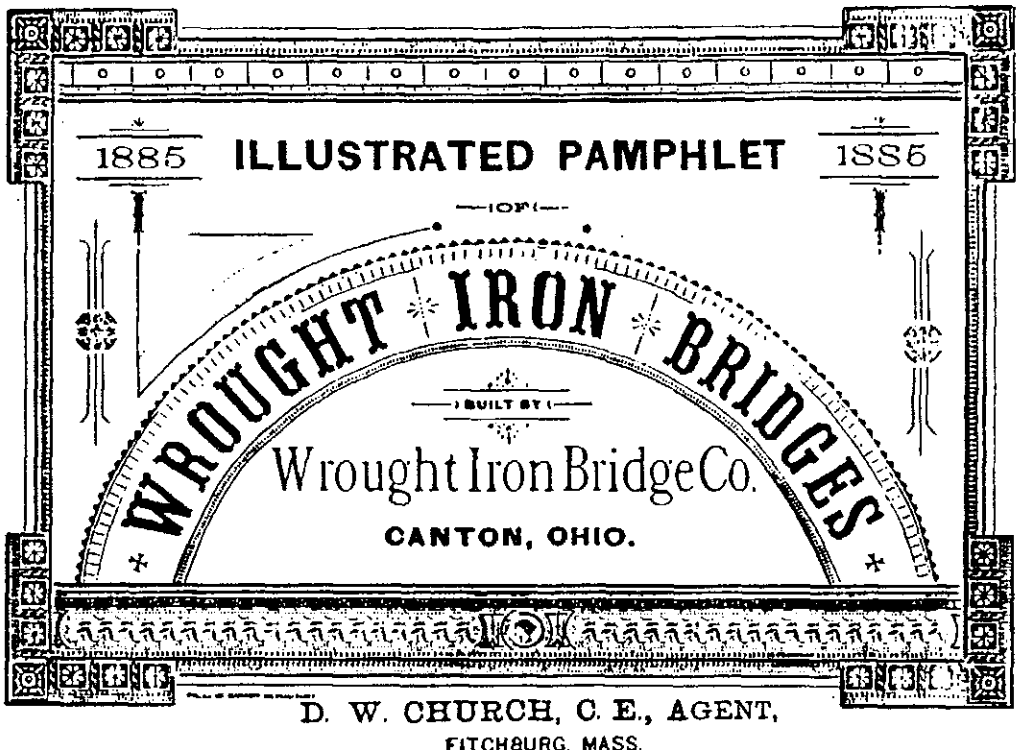
Figure 15

The Bluffton Bridge marked a watershed for bridge building in Winneshiek County. The county supervisors had contracted with bridge companies during the 1870s for iron trusses, such as the Goddard Bridge in Washington Township or the the Womeldorf Bridge in Pleasant Township, built by Wrought Iron in 1874 and 1875, respectively.[102] These had all been relatively small pony structures, however - Pratt half-hips and bedsteads - used in short span situations. The Bluffton Bridge represented the first time that the county purchased a through truss as an alternative to a medium-span bowstring on a rural crossing: a marked departure from past practice.

The Bluffton Bridge presaged the building trend in the county for the rest of the 19th Century. The county continued to erect iron, and later steel, trusses on its rural roads throughout the 1880s and 1890s, though not in the quantity that had characterized the decade before. No iron bridge construction was recorded in Winneshiek County between 1881 and 1883.[103] In 1884, the Wrought Iron Bridge Company erected the Twin Bridge - consisting of two 116-foot Pratt through trusses identical to the Bluffton Bridge - and a 160 foot iron span at Childs Ford in Decorah Township.[104] The Kendallville Bridge, a 100-foot iron span, was erected in 1887, along with 58 and 70-foot iron bridges on Washington and Water Streets in Decorah.[105] The last iron bridge of the 1880s was a 70-foot structure built over Trout Run in Decorah Township.[106]

The change in character of Winneshiek County's bridges occurred well within the mainstream of state and national trends, for after 1880 the bowstring was specified increasingly less frequently for roadway crossings. The Wrought Iron Bridge Company, at the forefront of bowstring innovation in the 1870s, was also at the forefront in the shift toward other structural configurations a decade later. David Hammond foresaw the decline of the bowstring arch-truss as a highway bridge type in the mid-1870s, as evidenced in his patent activity of the time. In an 1874 patent, the inventor offered a single-intersection truss design as an alternative to the arch, stating: "The straight truss is simplified and made available for short spans in place of the arch, to which it is preferred for appearance, and also for the protection which the truss affords at the sides." Hammond's last patent for a bridge type, granted in 1876, was for a double-intersection through truss. (See Figure 15).[107]

Another indication of Hammond's change of design appears in the advertising of the Wrought Iron Bridge Company. Of the fourteen standard bridge configurations presented in the company's 1874 "Book of Designs," half were bowstring variations. The illustration of a bowstring on the cover and the prominent placement of bowstrings first among the suggested designs indicates the intensity with which the company promoted this specific bridge type. A similar illustrated pamphlet (shown in Figure 16) issued by the company in 1885, however, contained no bowstrings at all among its standardized designs. Wrought Iron had by then dropped what had once been its mainstay bridge type completely from its inventory. As this company and others discontinued the bowstring in its bid offerings, clients were guided toward alternative truss types.



[108]

Figure 16

The acceptance of wrought iron as a structural material was widespread by this time, as evidenced by the fronticepiece of Wrought Iron's 1885 pamphlet:

> The construction of durable Iron Highway Bridges instead of perishable wooden structures, securing as it does, an ornamental and permanent improvement to the public highways and avoiding their frecuent obstructions for the repair or rebuilding of wooden bridges, failing from decay, storm or fire, has become an imperative public want, wherever trial has been made of properly designed and constructed work.
>
> The only objections to the adoption of Iron Bridges have arisen from the construction by unscrupulous and inexperienced bridge builders, of light and inferior work, badly designed and poorly built of inferior material, and there is no case of failure of Iron Bridges which cannot be clearly shown to have resulted from some of these causes. Iron of poor quality, and rightly used, has never yet failed to meet all the requirements of a first-class bridge material, but it must be properly used to give goood results; and on the ground of their extensive experience in its practical use, and their facilities for ascertaining its quality and manufacturing it into the strongest designs for work, that this Company desires to call the attention of the public to its records and facilities.[109]

By 1880, the Wrought Iron Bridge Company had built more roadway spans than any other iron bridge fabricator in America, according to one account. The company had by then erected some 3,300 structures in twenty-five states and Canada, varying from 20 to 301 feet in length and from 6 to 120 feet in width.[110] With an aggregate length of over thirty-three miles, these included arch, truss, swing and plate bridges. Around this time, the emphasis for Wrought Iron - and for the bridge industry in general - began to shift overwhelmingly toward the wrought iron truss, particularly the single- and double-intersection Pratt, for roadway bridge construction. The Pratt was easily produced and economically assembled from prefabricated components, was versatile in its range of span lengths and live load capacities and offered a degree of lateral stability in its through configuration that the bowstring could only approximate through a network of braces, girders and ties. Rapidly gaining in popularity, the Pratt truss would soon acquire the distinction as America's stan- dard roadway bridge type of the 1880s and 90s, as the bowstring had been in the 1870s.

The significance of the Lower Plymouth Rock Bridge does not lie in its representation of unusual or innovative technology. At the time of its construction in 1877, it was one of thousands of similar structures erected by the Wrought Iron Bridge Company. Rather, the Lower Plymouth Bridge is important for its representation of two national bridge trends: the construction of rural roadway bridges by county governments and the design and manufacture of wrought iron bowstring arch-trusses in the 1870s. Winneshiek County's bridge building program during this decade was representative in the way that bridge funds were allocated and bridges were purchased. At the same time, it was novel and ambitious, due in large part to George Winship. As one of the last iron bowstrings contracted for by the county, the Lower Plymouth Rock Bridge represents the culmination of this program and provides an opportunity to document county-level bridge building in Iowa. Secondly, as a standardized structure manufactured by one of the country's principal 19th Century bridge fabricators, it is an unaltered example of that company's most advanced medium-span bowstring design. The Lower Plymouth Rock Bridge affords a degree of documentation for what was an American standard rural roadway span of the 1870s.

Finally, the Lower Plymouth Rock Bridge is intrinsically significant simply for its existence. Although a great number of bowstring arch-trusses were erected by Wrought Iron and other bridge fabricators in the 1860s an 70s, few remain today. Iowa, once one of the Wrought Iron Bridge Company's largest bowstring customers, is typical of the national attrition. The Iowa Department of Transportation has identified as few as twenty-four bowstrings remaining in the state. Five of these are in Winneshiek County. All date from the 1870s. Fewer yet have retained the degree of contextural and structural integrity as this bridge. The bridge remains in an essentially rural setting on a farm-to-market road. Other than the addition of deeper floor beams, replacement of the deck and minor superstructural repairs, the Lower Plymouth Rock Bridge remains in pristine condition. Too narrow, unable to function under current loading standards and now closed, it is scheduled for replacement in early 1986.

ENDNOTES

1 W.E. Alexander, History of Winneshiek and Allamakee Counties, Iowa (Sioux City, Iowa: Western Publishing Company, 1875), page 45.

2 Ibid., pages 241-243; Standard Historical Atlas of Winneshiek County (Davenport, Iowa: Anderson and Goodwin Company, 1905), Section II, pages 2-18; Gazeteer and Directory of Winneshiek County (Decorah: Edmund A. Kirby, 1875); W.J. Sparks, History of Winneshiek County with Biographical Sketches of its Eminent Men (Decorah, n.p.; 1877), page 88.

3 Sparks, page 44; Alexander, History of Winneshiek and Allamakee Counties, Iowa, page 203.

4 "Proceedings of the Board of Supervisors of Winneshiek County, Iowa," Decorah (Iowa) Republican, 11 March 1870.

5 "Proceedings of the Board of Supervisors of Winneshiek County, Iowa," Decorah Republican, 13 January 1871; Winneshiek County Board of Supervisors Records, 7 January 1871 (Book B, page 16).

6 U.S., Department of Commerce, Bureau of the Census, Eighth Census of the United States, 1860: Population. Decorah Township, Winneshiek County, Iowa, page 29.

7 Sparks, History of Winneshiek County with Biographical Sketches of its Eminent Men, pages 91-92.

8 Standard Historical Atlas of Winneshiek County, page 15.

9 U.S., Department of Commerce, Bureau of the Census, Eighth Census of the United States, 1860: Population. Decorah Township, Winneshiek County, Iowa, page 29.

10 U.S., Department of Commerce, Bureau of the Census, Ninth Census of the United States, 1870: Population. Decorah Township, Winneshiek County, Iowa, page 29.

11 Alexander, History of Winneshiek and Allamakee Counties, Iowa, page 211.

12 Winneshiek County Board of Supervisors Records, 7 January 1871 (Book B, page 16).

13 Ibid.

14 Winneshiek County Board of Supervisors Records, 2 January 1872 (Book B, page 94).

15 Ibid.

16 "Proceedings of the Board of Supervisors of Winneshiek County, Iowa," Decorah Republican, 17 January 1873.

17 Ibid.

18 Ibid.

19 Ibid.

20 "Proceedings of the Board of Supervisors of Winneshiek County, Iowa," Decorah Republican, 13 September 1872; Winneshiek County Board of Supervisors Records, 4 September 1872 (Book B, page 111).

21 This goal was only partially achieved in later years, as the county experienced difficulties in finding both materials and masons to build the arch bridges. The scarcity of suitable stone in Burr Oak, Sumner, Jackson, Washington and Military Townships prompted the board to authorize a substitution of short-span iron superstructures for stone arches in September 1874. The following year, the county contracted for a 28-foot iron bridge in each of these townships. (The existing arch-rod truss bridge in Bloomfield Township (Winneshiek County Structure #4) is probably one of these 1875 structures, moved to its present position over the Turkey River. Unfortunately, no more information about these bridges was recorded by the board of supervisors.) "Proceedings of the Board of Supervisors of Winneshiek County, Iowa," Decorah Republican, 14 January 1876.

22 Standard Historical Atlas of Winneshiek County, page 15.

23 Winneshiek County Board of Supervisors Records, 3 September 1872 (Book B, page 109).

24 "Proceedings of the Board of Supervisors of Winneshiek County, Iowa," Decorah Republican, 16 January 1874; Winneshiek County Board of Supervisors Records, 6 January 1874 (Book B, pages 190-194).

25 Ibid.

26 Ibid.

27 "Proceedings of the Board of Supervisors of Winneshiek County, Iowa," *Decorah Republican*, 18 April 1873; James Hippen, ed. "Preliminary Report on 'Historic Bridges' in Winneshiek County, Iowa," unpublished report, January 1971.

28 "Proceedings of the Board of Supervisors of Winneshiek County, Iowa," *Decorah Republican*, 16 January 1874; Winneshiek County Board of Supervisors Records, 6 January 1874 (Book B, pages 190-194).

29 "Proceedings of the Board of Supervisors of Winneshiek County, Iowa," *Decorah Republican*, 16 January 1874.

30 Winneshiek County Board of Supervisors Records, 8 January 1875 (Book B, pages 255-258). "Proceedings of the Board of Supervisors of Winneshiek County, Iowa," *Decorah Republican*, 16 January 1874.

31 *Ibid.*

32 *Ibid.*

33 Winneshiek County Board of Supervisors Records, 8 January 1875 (Book B, pages 255-257).

34 *Ibid.*

35 King and Son were apparently successors to the King Wrought Iron Bridge Manufactory and Iron Works, also of Topeka. Formed by Zenas King either immediately before or associated with the formation of his highly successful King Iron Bridge and Manufacturing Company of Cleveland, Ohio, the plant closed within a year after its founding. Zenas King was the Wrought Iron Bridge Company's primary competitor for bridge construction in the 1870s. Combined, the two firms erected most of the bowstring arch-trusses in America. Victor C. Darnell, ed., *A Directory of American Bridge-Building Companies 1840-1900* (Washington, D.C.: Society for Industrial Archeology, 1984), pages 17-18, 50.

36 These were:

Daubersmith Bridge(s)	1872-73	60'	and 70' bowstring arch-trusses
Fort Atkinson Bridge	1872-73	B4'	bowstring
Gillece Bridge	1873	104'	bowstring
Goddard 8ridge	1874	34'	type unknown
Stich Bridge	1874		length and type unknown
Upper Plymouth Bridge	1874	130'	bowstring
Drake Bridge	1874	130'	bowstring
Decorah Bridge	1874		through truss, length unknown

37 "Bridge Building," The American Pictorial Monthly, Mid-Summer Edition 1902 page 25; "Third Street S.E., Bridge - 1883, Canton, Ohio," unpublished report, Ohio State Historical Society, pages 4-5.

38 Ibid.

39 Book of Designs of Wrought Iron Bridges Built by the Wrought Iron Bridge Company of Canton, Ohio (Canton, Ohio: Hartzell & Saxton, 1874), page 2; William Henry Perrin, History of Stark County, Ohio (Chicago: Baskin & Batley, 1881), page 337.

40 "Third Street S.E., Bridge - 1883, Canton, Ohio," page 14; Stark County (Ohio) Commissioners Journal, Volume 5 (1864-1874).

41 Engineering News, 25 August 1877.

42 William Henry Perrin, History of Stark County, Ohio, page 337.

43 Book of Designs of Wrought Iron Bridges Built by the Wrought Iron Bridge Company of Canton, Ohio, page 3.

44 Ibid., page 1.

45 Ibid., page 28.

46 Ibid., page 29.

47 Ibid., page 52.

48 David Plowden, Bridges: The Spans of North America (New York: The Viking Press, 1974), page 61.

49 Patent files: 16,572 (3 February 1857), 33,384 (3 February 1861), 148,010 (24 February 1874).

50 Book of Designs of Wrought Iron Bridges Build by the Wrought Iron Bridge Company of Canton, Ohio, page 9.

51 David A. Simmons, "The Risk of Innovation: Ohio Bridge Patents in the 19th Century." Paper presented at Historic Bridge Conference, Columbus, Ohio, 1 November 1985, page 119.

52 Ibid.

53 Patent file 56,043; 3 July 1866.

54 David A. Simmons, "The Risk of Innovation: Ohio Bridge Patents in the 19th Century," page 119.

55 Patent file 86,538; 2 February 1869.

56 Patent file 102,392; 26 April 1870.

57 Patent file 135,802; 11 February 1873.

58 Ibid.

59 Book of Designs of Wrought Iron Bridges Built by the Wrought Iron Bridge Company of Canton, Ohio, page 55.

60 Engineering News, 25 August 1877.

61 Illustrated Pamphlet of Wrought Iron Bridges Built by Wrought Iron Bridge Co. Canton, Ohio (n.p., 1885), page 22; Book of Designs of Wrought Iron Bridges Built by the Wrought Iron Bridge Company of Canton, Ohio, page 9.

62 Illustrated Pamphlet of Wrought Iron Bridges Built by Wrought Iron Bridge Co. Canton, Ohio, page 22.

63 Ibid.

64 Ibid.

65 "Proceedings of the Board of Supervisors of Winneshiek County, Iowa," Decorah Republican, 14 January 1876.

66 Winneshiek County Board of Supervisors Records, 8 January 1875 (Book B, pages 255-257).

67 "Proceedings of the Board of Supervisors of Winneshiek County, Iowa," Decorah Republican, 14 April 1876.

68 Ibid.

69 "Proceedings of the Board of Supervisors of Winneshiek County, Iowa," Decorah Republican, 13 April 1877.

70 Standard Historical Atlas of Winneshiek County, Section II, page 16.

71 Ibid.; Alexander, History of Winneshiek and Allamakee Counties, Iowa, page 203; Decorah Republican, 19 January 1877.

72 Ibid.

73 Standard Historical Atlas of Winneshiek County, Section I, page 34; Plat Book of Winneshiek County, Iowa (Minneapolis: Warner & Foote, 1886), page 36.

74 Standard Historical Atlas of Winneshiek County, Section II, page 16.

75 "Proceedings of the Board of Supervisors of Winneshiek County, Iowa," Decorah Republican, 17 January 1866.

76 "Proceedings of the Board of Supervisors of Winneshiek County, Iowa," Decorah Republican, 25 January 1878.

77 "Proceedings of the Board of Supervisors of Winneshiek County, Iowa," Decorah Republican, 15 June 1877.

78 Ibid.; Book of Designs of Wrought Iron Bridges Built by the Wrought Iron Bridge Company of Canton, Ohio, page 32.

79 Ibid.

80 Patent file 128,509; 2 July 1872.

81 Patent file 184,521; 21 November 1876.

82 Book of Designs of Wrought Iron Bridges Built by the Wrought Iron Bridge Company of Canton, Ohio, page 32.

83 Ibid.

84 Patent file 184,490; 21 November 1876.

85 Ibid.

86 Patent file 184,522; 21 November 1876.

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100 Winneshiek County Board of Supervisors Records, 8 January 1881 (Book C, page 39).

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103 Winneshiek County Board of Supervisors Records, 9 January 1882 (Book C, page 89), 10 January 1883 (Book C, page 149). and 13 January 1884 (Book C, page 203).

104 Winneshiek County Board of Supervisors Records, 9 January 1885 (Book C, page 276).

105 Winneshiek County Board of Supervisors Records, 6 January 1888 (Book C, page 453).

106 Winneshiek County Board of Supervisors Records, 6 January 1889 (Book C, page 504).

107 Patent file 184,520; 21 November 1876.

108 Illustrated Pamphlet of Wrought Iron Bridges Built by Wrought Iron Bridge Co. Canton, Ohio.

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110 William Henry Perrin, History of Stark County, Ohio, page 337.

UNITED STATES PATENT OFFICE.

DAVID HAMMOND, OF CANTON, OHIO.

IMPROVEMENT IN BRIDGES.

Specification forming part of Letters Patent No. **56,042**, dated July 3, 1866.

To all whom it may concern:

Be it known that I, DAVID HAMMOND, of Canton, in the county of Stark and State of Ohio, have invented a new and valuable Improvement in Wrought-Iron Trussed Girders for Bridges or other Structures; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, forming a part of this specification, of which—

Figure 1 is a horizontal plan of girder applied to a bridge. Fig. 2 is a side elevation. Fig. 3 is a vertical cross-section at middle of bridge. Fig. 4 is a cross-section, showing application of double-T iron, clamping-pieces, covering-piece, and securing-clamp. Fig. 5 is the details of double-bolted clamping-piece. Fig. 6 is the details of single-bolted clamping-piece, and Fig. 7 is the details for securing-clamp for covering-piece.

The nature of my invention consists in the novel construction of a wrought-iron arch of double-T iron and novel clamping-pieces, and also in the combination of a covering-piece which excludes moisture, and also serves to prevent any lateral motion of the arch, and, by being firmly secured thereto, serves to materially strengthen the arch, with said arch and securing-clamps of novel construction, whereby I obtain an arch of great strength and simplicity with a comparatively small weight and cost of construction.

To enable others skilled in the art to make and use my invention, I will proceed to describe its construction and application.

The arch B is composed of two continuous pieces of double-T iron, *b b*, which are set up parallel to each other and at a distance from each other equal to the lengths of the clamping-pieces D or P. These clamping-pieces are of a novel construction, being either double-bolted, as shown in Fig. 4 and in detail in Fig. 5, or single-bolted, as shown in detail in Fig. 6, and in their application in Figs. 1 and 2. They are made of cast or wrought iron, having bolts M M at their sides, which bolts pass through the double-T iron and are secured by nuts on the outside, thus firmly connecting the two pieces of the arch to each other. In the center of these clamping-pieces D or P, I bore a hole, N, through which pass the supporting-rods F F and brace-rods E E, the single-bolted clamping-pieces, by their peculiar construction, being allowed to rotate so as to accommodate themselves to the directions of the braces.

The ends of the arch are connected by the chords *a a* and bolts *s s*, which bolts pass through the ends of the arch, the ends of the chord, and cast-iron blocks which are put in to fill the space in the double-T iron and to keep the two pieces of the chord apart, thus firmly securing the ends of the arch and the chords to each other.

The suspension-rods F pass through the clamping-pieces D or P, and are secured by nuts on their lower ends. They pass on each side of the chord-pieces *a a*, as shown in Fig. 4, and pass through the supporting-piece *f f*, and are secured by nuts on the lower side of the supporting-piece, forming a stirrup for the support of the chords.

The string-pieces C C are placed on the top of the chords *a a*, and are bolted to the suspension-rods F F, thus forming a firm connection for the two girders.

The covering-piece H is placed on the top of the arch, and is secured thereto by the securing-pieces J J, of a novel construction. These securing-pieces, as shown in detail in Fig. 7, have their edges or sides *d d* so formed as to fit the lower part of the upper T of the double-T iron of which the arch is composed, and have a bolt, *c*, on their upper side, which passes through the covering-piece H, and is secured by a nut, K, on its upper side, thus firmly securing the covering-piece to the arch.

I do not claim in girders the use of the shoes R, the chords *a a*, the suspension-rods F, the string-pieces C C, nor the braces E E, as these have been heretofore used and patented; but

What I do claim as my invention, and desire to secure by Letters Patent, is—

1. The peculiar combination of the double-T irons *b b* and clamping-pieces D or P with bolts M M and hole N, substantially in the manner and for the purpose herein set forth.

2. The peculiar combination of the covering-piece H, the double-T irons *b b*, and the securing-pieces J J, with bolt *c* and nut K thereon, substantially in the manner and for the purpose herein set forth.

DAVID HAMMOND.

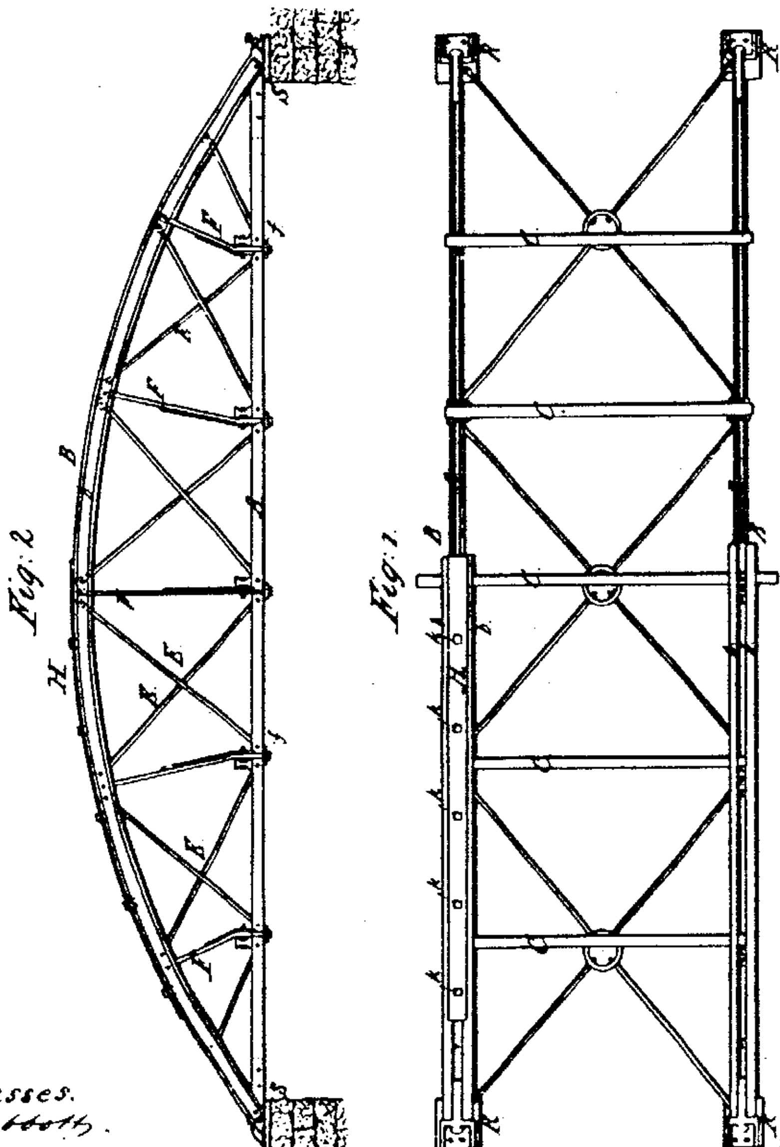
Witnesses:

J. ABBOTT,
GEO. T. TILDEN.

Sheet 1, 2 Sheets.

D. Hammond.
Truss Bridge.

No. 56,043. Patented Jul. 3, 1866.



Witnesses.
J. Abbott.
Geo T Tilden.

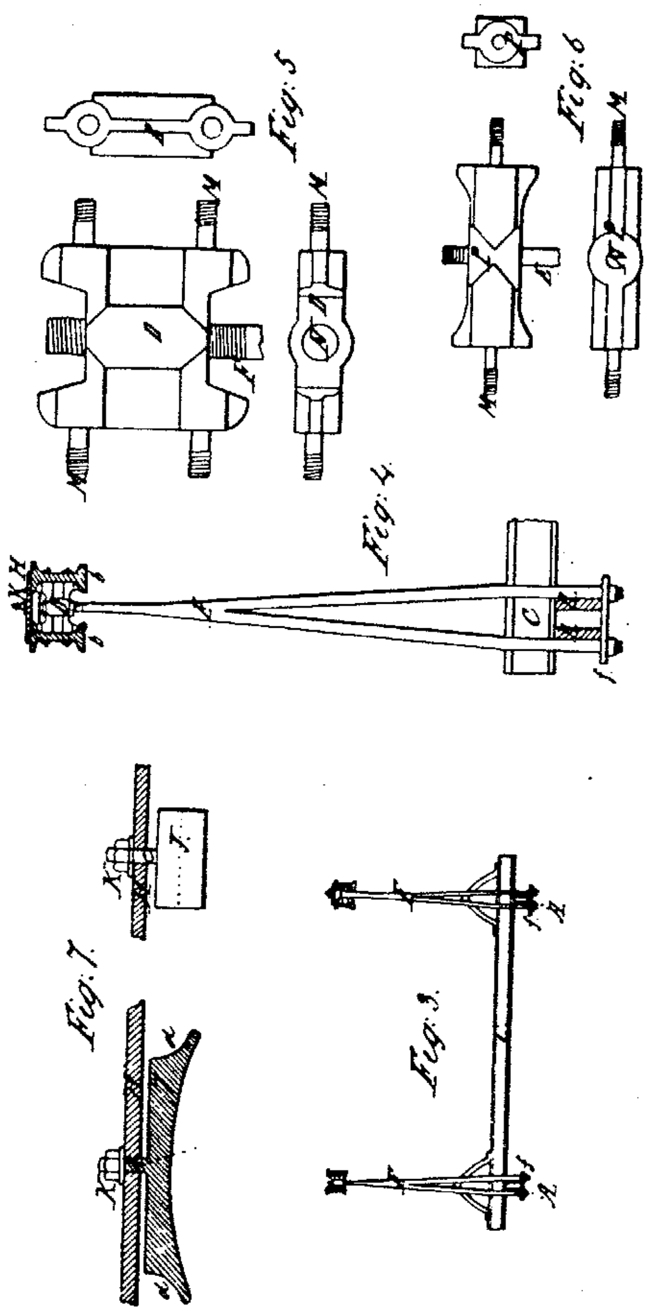
Inventor
David Hammond.

Sheet 2, 2 Sheets.

D. Hammond.

Truss Bridge.

No. 50,043. Patented Jul. 3, 1866.



Witnesses
J. Abbott
Geo T Tilden

Inventor
David Hammond

United States Patent Office.

DAVID HAMMOND AND W. R. REEVES, OF CANTON, OHIO.

Letters Patent No. 86,538, dated February 2, 1869.

IMPROVED GIRDER FOR BRIDGES.

The Schedule referred to in these Letters Patent and making part of the same.

To all whom it may concern:

Be it known that we, DAVID HAMMOND and W. R. REEVES, both of Canton, in the county of Stark, and State of Ohio, have invented new and useful Improvements in Wrought-Iron Girders for Bridges and other structures; and we do hereby declare that the following is a full, clear, and exact description of our invention, reference being had to the accompanying drawings, forming a part of this specification, and to the letters of reference marked thereon, of which drawings—

Figure 1 is a side view of our improved girder, applied to a bridge.

Figure 2 is a half plan of the same.

Figure 3 is a half plan of the same, as seen from below the bridge

Figure 4 is a cross-section of the same.

Figures 5 and 6 are two forms of cross-section for the arch.

Figures 7 and 8 are plan and section, showing the details of the shoe, with its block and the chord and arch-pieces.

The nature of our invention consists in new and useful improvements in the construction of the girder shown in our patent of June 21, 1864, said improvements consisting, first, in the use of channel or L-iron for the arch-pieces, in the place of the plate-iron there shown, by the use of which we are enabled to firmly rivet the arch-pieces and covering-piece together, instead of depending wholly on the clamping-bolts, clamping-pieces, and suspension-rods and bracing for the binding of said pieces together, as in the case of our previous patent, whereby we greatly increase the resistance of our arch to any horizontal deflection, and thus greatly increase its strength; and second, in the peculiar manner of securing the ends of the arch-pieces and chords in the shoes, whereby we greatly lessen the probability of their pulling apart, and thus increase the stability of our girder.

To enable others skilled in the art to make and use our improved girder, we will proceed to describe its construction and application.

The arch A of each girder is composed of three principal pieces, B C C, the two arch-pieces C C being formed of channel or L-iron, as shown in figs. 5 and 6, which are curved to the proper shape, and set up parallel to each other, as shown.

The covering-piece B is made of heavy plate-iron, and is laid on the top of the two arch-pieces C C, as shown.

The rivets *d d*, or bolts if preferred, pass through the upper flanges *x x*, which are formed on the arch-pieces C C, when they are rolled, and through the covering-piece B, thus firmly binding them together.

The clamping-pieces J J are made as shown in detail in figs. 5 and 6, and are secured by the bolts *k k*, which pass through them, and up between the arch-pieces C C, through the covering-piece B, and are secured by nuts *l l*, as shown.

The chords D D of the girder are formed of two pieces of plate-iron, set up parallel to each other, and have the heads *p p* formed on one side at their ends, as shown in fig. 7.

They rest at said ends between the arch-pieces D D in the shoe E, the heads *p p*, bearing against the parts *r r* of the shoe, as shown.

The arch-pieces C C abut against suitably-formed faces in the shoes E, and a block, R, having a head, as shown, or without this head, if desired, is inserted between the chords D D.

A bolt, *s*, passes through the sides of the shoe E, the arch-pieces C C, chords D D, and the block R, thus firmly uniting them together.

It is readily seen that if the block R be made with a head, as shown, and one or more bolts, *t*, be bolted through the chords D D and the block R, that the strength of resistance to any tendency of the chords D D to pull out of the shoe E will be greatly increased, although a good combination of the arch-pieces, chords, and shoe may be effected without the use of the head on the block R, if the heads *p p* on the chords D D be made very strong and heavy.

The suspension-rods F are made of thin plate-iron, bent in the form shown by red-dotted cross-section in fig. 4, and have the bolts *a a* and *f f* attached to them, as shown.

The bolts *a a*, which are attached to the upper part of the suspension-rods F, pass through the irons *k*, which bear on the lower parts of the arch-pieces C C, thence up, by the sides of said arch-pieces, through the covering-piece B.

The nuts *b b* and *c c* on the bolts *a a* bind the arch A and the irons *k* firmly together, and thus serve to aid in the combining of the arch, and to attach the suspension-rods to the arch.

Slots are cut in the lower part of the suspension-rods F, which admit the chords D D, and the bolts *f f*, at the lower ends of the suspension-rod F, pass through the irons Q Q, on which the chords D D rest, and have the nuts *h h*, which support the irons Q Q, and thus complete the connection between the arch and chords.

The irons Q Q have their edges rolled, and holes punched in them, into which are hooked the braces G G, as shown.

These braces are inserted between the chords D D, and run into the rings P P, as shown.

Other braces, I I, are secured to the arch A by means of eyes *m*, formed on their ends, which set between the arch-pieces C C, and are secured by bolts *e e*, which pass through the arch-pieces C C and the eyes on said braces I I.

The end braces H H are secured to the covering-piece B, as shown in fig. 1.

The braces I I run into the rings P P, and, in connection with the braces G G and posts F F, form a firm trussing against any vertical deflection of the arch.

The horizontal braces M M have eyes formed on their ends, which are put over the bolts *f*, under the irons Q, and above the nuts *h*, as seen in fig. 4.

The end-braces are attached to the shoes E E, as shown, and the braces unite in rings N, thus forming a firm bracing against any lateral vibrations of the bridge.

The cross-stringers L L are notched down on to the chords D D, as shown, and the flooring of the bridge may be laid on them in a diagonal manner, to aid in bracing the bridge against lateral vibrations, or floor-stringers may be laid across these cross-stringers, and the flooring laid in the ordinary manner.

Having thus fully described the construction of our improved girder, we do not here claim as our invention the principle of combining the three arch-pieces, B O O by means of the clamping-piece J, clamping-bolt *k*, and nut *l*, nor the manner of combining the suspension-rods F, braces G G H, arch A, and chords D D, nor the cross-beams L, horizontal or vertical bracing M M and G I, here shown, or the mode of constructing the suspension-rods F, nor the shoes E, or chords D D; but

What we do claim as our invention, and desire to secure by Letters Patent, is—

1. The peculiar arrangement and combination of the plates C C, flanges *x x*, bolts or rivets *d d*, covering-piece B, bolt *k*, and clamping-pieces J, when said flanges *x x* are formed on the plates C C when rolled, and whether the lower flanges *w w* are or are not used, the several parts being arranged substantially as and for the purpose herein specified.

2. The peculiar arrangement and combination of the arch-pieces O O, chords D D, with heads *p p* thereon, block R, and shoe E, the several parts being arranged substantially in the manner and for the purpose herein specified.

As evidence that we claim the foregoing, we have hereunto set our hands, in the presence of two witnesses, this 3d day of March, 1868.

DAVID HAMMOND.
W. R. REEVES.

Witnesses:
JOB ABBOTT,
ED. N. BEEBOUT.

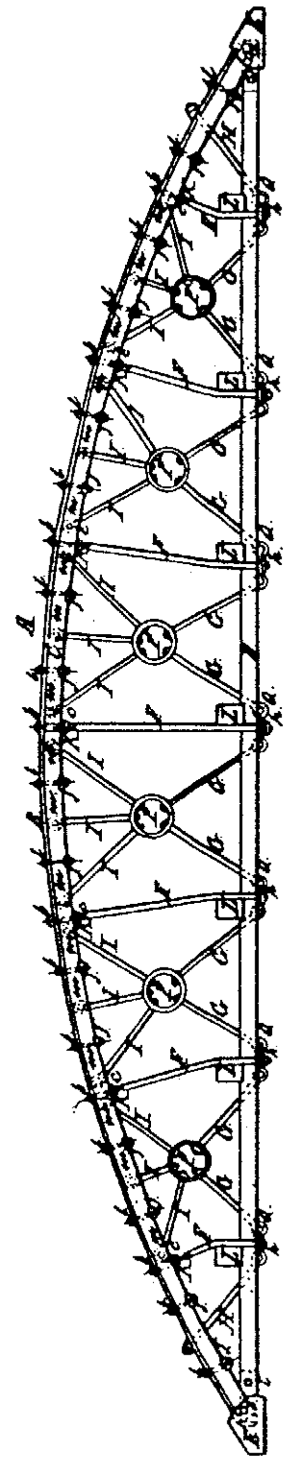
Sheet 1, 3 Sheets.

Hammond & Reeves.

Bridge Truss.

No. 86,538. Patented Feb. 2, 1869.

Fig. 1.



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Ed. A. Riboud

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By Jab. Abbott
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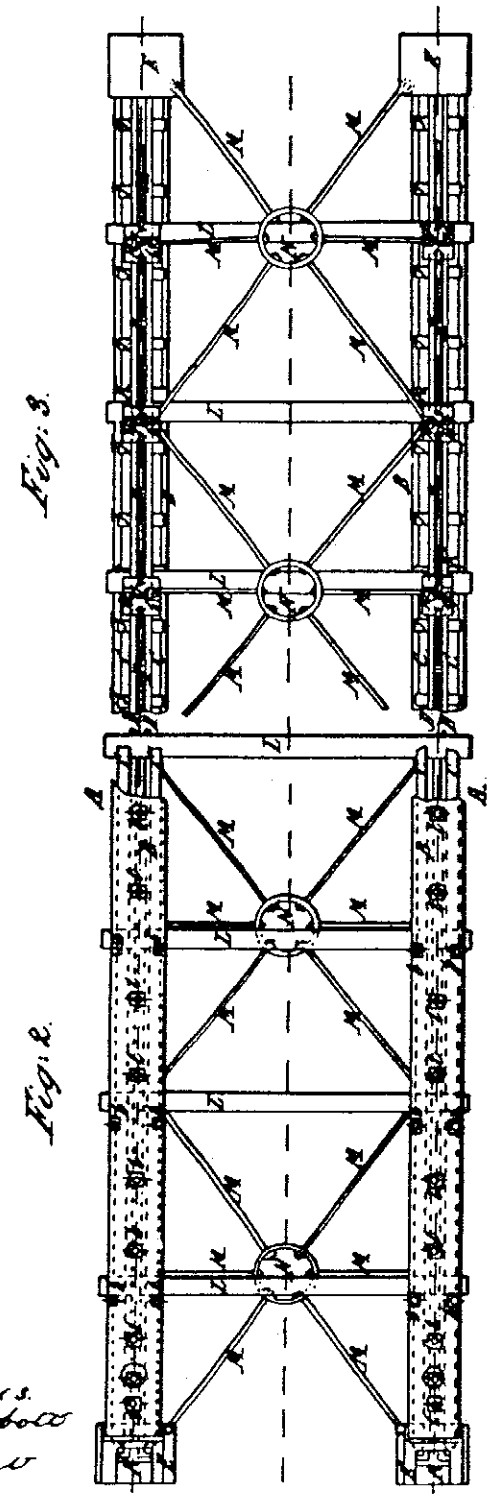
Sheet 2, 3 Sheets.

Hammond & Reeves.

Bridge Truss.

No. 86,538. Patented Feb. 2, 1869.



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Sheets, 3 Sheets.

Hammond & Reeves.
Bridge Truss.

No. 86,538. Patented Feb. 2, 1869.

Fig 4.

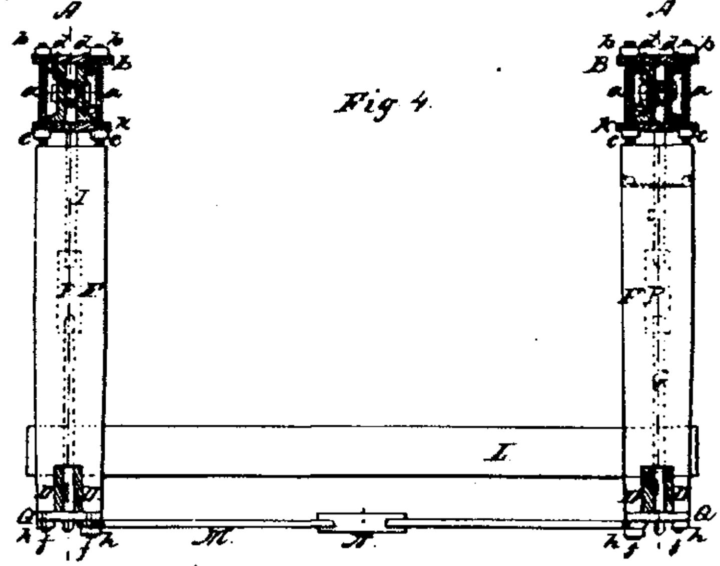


Fig 5.

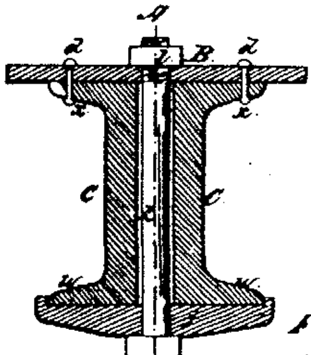


Fig 6.

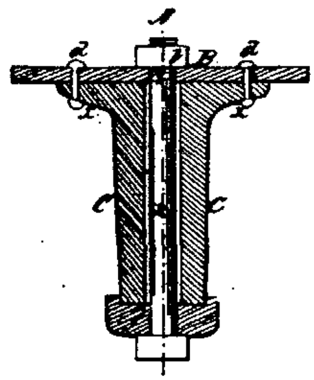


Fig 7.

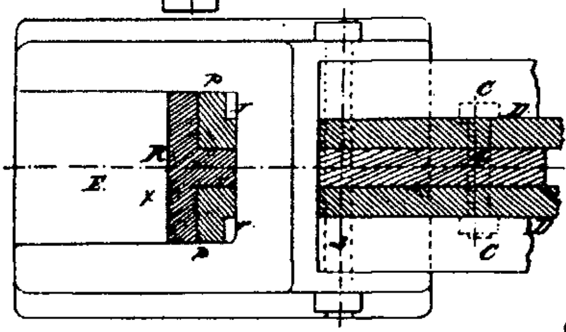
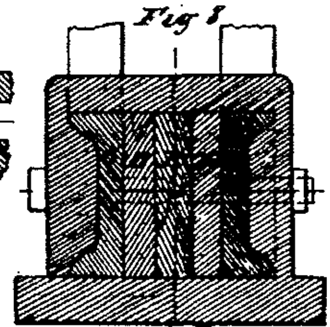


Fig 8.



Witnesses
Ruth K. Abbott
Ed. A. Bebout

Inventor.
David Hammond
H. R. Reeves
By J. A. Abbott
Attorney.

United States Patent Office.

DAVID HAMMOND AND JOB ABBOTT, OF CANTON, OHIO.

Letters Patent No. 102,392, dated April 26, 1870.

IMPROVEMENT IN TUBULAR ARCH-GIRDERS FOR BRIDGES AND OTHER STRUCTURES.

The Schedule referred to in these Letters Patent and making part of the same.

To all whom it may concern:

Be it known that we, DAVID HAMMOND and JOB ABBOTT, both of Canton, in the county of Stark and State of Ohio, have invented certain new and useful Improvements in Tubular Arch-Girders; and we do hereby declare that the following is a full, clear, and exact description of that portion of said invention which we have designated as part A, reference being had to the accompanying drawings forming a part of this specification, and to the letters of reference marked thereon, of which drawings—

Figure 1 is a plan showing several modifications of our girder.

Figure 2 is a sectional elevation of the upper girder, shown in fig. 1.

Figure 3 is an elevation of the lower girder, shown in fig. 1.

Figures 4, 5, and 6 are cross-sections of the arches of girders shown in fig. 1.

Figures 7 and 8 are cross-sections of the girders shown in figs. 2 and 3.

The nature of our invention consists in the construction of a girder with an arch composed essentially of two pieces of rolled iron, having a curved or polygonal-shaped web, with flanges on each side, said arch-pieces being curved to the required curve for the arch, and being placed parallel to each other in such a manner as that two flanges (one of each piece) shall be in the same curved horizontal plane, and said two principal arch pieces being so combined with other arch-pieces as to form a tubular arch of great strength and stiffness, which admits of a very economical distribution and proportion of material to any required case of construction, and forms, when combined with suitable shoes, chords, posts, and braces, a very cheap and strong girder for bridge construction, or other constructions of like character.

To enable others skilled in the art to make and use our invention, we will proceed to describe more fully its application and construction.

The principal arch-pieces A A are of the form shown in fig. 4, being made with the central web A of the circular cross-section shown, (or of a polygonal or other cross-section closely approaching a circular cross-section, if preferred,) and having a flange, *a* or *a'*, on each edge, as shown.

These pieces are curved to conform to the curve of the arch required, and are set up parallel to each other, with the flanges *a a* in the same horizontal straight line, as seen in fig. 4. The character of the other pieces of the arch will depend on the capacity and requirements in any particular case of construction, but the following examples will clearly illustrate this point.

For example, let it be required to construct a girder for a bridge for foot-walk of one hundred feet span and six feet width of track. The arch for such girder need not have a great crushing capacity, as the load to be carried can never be very great, but it must have great lateral capacity to resist a lateral bending of the arch, as the track is too narrow to admit of good lateral bracing without great expense.

Accordingly, the broad plate B is used in combination with the arch-pieces A A, as shown in fig. 5, the flanges *a a* being riveted to said plate, as shown, and the other flanges *a' a'* being brought up to each other and riveted together, as shown in fig. 6, or they may be held apart by thimbles, *f*, which are placed around the rivets which unite the flanges *a' a'*, as shown in fig. 1, when a greater lateral capacity against bending is required, without an increase of cross-section in the arch.

When both an increase of lateral capacity and crushing strength are required, the channel-bars H or L, as shown in fig. 4, may be used between the flanges *a' a'*, where they can be secured either by two rows of rivets, one through each flange *a'* and a flange of the channel-bar, or by a single row of long rivets passing through both flanges *a' a'* and the flanges of the channel-bar, the first being the preferable mode of riveting.

We would here state that by the term "channel-bar" we designate any bar-iron with flanges of suitable width at its edges, whether the web of such bar be plain or curved, or whether the flanges be at right angles to the plane of the web or not, the flanges *a' a'* of the arch-pieces A A being made to conform to the inclination of the flanges of the channel-bar in each case.

In each of the above-described modifications it will be observed that the plate B forms the principal resistant to the lateral bending of the arch, while the arch-pieces A A, either directly in combination with each other and the plate B, or in combination with the thimbles *f* or channel-bars H or L and the plate B, form a tube which is the principal resistant to the crushing strain on the arch; and, further, that by having the pieces A A made with their webs of a curved or polygonal cross-section, the material is placed further away from the axis of the tube forming the arch, and the crushing capacity of such tube is consequently increased without any increase in its cross-section.

It will also be observed that the same capacity of material will be developed, whether the plate B is arranged below the arch-pieces A A, as shown in fig. 5, or whether said arch-pieces be placed below said plate, in which case the cross-section shown in fig. 5 would be simply reversed.

For a second example, let it be required to construct a girder for a railroad bridge of one hundred and fifty feet span and twelve feet width of track.

The arch for such a girder must have a large cross-section to resist crushing strain, as well as great lateral capacity to resist horizontal deflection, as the track is too narrow in proportion to the span and moving load to give good lateral bracing. Accordingly, we combine two sets of arch-pieces, A A A' A', as shown in figs. 2, 4, and 7, by riveting together the horizontal flanges *a a a a* and uniting the upper and lower flanges *a' a' a a'* by rivets and thimbles *f*, or by channel-bars L, H, and K, or by combining these two methods, either by using a channel-bar along the ends and on the upper side of the arch, in combination with pieces of channel-bar riveted in at such points on the upper side as are to serve as points of attachment for the posts of the girder, with thimbles between such pieces and all along between the lower flanges of the arch; or a channel-bar may be used along the whole length of the upper or lower sides, or on both the upper and lower sides, as illustrated in fig. 2, the particular construction required depending very much on the amount of cross-section required in the arch, and also on the amount of lateral stability required, which must be determined on by the engineer in any particular case, and cannot, therefore, be definitely stated here.

For a third example, let it be required to construct a girder for a common road bridge of one hundred and fifty feet span and twenty feet width of track.

The arch for such a girder need have but a moderate amount of crushing cross-section, and the width of track is such that a good lateral bracing can be had; hence, the material in the arch should be so disposed as to give the greatest amount of crushing strength with a proper amount of lateral stiffness.

Accordingly, we combine the two sets of arch-pieces A A A' A', as shown in figs. 6 and 8, the flanges *a a a a* being united by rivets, as shown, and serving as ribs to give the requisite lateral stability to the arch, while the flanges *a' a' a' a'* are also united by rivets, as shown, thus securing a unity of action between the opposite arch-pieces A A A' A', the whole forming an arch in which the material is very symmetrically disposed around the axis of the arch, thus giving it great crushing capacity.

The general ideas of the methods used in constructing the arch having been thus fully shown, the manner of completing the girder is readily seen, and differs in but few points from that shown in other arch-girders heretofore constructed.

The ends of the arch rest on cast-iron shoes, C C, in which are turned seats for the heads D D of one or more chords, E E, of flat bar-iron, which unite the ends of the arch.

The posts F F and the tie-rods G G may be formed with eyes at their lower ends, which are secured between the chords E E by bolts *b b*, as shown in figs. 2 and 7, while the upper ends of the said posts and tie-rods are passed through the channel-bars H or L in the arch, and are secured by nuts *c c* and *d d*, as shown.

If it is found desirable not to punch holes in the chords E for the bolts *b*, the posts F may be attached to said chords by means of jam-nuts *h h*, which bind the clamping-pieces *i* and *j* (through which are passed the posts F) firmly to the chords E E, the tie-rods G' and G' being, in this case, passed through the lower clamps *j*, and secured by nuts *k k*, as seen in fig. 3.

The ends of the posts F may also be attached to the arch by passing them through the flanges *a a*, as shown in fig. 3, or by passing them through the web of the arch-pieces, as shown in fig. 8.

The tie-rods G' may also be attached to the arch by means of the plates N, riveted to the lower flanges *a' a'*, and provided with an axial rivet which passes through an eye at the upper end of the tie-rod, as shown in fig. 3.

A convenient mode of attaching both post and tie-rod to the arch is shown in figs. 3 and 8, where M represents a stirrup riveted to the flanges *a a*, and provided with a hole at its bottom, through which is passed the post F'.

The tie-rod G' is made with an eye, *g*, at its upper end, which fits over the post F', and both post and tie-rod are secured by the nut *c'*, as shown.

Having thus fully described our invention,

What we claim as new, and desire to secure by Letters Patent, is—

1. The combination of the arch-pieces A A with curved webs A and edge flanges *a a' a a'*, thimbles *f*, or channel-bars H, and broad plate B, the several parts being arranged and united by rivets or their equivalents, substantially as and for the purpose specified.

2. The combination of the arch-pieces A A with curved webs A and edge flanges *a a' a a'*, channel-bar H or L, arch-pieces A' A', with edge flanges *a a' a a'* and channel-bar K, the several parts being arranged and combined by rivets or their equivalents, substantially as and for the purpose specified.

3. The combination of the arch-pieces A A with curved webs A and edge flanges *a a' a a'*, channel-bar H or L, arch-pieces A' A' with edge flanges *a a' a a'* and thimbles *f f*, the several parts being arranged and combined by rivets or their equivalents, substantially as and for the purpose described.

4. The combination of the arch, composed of the arch-pieces A A A' A', with curved or polygonal webs and edge flanges *a a'* and channel-bars H and K, arch-shoes C C, chords E E, posts F F, and tie-rods G G, the several parts being arranged as and for the purpose specified.

As evidence that we claim the foregoing, we have hereunto set our hands in the presence of two witnesses, this 28th day of June, 1869.

DAVID HAMMOND
JOB ABBOTT.

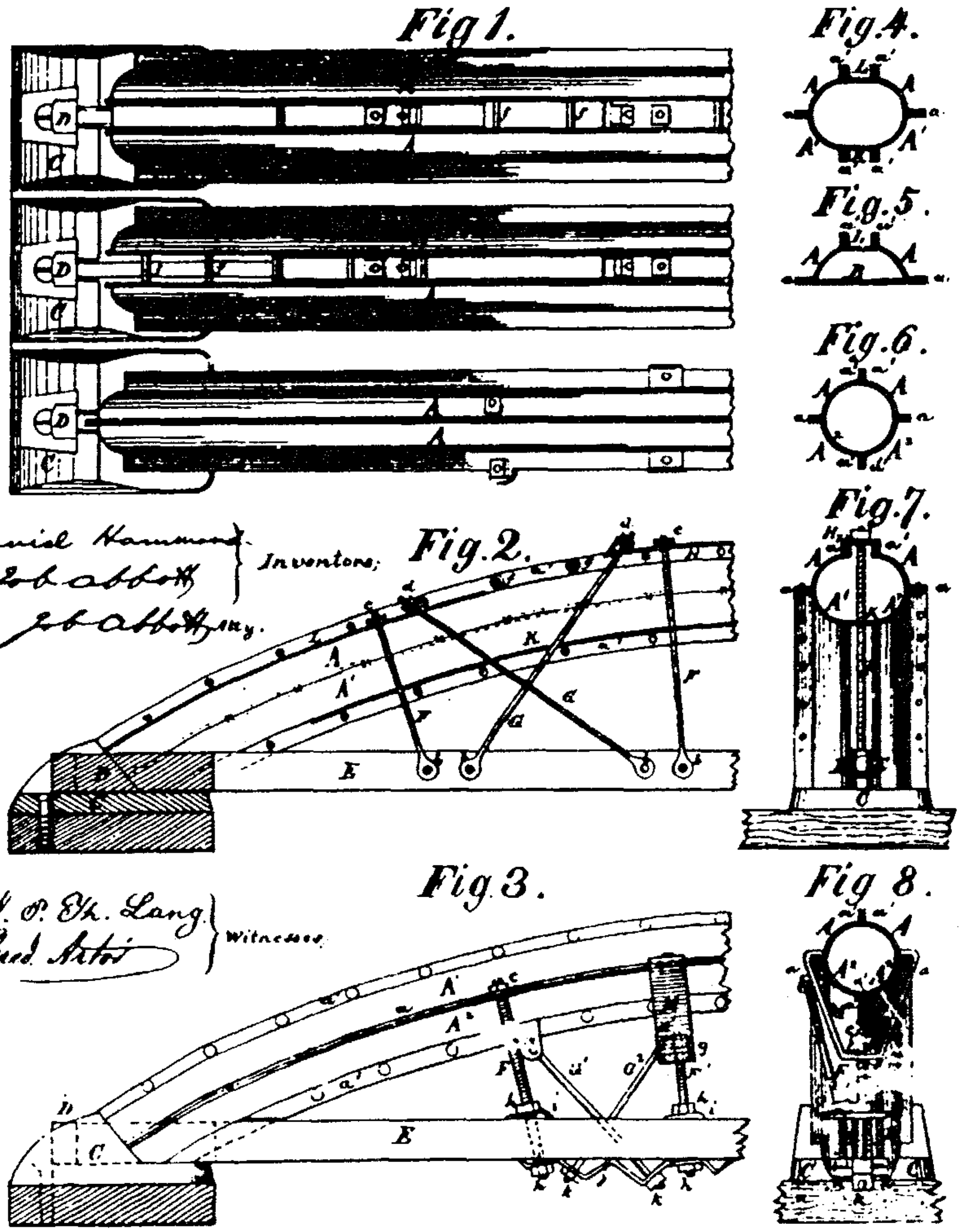
Witnesses:

[illegible] . FR. LANG,
FRED. AITOS.

Hammond & Abbott,

Truss Bridge.

No. 102,392, Patented Apr. 26, 1870



Daniel Hammond
Job Abbott
by Job Abbott Atty. } Inventors;

J. P. Th. Lang
Fred. Astor } Witnesses

UNITED STATES PATENT OFFICE.

DAVID HAMMOND, MICHAEL ADLER, AND JOB ABBOTT, OF CANTON, OHIO.

IMPROVEMENT IN IRON BRIDGES.

Specification forming part of Letters Patent No. **135,802**, dated February 11, 1873.

To all whom it may concern:

Be it known that we, DAVID HAMMOND, MICHAEL ADLER, and JOB ABBOTT, of Canton, in the county of Stark and State of Ohio, have invented certain new and useful Improvements in Arch-Girder Bridges; and that the following is a full, clear, and exact specification thereof, which will enable others skilled in the art to make and use the said invention.

It is well known to bridge constructors that the principal defect in the practical working of bow-string girders as heretofore constructed, especially in long spans, has been their want of sufficient stiffness to resist the action of a rolling load; that the lack of vertical stiffness has usually resulted from the want of sufficient compressive capacity in the posts, and the lack of lateral stiffness—first, from want of proper rigidity in the lower brace beams; second, from the imperfect manner of securing points of the arch by struts from the brace-beams; third, from the insufficient character of the overhead lateral bracing between the bridge-girders; and, lastly, from the want of sufficient lateral capacity in the arches of the girders; and that great difficulty has been experienced in overcoming these objections to this class of highway bridges, especially in this country—first, because the requirement of cheapness has prevented the use of exact and expensive details of construction in said bridges; second, because, as arch-bridges are practically constructed, it is necessary to have some adjustment in the length of the members of the vertical bracing in the girders, in order to allow for the variation in the form which the arches of the girders assume when erected in the bridge-span from the form which they have when lying on the trestles at the shop; and, lastly, because the requirement of sidewalks for highway bridges, in many cases, limits the width of the bearing between the lower beams and arches, so as to make it very difficult to obtain the proper lateral strength in long spans, where the distance between the arches and chords is very considerable.

Our invention is designed to obviate these objections to the plan of bow-string-girder construction for bridges of moderate spans, and to make it applicable to long bridge-spans, in which it has heretofore been considered inapplicable; and to this end it consists in the combination, with a bow-string girder, of an iron lattice girder brace post, which has an adjustable attachment either at the chord or arch of the girder, or at both of said points, and which is solidly secured to the lower brace-beams of the bridge and to the arch, so as to oppose the transverse stiffness of the lattice-girder to any tendency of the arch to move in a lateral direction. Said invention also consists in the combination, with the arches of the bridge-girders, of an iron lattice overhead girder, which is raised above the arches in order to give the proper headway on the bridge in cases where it could not otherwise be used, or which is used between the arches in cases where there is sufficient height to give the proper headway, and which, in either case, is rigidly secured to the arches, so as to oppose the transverse stiffness of the lattice-girder to any tendency to a lateral motion of the arches and girders. Said invention also consists in the combination, with the arches and brace-posts, of the bow-string girders of a bridge, of an iron lattice overhead girder, which is rigidly secured to said arches and to the lattice-posts below the arches, so as to oppose the lateral motion of the arches by both the transverse stiffness of a lattice-girder of considerable depth and by the strength of the brace-post against a force applied to bend it at a point considerably below its head, and hence acting with less leverage than if applied to the arch, as in the case of the overhead lattice-girder described in the preceding clause. Said invention also consists in the combination, with the lattice brace-posts and overhead lattice-girders of a bow-string-girder bridge, of a tension-rod extending from the outer part of the lower brace-beam across the post to the overhead lattice-girder, and acting as a tensional tie, in combination with the brace-post acting as a compressive strut in securing the arches and girders against lateral motion. Said invention also consists in the combination, with the arches of a bow-string-girder bridge, and with the lateral overhead members at the heads of the brace-posts, of lateral overhead struts secured to the arches at the heads of the intermediate posts betwee the brace-posts, and connected by half-rings at their centers to the lateral diagonal ties from the ends of the lateral members at the heads of the brace-posts, by which means the arches are secured against lateral bending at the heads of the intermediate posts without any addition of diagonal ties above those required to brace the arches only at the heads of the brace-posts. Said invention also consists in the construction of an arch composed of a central horizontal plate and two segments of the Phœnix or Keystone column on each side as the essential base of construction of the arch, and having combined therewith suitable plates, channel-bars, and column-segments, as is hereinafter more fully shown, the whole forming a double tubular arch in which the required compressive capacity for long spans is obtained in connection with such breadth of arch as to prevent any danger of lateral deflection. Said invention also consists in the combination, with the lower chords and brace-posts of a bow-string-girder bridge, of a pair of rolled channel or I beams, trussed by a hog-chain on the under side, and held from upward deflection by a tension-rod on the upper side, said pair of beams extending from girder to girder of the bridge, and forming supports for the floor-joists of the bridge, as well as brace-beams for the system of bracing for the bridge. Said invention also consists in the novel details of construction for the lateral hitch-blocks for the attachment of the lateral diagonal ties to the brace-beams or lateral girders, the girder-blocks for the attachment of the lateral overhead girders to the brace-posts, the arch-block for the attachment of the lateral overhead struts to the arch at the heads of the intermediate posts, the combined wrought and cast iron chord-plate for the attachment of the vertical diagonal ties, and the connections for the brace-beams and posts, these several improvements in detail making our before-specified improvements in bracings of easy application to the other parts of the bridge, and greatly facilitating the construction of the bridge in the shop and its erection on the bridge-site.

In the accompanying drawing, Figure 1 is an elevation of a half-span of a bow-string-girder bridge illustrating our improvements. Fig. 2 is a plan of the same, showing a half-plan of the arch and bracing and a half-plan of chords. Figs. 3, 4, and 5 are side views of posts Nos. 2, 4, and 6 of said girder. Fig. 6 is a central cross-section of bridge at post No. 8, showing the deep overhead lattice-girder and two modifications of the lattice brace-posts. Figs. 7 are enlarged detail views of the end of the raised overhead lattice-girder and its arch attachments. Figs. 8 are views of a modified form of the same. Figs. 9 are detail views of the connections for the overhead lattice-girder between the arches. Figs. 10 are detail views of the connections for the overhead lattice-girders between the arches and brace-posts. Figs. 11 are detail views of the half-ring connections at the centers of the lateral overhead struts. Figs. 12 and 13 are detail views of modified forms of the constructions shown in Figs. 10. Figs. 14 are detail views of the arch-connections for the lateral overhead struts. Figs. 15, 16, and 17 are detail views of the lower chord-connections for posts Nos. 2, 1, and 3. Figs. 18, 19, 20, and 21 are detail views of the lower chord-connections for posts Nos. 7, 4, 6, and 8. Figs. 22 and 23 are detail views of the cast thimbles for the brace-beams. Figs. 24 are elevation and plan of portion of bow-string girder, showing one form of our improved arch and brace-beam construction. Fig. 25 is an enlarged end view of the same. Fig. 26 is an end view of the brace-beams in Fig. 25. Figs. 27 are detail views of the brace-beam and post-blocks. Figs. 28 and 29 are elevation, plan, and enlarged end view of a modified form of our improved arch and brace-beams.

A is an arch of the general form described in Letters Patent No. 102,392, granted to D. Hammond and J. Abbott April 26, 1870. The ends of said arch abut against cast shoes B, which rest on the abutments, and are connected by the chords C, composed of two or more plates of iron placed edgewise and abreast, and upon which the wooden floor-joists for the bridge are usually placed. The struts or posts Nos. 1 to 8 and the diagonal ties A′ are arranged between the chords C and arch A, and iron brace-beams T are placed on the chords, usually at the foot of every other post, as in the ordinary plans of bow-string-girder construction, said brace-beams being united by diagonal ties U placed below the bridge-flooring, so as to form, with the chords C and ties U, a rigid system of lateral bracing, by which any lateral deflection of the bridge at the chord-level is prevented; the principal features of our invention consisting, first, in the improved construction of the brace-posts 2, 4, 6, and 8, by which the arch A is secured laterally from the system of bracing between the chords C; second, in the improved construction of the lateral overhead bracing, where the span of the bridge is such as to allow of the use of said overhead bracing; and, lastly, in the improved construction of the arches A, by which the lateral capacity of the arches themselves is so increased as to adapt them to very long spans.

We will describe the details of our improvements in the order indicated, that the mechanic may understand the application of our improvements to such length of spans as he may have to construct.

The triangular lattice-posts 2, 4, and 6 are specially designed for bridges without sidewalks, in which the projection of the post beyond the outer plane of the arch offers no obstruction to travel; and it is usually constructed of four angle-irons, *f f*, placed two at each side, and having between them the lattice-bars F, which are secured by rivets run through the parallel flanges of the angle-bars and the ends of the lattice-bars, and through the crossings of the lattice-bars. The flanges of the angle-bars at right angles to the plane of the posts are here shown on the inside, or toward the center of the posts; but, if preferred, they can be turned to the outside of the posts, and plates can be riveted to them to increase the capacity of the posts; or T-bars or star-iron (sometimes called X-iron) can be used at each side in place of two angle-bars, the lattice-bars being riveted to one leg of the T or X bar. The upper ends of the angle-bars *f* are riveted in the recessed faces of the flattened ends *f′* of the arch-bolt F′, (see Figs. 7, 9, and 14,) which passes through the arch A, and is secured by jam-nuts above and below the arch; and in the form of chord-connection shown in Figs. 15 the inner angle-bars *f* are bent out at *a*, to pass down on each side of the brace-beam T, and are flattened and headed below to fit between and support the chord-bars C C, which are clamped to them by through-bolts C′ C′. The lower ends of the outer angle-bars *f* have riveted between them the bolt *b*, which extends down through a cast thimble, *c*, with jam-nuts above and below, the rear end *y* of said thimble (see Figs. 22) being of the form of the cross-section of the brace-beam T, to the end of which it is secured by a strap, *c′*, which fits around the recessed part of the thimble-body, and to the web of the brace-beam, to which it is riveted or bolted; the brace-beam T being rigidly secured to the chords C in this case by a bolt, *t*, (see Figs. 15,) passing through the flanges of the beams and between the chords, with washer and nut below. The form of chord-connection shown in Figs. 19 is, however, preferable to that shown in Figs. 15, as it avoids any blacksmith-work on the angle-bars *f*. It consists of a bolt, E, having a broad flat head, *e*, which fits over the beam T, and is riveted to the bars *f*, and which passed down between the chords C through a washer, Y′, which is grooved to admit the chords, so as to hold them in position, and beneath which may be placed the tie-plate D, through which the bolt E extends, with nut below, as shown. The tie-plate D is designed to obviate the necessity of punching the chords C for a bolt to pass through the eyes on the lower ends of the diagonal ties A′, which are placed between and secured to said chords in this way in the three end panels of the girder, shown in Fig. 1, and it consists of a wrought-iron plate having its end cut out in the center and turned over to form eyes *d*, like those on the broad leaf of a strap-hinge; the ties A′ being secured to said plate by pins *d′* passing through said eyes *d d*, and through the eyes on the ends of the ties A′, which in this case extend down between the chords C′ and between the eyes *d d*, as shown in Figs. 19 Figs. 20 shows a modified form of the chord-connection in Figs. 19, two bolts, E E, being used, one on each side of the beam T, instead of the single bolt E in the former case; the beam T being held from sliding, in this as in the former case, by clamping it between the chords C and bolt-heads *e*, or the ends of the angle-bars *f*, thus obviating the use of the bolt t, shown in Figs. 15. The intermediate posts 1, 3, 5, and 7 are designed to act simply as ties or struts without aiding materially in securing the lateral stability of the arch, and are constructed of four angle-bars, *f f f f*, riveted back to back in column form, with intervening thimbles, in the form shown in detached section 8′ in Figs. 13. Their upper ends have an arch-bolt, F′, riveted into them, in the manner described in Figs. 7, by which they are attached to the arch A, and the chord-connections are made either by a headed plate, E″, riveted between their lower ends and secured between the chords C C by bolt C′, as shown in Figs. 16, or by means of two bolts, E′, riveted between the angle-bars, and run down between the chords C, and through a grooved washer, Y′, as shown in Figs. 17; or, where an adjustment in length at the lower end of post is desired, the single bolt E′ may be used, with a grooved washer, Y′, above and below the chords C, and with jam-nuts above and below said chords, as shown in Figs. 18.

The tie-piece Y shown in Figs. 18 is designed to be used in place of the tie-plate D in Figs. 19, and consists of a short piece of plate-iron with flanges bent on each edge, or of rolled channel-bar, or of rolled I-beam, having a space, *y*, cut out of its web at each end, and having its heads punched for the passage of the tie-pins *d′*. The lower grooved chord-plate Y′ is made to fit in the upper part of the piece Y, and a filling-piece may be used on its under side to form a bearing for the nut on the lower end of the bolt E′.

The form of post shown at 8, Fig. 1, and in Figs. 6, 10, 12, 13, and 21, is designed particularly for bridges with sidewalks, in which the width of the post should not exceed the width of the arch. The angle-bars *f f* composing its sides are placed parallel, instead of at an angle with each other, and are riveted to the lattice-bars F, as before described. The upper ends of these angle-bars are usually riveted to the arch-bolt F′, as before shown, and the lattice-bars may be carried to the top of the space between the angle-bars, if desired, as shown on left hand in Fig. 6; but as the posts are subject to a compression under a rolling load on the bridge, the plate V should be riveted in between the bent upper ends of the bars *f*, as shown in Figs. 10, and the lattice-bars commenced below said plate, in order to secure the angle-bars more effectively against buckling in their bent parts.

Where the sidewalk-post is used in connection with a deep overhead girder, as shown on right hand in Fig. 6 and in Figs. 13, the angle-bars *f* can be brought together near the lower edge of the overhead girder, and from thence run up to the arch-bolt F′ in a column form, as shown, their upper portions being united, in the form shown in detached section 8′, by means of rivets and intervening thimbles.

If no adjustment of the arch-and-post connection is required, the plate L′ may be riveted between the angle-bars *f*, as shown in Figs. 12, and the arch-bolt F′ be riveted to said plate, as shown, the ends of the angle-bars simply abutting against the arch-flanges, or being bent over and riveted to said flanges, as shown.

The bolts E′ are riveted between the lower ends of the angle-bars *f*, as shown in Figs. 21, and are secured in cast thimbles *c″*, which are made with a rear flange, 13, shown in Figs. 23, which fits into the brace-beam T, to which said thimbles are secured by straps 14 bent into and around the recessed body of the thimble, and lying up to the web of the beam, to which they are riveted. This connection secures the post firmly to the brace-beam instead of to the chords, as in the other forms of posts, and the beam is secured to the chords C by bolts 15, which run through thimbles *c″* (secured on each side of the beam T in the manner just shown) and pass down between the chords C, below which they are secured by washers and nuts in a manner evident from the preceding descriptions.

Where the span of the bridge is from ninety to one hundred feet and over it becomes practicable to use overhead bracing for the arch, the first form of which—the raised lattice-girder shown in Figs. 4, 7, and 8—is used where the distance between the flooring of the bridge and arch is insufficient to allow of the placing of the girder between the arches. This girder is usually constructed of four angle-bars, *g*, although T or X iron can be used, as in the brace-posts, with intervening lattice-bars G riveted at each crossing; and the end angle-bars *g′* are combined with the body of the girder by plates L K riveted in at the corners of the girder, as shown, by which a very rigid construction is effected; though, if preferred, the lattice-work G can be carried out in place of the plate L, and the plate K be omitted; or either of the plates L or K may be used and the other omitted; but the use of both plates is to be preferred. The end angle-bars *g′ g′* rest on the arch-flanges, to which they may be riveted by bending out their ends, and the bolt H is riveted to the plate L and runs down through the arch, with nut below, as shown in Figs. 7. In the modified and cheaper, though less rigid, form of construction, shown in Figs. 8, the arch-bolt H is flattened out and riveted between the angle-bars *g g*, the end angle-bars *g′* and plates L K being dispensed with.

At those points where the distance between the flooring and arch is sufficient to admit of it, the lattice-girder, shown in Figs. 5 and 9, is used, the depth of the girder being the same as that of the arch, and its ends fitting up to the arch, to which it is secured by plates O O riveted to the upper and lower angle-bars *g*, and having holes for the passage of the arch-bolt F′ at the head of the brace-post.

At those points where the distance between the bridge-flooring and the arch is considerably more than the headway required, the deep lattice-girder, shown in Figs. 6, 10, 12, and 13, is used, the object being to secure greater transverse stiffness than could be economically obtained in the shallow girders, shown in Figs. 4 and 5. These deep girders are constructed with angle-bars *g g′ g* and lattice-bars G, in the same manner as the shallow girders before described, the bars G′, of angle or T iron, being riveted at intervals on the lattice-bars, as shown in Fig. 6, to stiffen the lattice-work against buckling sidewise. The upper corners of the girders are secured to the arches A by plates O riveted to the upper angle-bars *g*, which rest on the arch A, and through which the arch-bolts F′ are passed. The lower corners of the girders are secured to the brace-posts by bolts 16, which pass between the angle-bars *f* of the posts through a washer at their back, and through a girder-block, G″, which is riveted to the lower angle-bars *g* of the overhead girders, as shown in Figs. 10 and 13, the bolt 16 being held by jam-nuts from sliding in either the girder-blocks G″, or between the angle-bars *f*, when the neck brace-posts, shown in Figs. 13, are used. The use of the girder-blocks G″ allows of the placing of the deep girder in position between the arches and posts after the bridge-girders have been raised, the bolt 16 being inserted after the girder is placed in such position, which is a great convenience in putting up the bridge, and which could not be conveniently effected were the bolt 16 riveted to the girder-flanges.

Where the straight-sided post, shown in Figs. 12, is used, the girder is attached to the arch by a T-shaped plate, O′, riveted to the girder and arch flanges, as shown, and by one or more clamping-bolts, 17, run between the angle-bars of the lattice posts and girders, and bearing on washers at each end.

As will be seen in Fig. 2, the overhead lattice-girders G, of some of the forms just described, are used at the heads of each of the brace-posts 4, 6, and 8, where the height of the arch admits of their use. But these are alternate posts in the girder; and in order to brace the arch at the heads of the other posts 5 and 7, the lateral struts Q are used, these struts usually consisting of four angle-bars, *q q*, riveted together in column form, although other forms of compression members may be used. The bolts Q′ are riveted to the ends of these angle-bars, as shown in Figs. 14, and are secured by jam-nuts in the arch-block W, which is made to fit on the arch C, where it is secured by the arch-bolt F′ of the underlying post, this mode of constructing and attaching the arch-block W being, however, susceptible of modification by the use of a wrought-iron loop in place of the block, said loop being either riveted to the arch or secured thereto by the bolt F′, and one or more additional bolts when required. The half-rings R are riveted between the angle-bars *q q* of the struts Q, as shown in Figs. 11, and on the tops of the lattice-girders G are riveted the hitch-blocks N, which are secured by rivets passing down through the body of the blocks and the flanges of the girders, and which have holes for the passage of the lateral ties, and beveled end faces for the nuts at the ends of the lateral ties, and said ties P are run from the hitch-blocks N on the first girder G to the half-ring R on the first strut Q; thence from the opposite half-ring R on the same strut to the hitch-blocks N on the next girder G, and so on, as shown in Fig. 2, thus forming a system of brace-ties between the girders G, and at the same time securing the struts Q, and consequently the points of the arches at their ends, against lateral motion. The action of the lateral ties P on the first or raised lattice-girder G tends to bend said girder over sidewise, to prevent which a tie-rod, M, (see Figs. 1 and 7,) is run from near the top of said girder to a point on the arch considerably back of the girder; or, if preferred, a strut, M′, can be used between the girder and arch, as indicated by dotted lines in Figs. 7. To aid the brace-posts 8 in resisting lateral deflection the tension-rods S are run from thimbles *c* at or near the ends of the brace-beams T, across the posts 8, to the lower angle-bars of the overhead girders G, to which they are attached, as shown in Fig. 6.

The construction and application of the lattice-posts and overhead girders to the bridge-girders being thus fully shown, their action in preventing any lateral deflection of the bridge, arches, or girders will be evident from an inspection of Figs. 4 to 6, in which the arrows L′ represent forces tending to deflect the arches and girders laterally, and the arrows R the resulting direction of strains thrown on the different parts of the bracing, from which it will be evident that no lateral motion of either the arches or girders can possibly take place without overcoming the transverse strength of one or more of the lattice members of the bracing, which are of such form that, with a very moderate amount of metal, they can be made sufficiently strong to bear any strains that may be brought upon them.

We have thus far explained our plans for increasing the lateral stability of bow-string girders simply by the aid of a more effective system of brace-posts and overhead bracing than has been before used, using, for the purpose of illustration, a moderate span of girder, with the well-known column and channel-iron arch, as being the form of arch to which these plans of lattice brace-post and girder construction have been the most extensively applied, and we will now describe our improved form of arch and brace-beam construction, by means of which the plan of bow-string girder construction can be applied to almost any required length of span: The essential features of our improved arch consist of the horizontal plate *k*, which may be made of any width required to obtain the proper lateral capacity for the arch, and to which are riveted the four column-segments *m n m n*, two at each side, as shown. With these five essential parts are combined such other segments, channel-bars, and plates as may be required to form a double tubular arch of the proper cross-section—as, for example, in Fig. 25, the four segments *n n n n* are riveted to the parts *m n k*, so as to form a double tubular arch with two tubes of a circular section, and in Figs. 29 the channel-bars *x x* and plates *w* are riveted to the parts *m n*, so as to form a double tubular arch of considerably greater capacity than that shown in Fig. 25. If a still greater capacity were required, two column-segments could be used in place of the plates *w* in Figs. 29, so as to form two arch-tubes of the same section as the arch A, shown in Figs. 9, as shown in detached section above Fig. 29, the plate *k* extending the full width of the arch, as shown, or only between the two tubes, as preferred; while, if a smaller section than that shown in Fig. 25 were desired, plates could be used in place of the column-segments shown in Fig. 25, thus forming a double tubular arch of the form shown by detached section between Figs. 24 and 25, the particular form of arch to be used in any case depending on the bridge-span and load, and being, therefore, a matter of judgment for the constructor.

The construction of the lattice-posts F in Figs. 25 and 29 and the mode of attaching them to the arches are similar to those shown in Figs. 12 and 10, and need not be further described here.

Where the span of the bridge is very long—say two hundred and fifty feet and over—the width of the roadway should be twenty feet and over, in order to secure proper lateral stiffness at the chord-level, which is the basis of all the bridge-bracing; but this width of track makes the use of wooden floor-joist, extending from chord to chord of girders, objectionable, and makes the use of iron floor-girders at the foot of each post desirable; while, in order to secure the best results in vertical stiffness in the girders, the panels should be made of considerable length—say from fifteen to eighteen feet; and this makes it desirable that each post should be a brace-post, and consequently that each iron floor-girder should act as a brace-beam, to accomplish which we make said girders of a pair of I-beams T′ T′ of moderate depth, which are trussed below, against downward deflection by the bridge-load, by a heavy hog-chain, *i*, attached to the beams next their ends by pins run through the webs of the beams, and running down under supports *i′ i′* on the under side of the beam, and which are held against upward deflection by the outward movement of the arches by a tension-rod, *i*, having an adjustable center support, *j*, on the beams T'.

Three plate-chords, C, are shown in Figs. 24 and 25, in which case the girders T' T' are secured to said chords by bolts 22 run down between the chords, through the grooved washers Y' above and below the chords, and the tie-plate D for the double set of diagonal ties A', down between the beams T' T', beneath which they are secured by washer and nuts.

The bolts E' are riveted to the angle-bars of the post F, and are secured by jam-nuts in the hole 21 of the piece *l*, (see Figs. 27,) which has the lugs 20 20 at its sides, and which fits in between the beams T', where it is secured by bolts *k* run through the webs of the beams and the lugs 20'.

In Figs. 28 and 29 four chords, C, are used, which are arranged in pairs under the sides of the post F, in which case the bolts E', riveted to the angle-bars of said posts, run down between the two chords and the two beams, and through the grooved washers Y' and tie-plates D, as shown, and are secured by washer and nuts below the beams, thus dispensing with the use of the bolts 22 and beam-pieces *l* in Figs. 24 and 25.

Having thus fully described our invention, what we claim therein as new, and desire to secure by Letters Patent, is—

1. The combination of an iron lattice brace-post with the arch and brace-beam of an iron bow-string bridge, said post having a vertical adjustment either at the arch or chord end, or at both of said points, substantially as and for the purpose specified.

2. The filling-plate V, in combination with the bent parts of the side bars of a lattice brace-post, F, for the purpose of preventing the buckling of said bent parts when the post is subjected to a compressive strain, substantially as specified.

3. The arch-bolt F', having a flattened head or "beaver-tail," *f'*, with recessed faces to receive post-bars *f f*, substantially as shown and specified.

4. The chord-bolt E with broad head *e*, in combination with the inside bars *f* of the lattice brace-post of a bow-string bridge, substantially as and for the purpose specified.

5. The combination, with the arches of a bow-string bridge, of an iron lattice-girder, Fig. 5, placed between said arches, and rigidly secured thereto by plates *o o* attached to its corners, and secured above and below the arch by a bolt run through said plates and arch, substantially as and for the purpose specified.

6. The combination, with the end of a raised lattice-girder for bow-string bridges, of an arch-bolt, H, rigidly secured to said girder, and extending down through the arches of said bridge, substantially as and for the purpose specified.

7. A raised lattice-girder for bow-string bridges, having its end bars *g' g'* arranged with bearings on the extreme horizontal parts of the arch A, and with a bolt, H, rigidly securing it to said arch, substantially as specified.

8. The combination, with the raised lattice-girder, Figs. 7, and arch A, of a tie, M, or strut M', for holding said girder against the action of the lateral ties P, substantially as specified.

9. The combination, with the arches and brace-posts of an iron bow-string bridge, of the deep iron lattice-girder, Figs. 6 and 13, secured to the arches at its upper corners by a plate, *o* or *o'*, and at its lower corners to the posts at points considerably below the arches by one or more bolts, 16 or 17, substantially as and for the purpose specified.

10. The girder-block G'', secured on the lower corners of the deep lattice-girders specified in preceding clauses, substantially as and for the purpose specified.

11. The combination, with the brace-beam, post, and overhead lattice girders of a bow-string bridge, of a tension-rod, S, extending from the outer post of brace-beam across the post to the overhead lattice-girder, substantially as and for the purpose specified.

12. The lateral hitch-blocks N for the attachment of the lateral ties to the brace-beams or overhead girders, said blocks having holes arranged for the passage on both ties and beveled end faces for the nuts of said ties, and being secured to said beam or girder by bolts or rivets passing through the body of the block and the flanges of the beam or girder, substantially as specified.

13. The lateral compressive strut Q, secured to the arches of a bow-string bridge at the heads of the intermediate posts, and connected at its center by lateral ties to the ends of the lateral strut or girder at the head of the brace-posts, substantially as and for the purpose specified.

14. The arch-block W, rigidly secured to the arch A, and having an eye or hole, in which the end bolt of the lateral strut Q can be secured by jam-nuts, substantially as specified.

15. The grooved washer Y' and wrought-iron tie-plate D, in combination with the chords C and post-bolt E or clamping-bolt 22, substantially as and for the purpose specified.

16. The tie-plate Y, consisting of a short piece of flanged iron plate or its equivalent, having its web cut away at *y y*, and with holes formed in its flanges for the insertion of the tie-pins *d'*, substantially as specified.

17. The cast end thimble *c*, having its end of the form of the section of the brace-beam T, and secured thereto by strap *c'*, fitting into the recessed part of thimble-body, and to the web of the brace-beam, substantially as specified.

18. The cast side thimble *c''*, having a rear flange, 13, fitting between the flanges at the brace-beam T, and secured thereto by strap

14, fitting into recessed part of thimble-body, substantially as specified.

19. A wrought-iron double tubular arch, having as the base of construction a horizontal plate, with two column-segments at each side, said base having combined with it suitable plates, channel-bars, and segments, to form an arch of the required cross-section and lateral capacity, substantially as is herein specified.

20. The combination, with the lower chords and brace-posts of a bow-string bridge, of a pair of rolled I or channel beams, trussed by a hog-chain on the under side, and held from upward deflection by a tension-rod on the upper side, substantially as and for the purpose specified.

As evidence of the foregoing, witness our hands this 25th day of September, A. D. 1872.

DAVID HAMMOND.
MICHAEL ADLER.
JOB ABBOTT.

Witnesses:
JENNIE M. GRANT,
GEORGE E. BUCKLEY.

6 Sheets--Sheet 1.

D. HAMMOND. M. ADLER & J. ABBOTT.

Iron-Bridges.

No. 135,802. Patented Feb. 11, 1873.

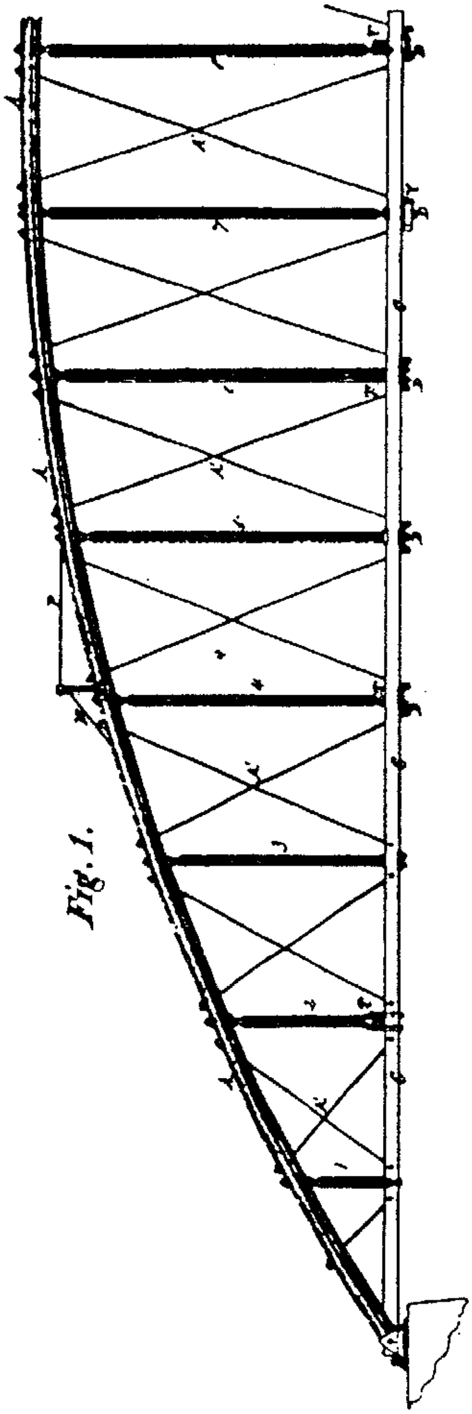


Fig. 1.

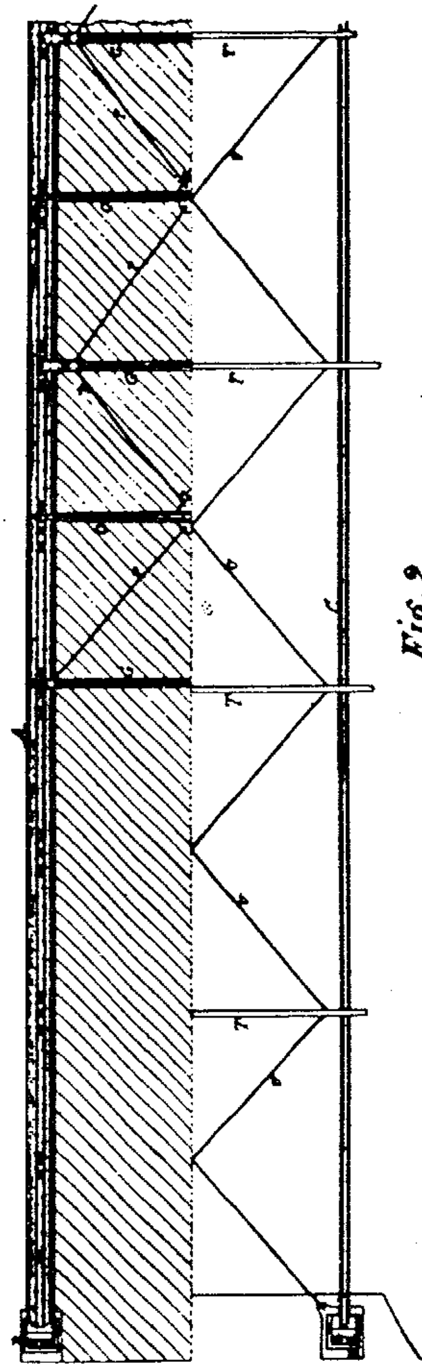


Fig. 2.

Witnesses: George E. Lushpky, Jennie M. Grant

Inventors: David Hammond, Michael Adler, Job Abbott, by Job Abbott Attorney.

6 Sheets--Sheet 2.

D. HAMMOND, M. ADLER & J. ABBOTT.

Iron-Bridges.

No. 135,802. Patented Feb 11, 1873.

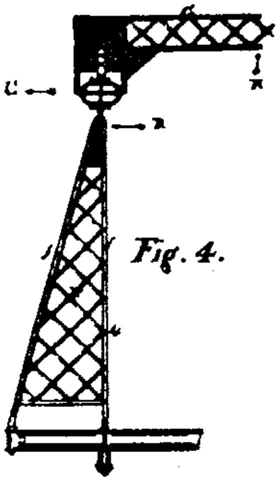


Fig. 4.

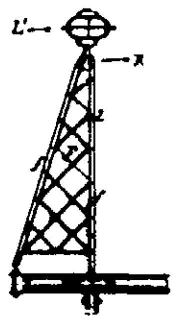


Fig. 3.

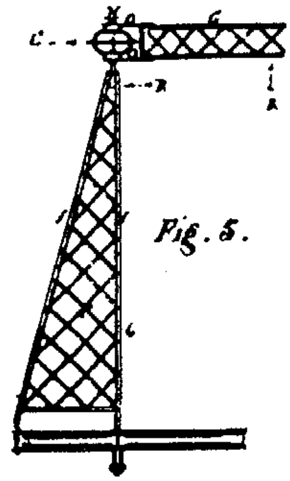


Fig. 5.

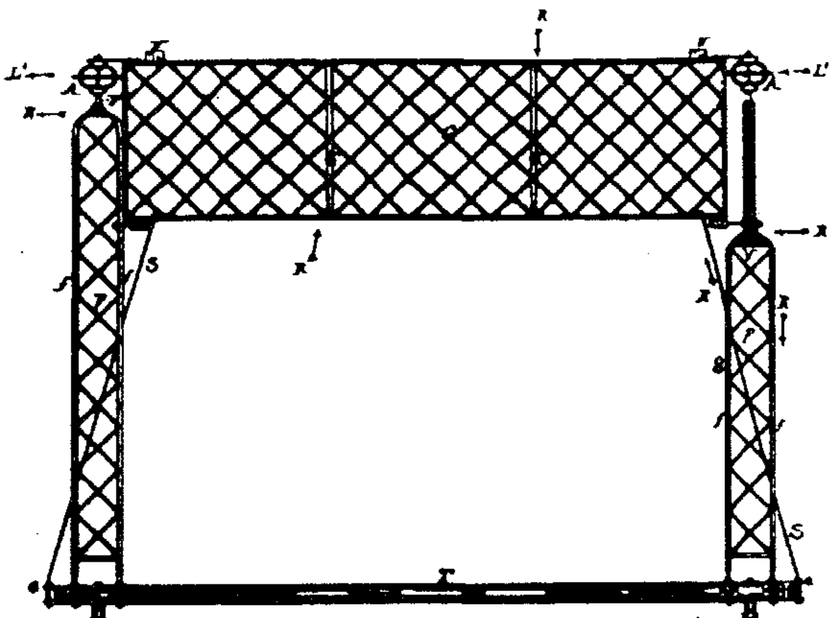


Fig. 6.

George E. Buckley
Jennie M. Grant
} Witnesses.

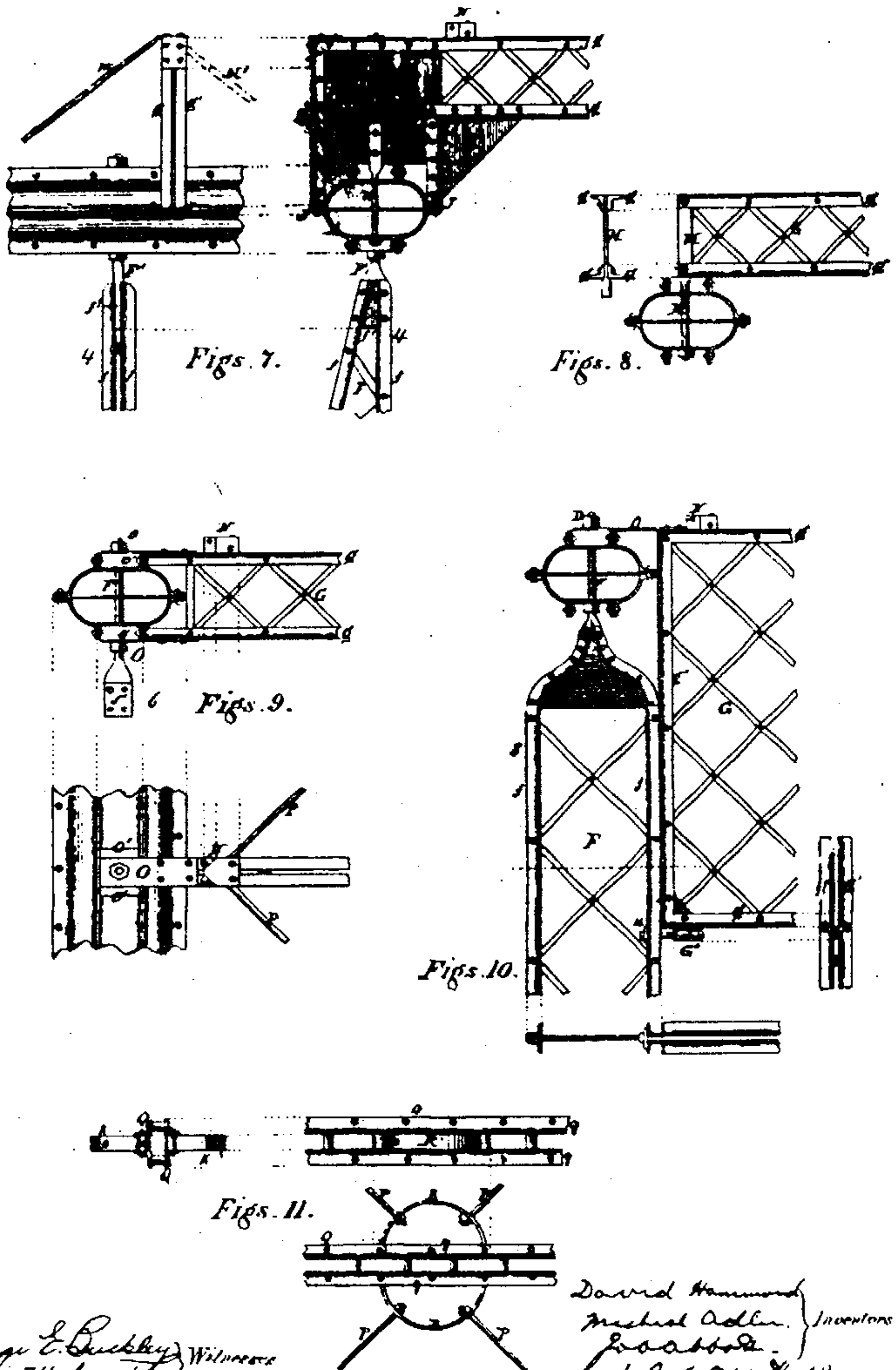
David Hammond
Michael Adler.
Job Abbott
} Inventors
by Job Abbott Attorney

6 Sheets--Sheet 3.

D. HAMMOND, M. ADLER & J. ABBOTT.

Iron-Bridges.

No. 135,802. Patented Feb. 11, 1873.



George E. Buckley
Jordan M. Grant } Witnesses

David Hammond
Michael Adler
J. O. Abbott } Inventors
by Job Abbott, Attorney.

AM. PHOTO-LITHOGRAPHIC CO. N.Y. (OSBORNE'S PROCESS.)

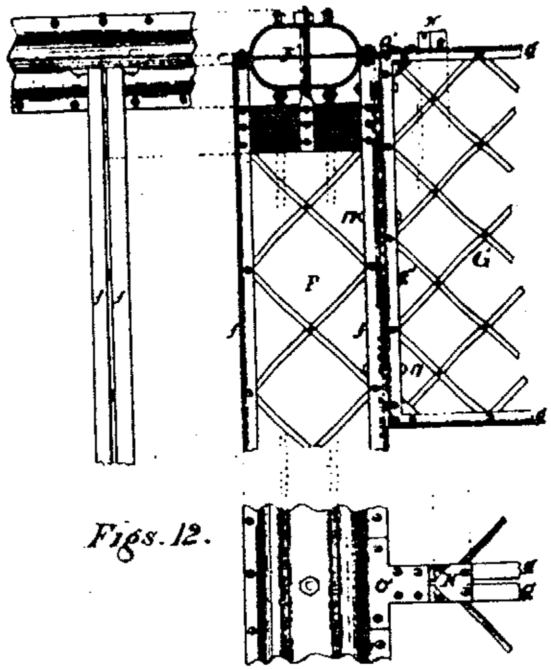
6 Sheets--Sheet 4.

D. HAMMOND, M. ADLER & J. ABBOTT.

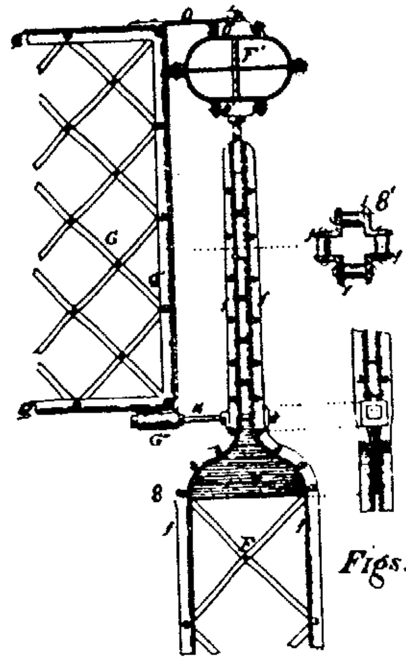
Iron-Bridges.

No. 135,802.

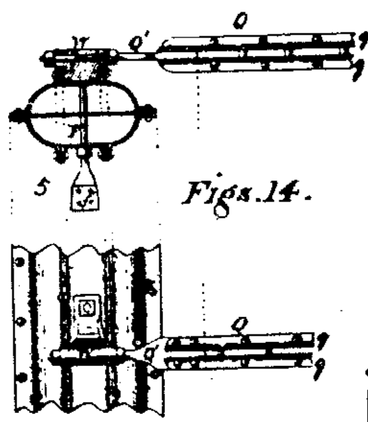
Patented Feb. 11, 1873.



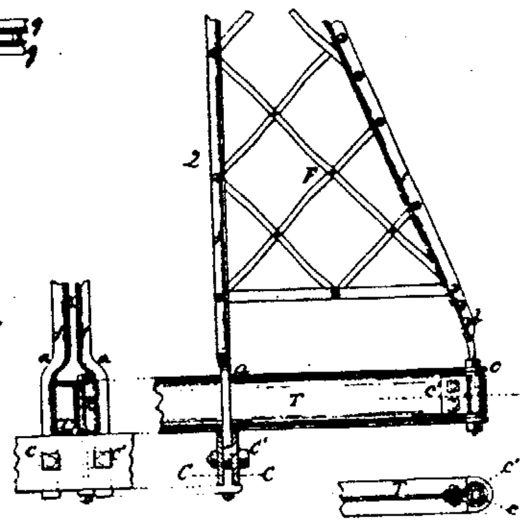
Figs. 12.



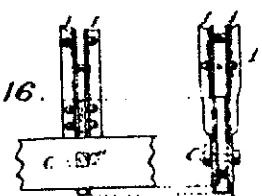
Figs. 13.



Figs. 14.



Figs. 15.



Figs. 16.

George E. Buckley
Jahme M Grant } Witnesses.

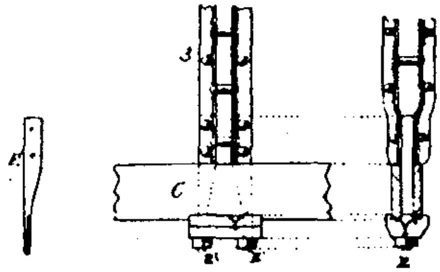
David Hammond.
Micheal Adler
J. B. Abbott } Inventors
by J. B. Abbott Attorney.

6 Sheets--Sheet 5.

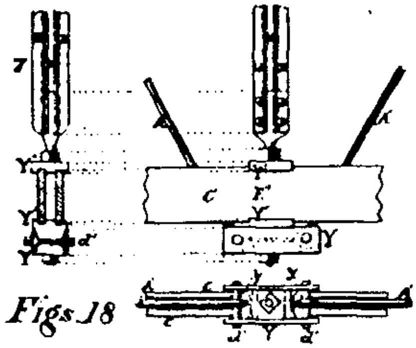
D. HAMMOND, M. ADLER & J. ABBOTT.

Iron-Bridges.

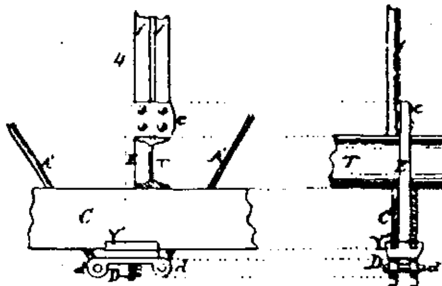
No. 135,802. Patented Feb. 11, 1873.



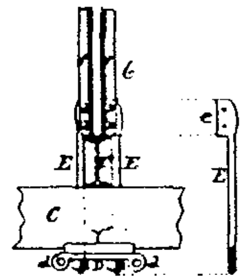
Figs. 17.



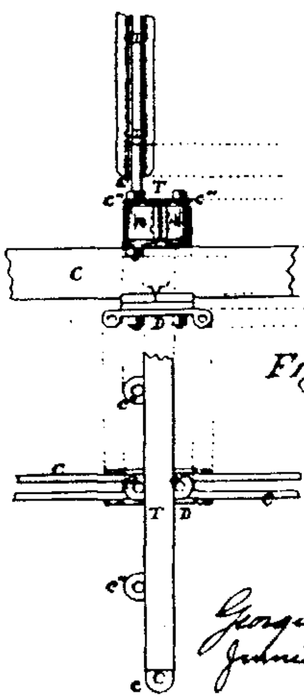
Figs. 18

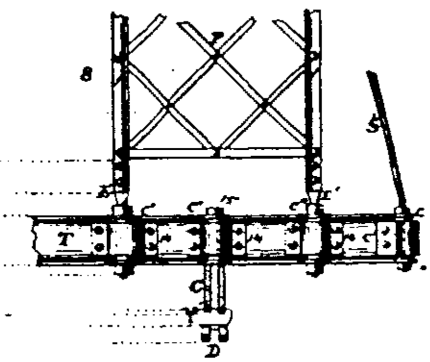


Figs. 19.



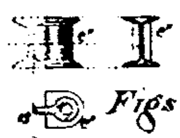
Figs. 20.





Figs. 21.

Figs. 22.



Figs. 23.

George E. Tuckley } Witnesses.
Jennie M. Grant }

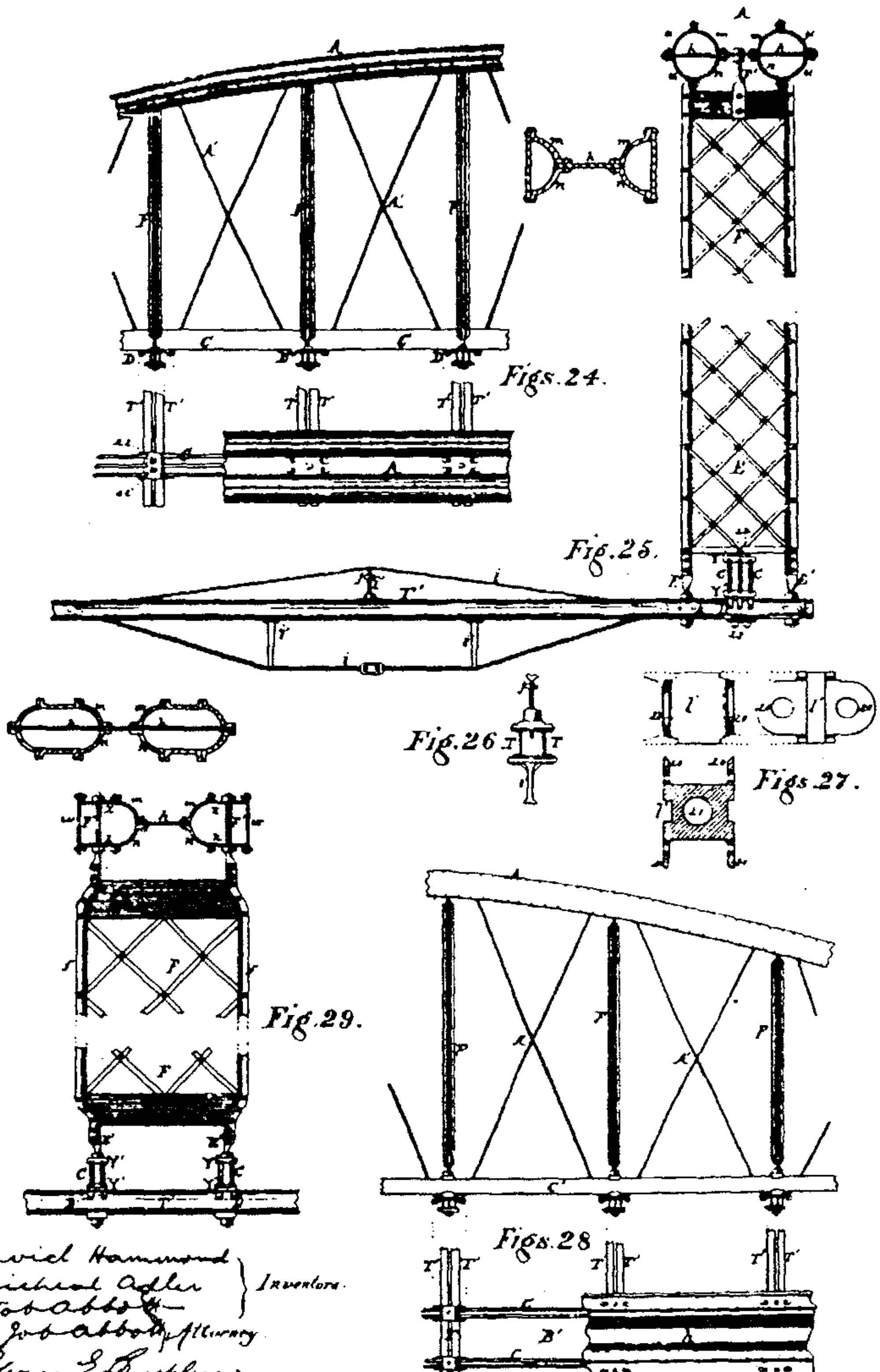
David Hammond }
Michael Adler } Inventors
Job Abbott }
by Job Abbott Attorney.

6 Sheets--Sheet 6.

D. HAMMOND, M. ADLER & J. ABBOTT.

Iron-Bridges.

No. 135,802. Patented Feb. 11, 1873.



David Hammond
Michael Adler
Job Abbott
by Job Abbott, Attorney
} Inventors.

George E. Buckley
Johnie M. Grant.
} Witnesses.

UNITED STATES PATENT OFFICE.

JOB ABBOTT, OF CANTON, OHIO, ASSIGNOR TO WROUGHT IRON BRIDGE COMPANY, OF SAME PLACE.

IMPROVEMENT IN METALLIC ARCH-BRIDGES.

Specification forming part of Letters Patent No. 184,490, dated November 21, 1876; application filed August 19, 1876.

To all whom it may concern:

Be it known that I, JOB ABBOTT, of Canton, in the county of Stark and State of Ohio, have invented certain new and useful Improvements in Arch-Bridges; and that the following is a full, clear and exact specification thereof, which will enable others skilled in the art to make and use the said invention.

My invention is designed to obviate the difficulty experienced in constructing long-span arch-bridges, of getting the diagonal ties to lie at or near the proper angle, to secure stiffness and economy without making the panels of too great length, as well as to effect a saving of material by reducing the number of posts required; and to this end it consists in connecting the diagonal ties in each panel of an arch-bridge at or near the center of the panel and uniting this point of support with the upper and lower chords of the girder; also in securing the center of the intermediate post of an arch-bridge by means of rods from said central diagonal-tie connections, thus reducing the effective length and increasing the stiffness of said post, as is hereinafter more fully shown.

The accompanying drawing is a view of the central panels of an arch-bridge embodying my invention.

A is an arch of any desired form of section. B is the lower chord, and C D C are the girder-posts, which are usually made widest laterally, to aid in holding the arch against lateral deflection. K is the center diagonal connection, which is here shown as being made of two plates of circular form, between which the eyes on the diagonal rods are secured by bolts run through the plates and eyes, although a pin-and-eye connection may be used instead, if preferred, especially when double ties are used. The diagonal ties E F G H are made in two lengths, the lower parts E G being secured by eyes to the lower chords B and center plates K, and the upper parts F H being secured by eyes in said center plates, and having their upper ends run through the arch A with washer and nut above for tightening up the rods. The suspension-rods I are secured to the center-plate K and lower chords B, and thus serve as supports for the chords midway between the posts, and the rods J run from the center plate K to the arch A and serve to hold the arch against buckling upward, as well as to transfer a portion of the load on the chords to the arch. The rod L has its ends secured between the plates K, and is run through and secured in the web of post D by jam-nuts, thus holding said post from bending longitudinally at the center.

The advantages resulting from this construction will be more readily seen on applying it to a long span of two hundred feet or more, although it can be economically used in spans of one hundred feet and over.

A two-hundred-foot span is ordinarily made with fourteen panels, of about fourteen feet length, and is usually twenty-five feet deep, so that the center ties have a vertical height of about twenty-five feet in fourteen feet, instead of running at the economical angle of forty-five degrees, and each girder requires thirteen posts.

If the eight central panels be made into four double panels, as would be done in applying this plan of construction, it is seen that four of the posts will be replaced by light suspension-rods I J, thus reducing the number of posts to nine, that the three longest remaining posts will be held at the center by rods L, thus halving their length and reducing their cross-section, and that the central diagonal ties will be laid down at an angle of much nearer the economical angle, besides being much reduced in total length, thus materially lessening the cost of the girder, and at the same time increasing its stiffness.

What I claim herein as new, and desire to secure by Letters Patent, is—

1. The connection of the diagonal ties in a panel of a bow-string arch-bridge with each other, and with the arch and chord of said bridge at their intersection, substantially as and for the purpose specified.

2. The attachment of the center of an arch-post with the connection of the diagonal ties at their intersection, substantially as and for the purpose specified.

As evidence of the foregoing, witness my hand this 5th day of August A. D. 1876.

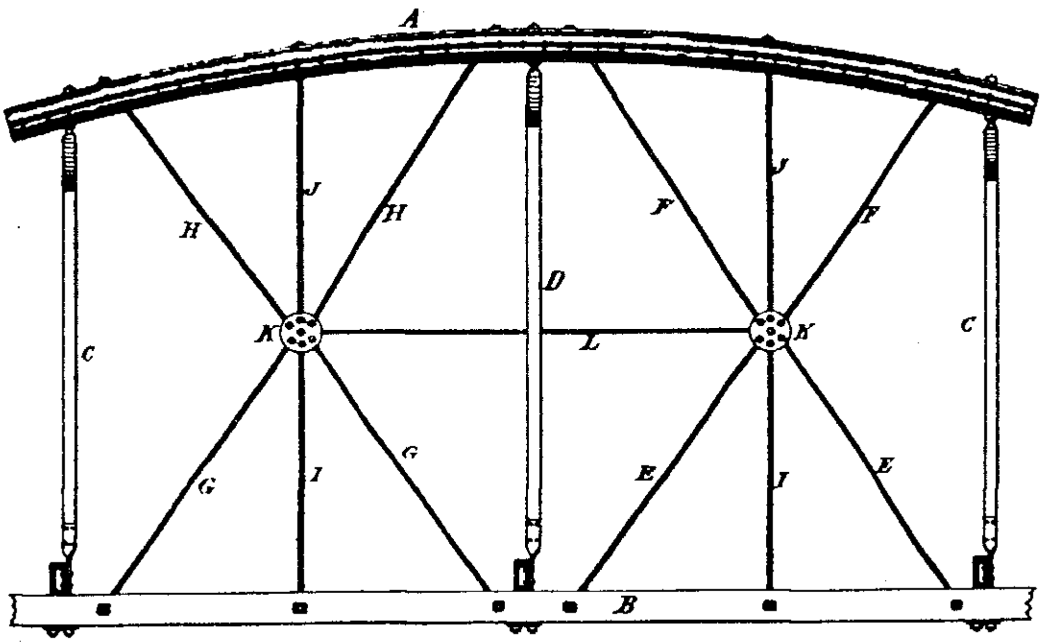
JOB ABBOTT.

Witnesses:
ELVIRA SNYDER.
RUTH K. ABBOTT.

J. ABBOTT.

METALLIC ARCH BRIDGES.

No. 184,490. Patented Nov. 21, 1876.



Ruth L. Abbott
Andrew Chaffin } Witnesses

Job Abbott Inventor.

UNITED STATES PATENT OFFICE

DAVID HAMMOND, HENRY G. MORSE, AND JOB ABBOTT, OF CANTON, OHIO

IMPROVEMENT IN TRUSS-BRIDGES.

Specification forming part of Letters Patent No. 184,520, dated November 21, 1876; application filed August 19, 1876.

To all whom it may concern:

Be it known that we, DAVID HAMMOND, HENRY G. MORSE, and JOB ABBOTT, of Canton, in the county of Stark and State of Ohio, have invented certain new and useful Improvements in Truss-Bridges; and that the following is a full, clear, and exact specification thereof, which will enable others skilled in the art to make and use the said invention.

Our invention relates to certain improvements in the construction of truss-girders for bridges and other structures, by which greater economy and stiffness in construction is secured.

Said improvements consist in the construction of a truss-girder with pin-connections, having the posts held longitudinally at or near their centers by means of diagonal ties, which run through and have jam-nuts and washers on each side of the post, thus halving the length and increasing the stiffness of posts without the addition of useless or unsightly rods in the girder; also, in arranging the screw end of the diagonal tie which passes through the post so as to serve both as the screw for the nuts by which the post is held at the center, and as a screw for the sleeve-nut, by which the length of the rod is adjusted; also, in the construction of a truss-girder in which the main ties run from the head of one post to the foot of the next post, or across one panel, and the counter-ties run from the head of one post across the next post to the foot of the second post, or across two panels, by which arrangement the posts of a single intersection-truss can be held longitudinally at the center by the counter-ties; also, in the construction of a truss-post having the cross-section below the floor-beam greater than the cross-section above said beam, thus adapting the post economically to partial-deck spans; also, in the construction of the lower chord-bars of a truss-girder in pairs running across two or more panels, with secondary chord-bars running over single panels, and taking up the longitudinal strain from the intermediate diagonal ties, thus reducing the number of heavy bar-heads and chord-pins; also, in the construction of the upper corners of a wrought box-chord truss-girder by planing the end post to fit under the end of the upper chord, and uniting the two posts by inside plates and corner-pin, with additional beveled bearing-plates for battered end trusses, thus forming an economical all wrought-iron corner-connection, all of which is hereinafter more fully shown.

In the accompanying drawing, Figure 1 is an elevation of half-girder embodying our improvements. Fig. 2 is a partial plan of lower chords. Fig. 3 is a cross-section through the line x x in Fig. 1, and Fig. 4 is a view of corner-connection.

A is the upper chord, and B the end post, made of channel-bars and plate, in the ordinary form. The upper end of post B is planed off to fit under the end of chord A, and inside plates f f are riveted in the post and up between the chord channel-bars, as shown. The chord ends are re-enforced by plates d when required, and the corner-pin x runs through the chord ends and the plates ff, thus uniting the chord and end posts, the bearing-plates e e being riveted on the inside of the chord-channels against the plates ff, to take up part of the longitudinal thrust of the post.

The diagonals D D^1 D^2 are eye-bars of ordinary form, as also are the chord-bars E F G, the end chord-bars E being run over the two end panels, in the usual manner.

Instead of running the chord-bars in the intermediate panels in single lengths, as has been the previous practice, the bars F F run across two panels, or from post C to C^2, and an intermediate bar, G, is put in between posts C and C^1, to take up the longitudinal strain from the diagonal tie D^1, thus saving the four large bar-heads and heavy pin usually required at post C, and using only a short pin and lighter bar-head for bar G at said point.

The posts C C^1 C^2 are made of two channel-bars as principal members, and are arranged to receive the floor-beams M for a "partial-deck" truss, having the floor midway between the upper and lower chords. Above the beams M the posts are made of proper cross-section to sustain the vertical strain from the ties d^1 d^2, the channels being united by double-riveted cross-bars b b, while below said beams the cross-section of the post is increased by means of the plate K sufficiently to sustain the additional load brought upon it by the beam M.

The counter-ties H H run across two panels, as shown, being secured to the upper and lower chords at their ends. They are run through the posts C C near the center, and have the sleeve-nuts *h* placed near the post, as shown, so that the screw end on the upper half of the tie serves as a screw end for the sleeve-nut *h*, and also forms a screw for the jam-nuts *a a*, which, with the oblique washers *c c*, act to clamp the tie in the post.

In the double-intersection form of truss, where both diagonal and counter ties run across two panels, the posts near the ends, where no counter-ties are required, can be economically held at the center by a rod placed between the main diagonal ties, which can be reduced in section to an amount equal to the section of this center rod.

The advantages resulting from securing the centers of the posts in a pin-connection truss will be more evident by noticing that the posts have rounded ends in the longitudinal direction, in which they are held by the ties, while their bearings in a lateral direction, or in the line of the pins, are square-ended; and as the strength of a round-ended post is equivalent to a square-ended post of twice its length, with same diameter, by making the post twice as wide laterally as it is longitudinally, and holding it at the center, as specified, it will have the same strength as a square-ended post of the same section, and with both its lateral and longitudinal dimensions equal to the lateral diameter of the centrally-held post. The strain on the center post C^2 of the truss is usually so small as to make it unnecessary to hold said post in the center, in which case the center counter-tie I is only run across one panel.

What we claim herein as new, and desire to secure by Letters Patent, is—

1. A pin-connection truss having the posts held longitudinally at the center by diagonal ties run through and secured by jam-nuts and washers in the posts, substantially as and for the purpose specified.

2. The combination, with a truss-post, of a diagonal tie having sleeve-nut adjustment, and with one screw end for said sleeve-nut secured by jam-nuts and oblique washers in said post, substantially as and for the purpose specified.

3. A truss-girder having the main diagonal ties run across one panel, and the counter-ties run across two panels, and secured to the posts at the center, substantially as and for the purpose specified.

4. A truss-post for partial-deck spans, having the section below the floor-beams greater than the section above said beams, substantially as and for the purpose specified.

5. The construction of the lower chords of a truss-girder in pairs, running over two or more panels, with intermediate bars to take up the strains from intermediate diagonal ties, substantially as and for the purpose specified.

6. The within-described corner-connection for box-chord trusses, formed by fitting the end post under the chord end, and uniting the same by inside plates, bearing-plates, and corner-pin, substantially as and for the purpose specified.

As evidence of the foregoing, witness our hands this 26th day of July, A. D. 1876.

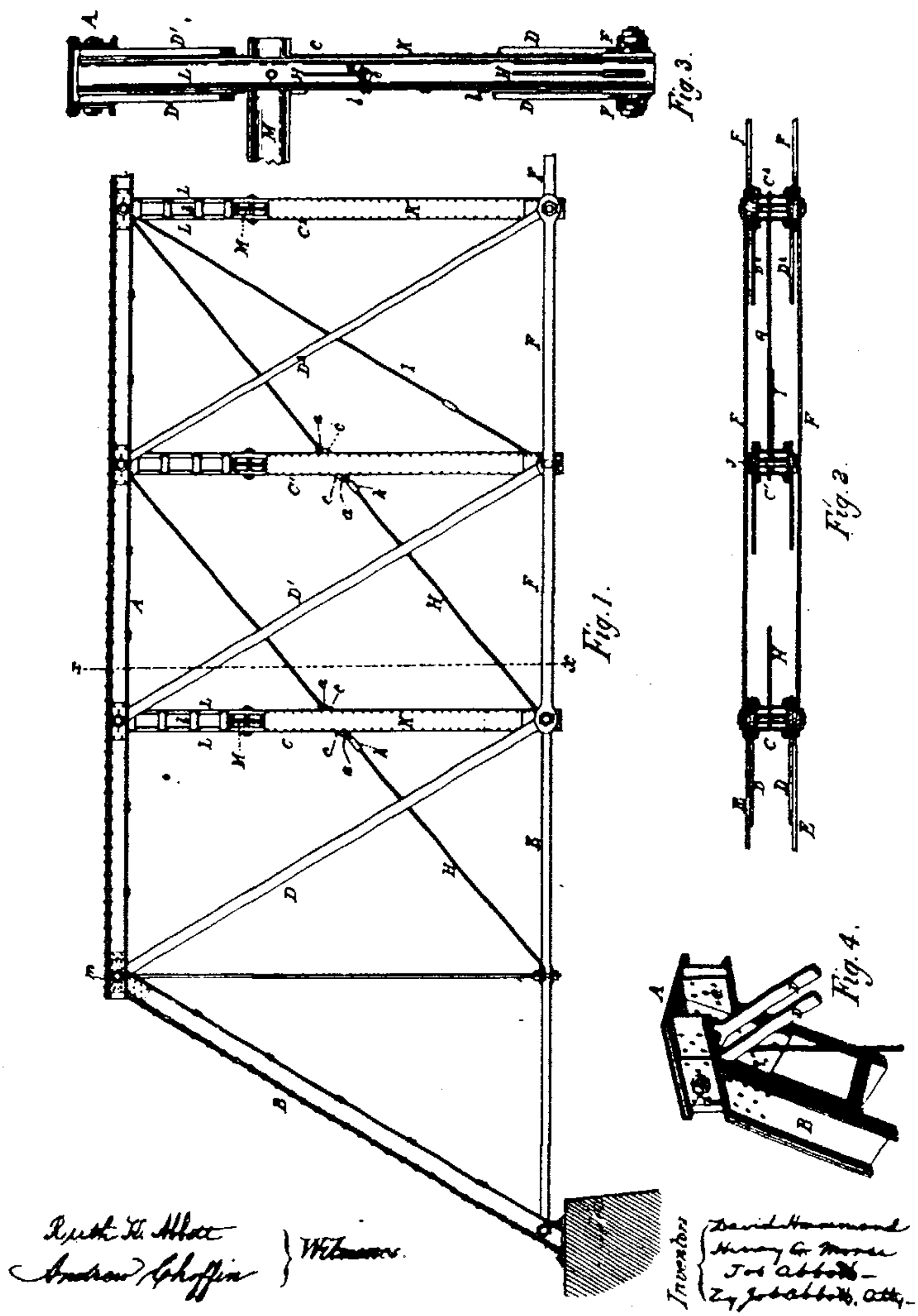
DAVID HAMMOND.
H. G. MORSE.
JOB ABBOTT.

Witnesses:
WM. BRITTON,
E. W. ECKERT.

D. HAMMOND, H. G. MORSE & J. ABBOTT.

TRUSS BRIDGE.

No. 184,520. Patented Nov. 21, 1876.



UNITED STATES PATENT OFFICE.

DAVID HAMMOND, OF CANTON, OHIO, ASSIGNOR TO WROUGHT IRON BRIDGE COMPANY, OF SAME PLACE.

IMPROVEMENT IN WROUGHT-IRON POSTS.

Specification forming part of Letters Patent No. 184,521, dated November 21, 1876; application filed August 19, 1876.

To all whom it may concern:

Be it known that I, DAVID HAMMOND, of Canton, in the county of Stark and State of Ohio, have invented certain new and useful Improvements in Wrought-Iron Posts; and that the following is a full, clear, and exact specification thereof, which will enable others skilled in the art to make and use the said invention.

My invention consists in the construction of a wrought-iron post composed of a central plate or lattice-web and two T-bars, provided with ribs on the inner edges of the heads, as is hereinafter more fully shown.

In the accompanying drawing, Figure 1 is a view of post embodying my improvement, and Fig. 2 is a section of same on line *x x*.

A is the web of the post, and B B are the T-bars, the legs C of which are secured by rivets *a* to web A. The T-heads B are made with flat backs, being made flat to allow of additional plates D being riveted on, to increase the cross-section of post, as indicated in dotted lines in Fig. 2.

The legs C can be made on one side of the center of the head B, if desired, so as to bring the web A into the axis of the post.

When used in bridges the chord-connections for the post ends are easily made by riveting on plates E and drilling them to receive the pins F.

The advantages resulting from this form of construction consist in a reduced cost, the plate and T-bars being cheaper iron than the rolled I-beam, and the labor being less than that of uniting a web with four angles; also, in the increased width of head and concentration of metal at the edges of the head, which increases the stiffness and strength of the same amount of cross-section over the I-beam post form.

What I claim as new, and desire to secure by Letters Patent, is—

1. The T-bars B C, having a flat head, with ribs *b b* on the inner edges thereof, substantially as and for the purposes specified.

2. The within described post, consisting of the web A and T-heads B B, having ribs *b b* on the inner edges of their heads, substantially as and for the purpose specified.

As evidence of the foregoing, witness my hand this 7th day of August, A. D. 1876.

DAVID HAMMOND.

Witnesses:

WM. BRITTON,
JOB ABBOTT.

D. HAMMOND.

WROUGHT-IRON POST.

No. 184,521. Patented Nov. 21, 1876.

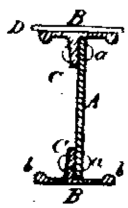


Fig. 2.

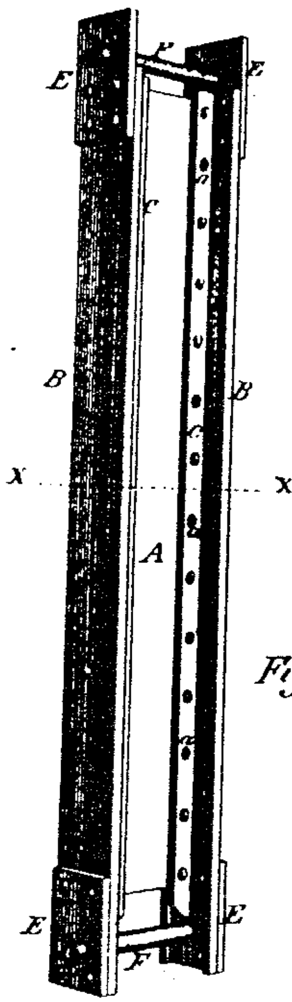


Fig. 1.

Ruth H. Abbott
Andrew Chaffin } Witnesses

David Hammond Inventor
by Job Abbott Attorney.

UNITED STATES PATENT OFFICE.

DAVID HAMMOND, OF CANTON, OHIO, ASSIGNOR TO WROUGHT IRON BRIDGE COMPANY, OF SAME PLACE.

IMPROVEMENT IN WROUGHT-IRON GIRDERS.

Specification forming part of Letters Patent No. 184,522, dated November 21, 1876; application filed August 19, 1876.

To all whom it may concern:

Be it known that I, DAVID HAMMOND, of Canton, in the county of Stark and State of Ohio, have invented certain new and useful Improvements in Wrought-Iron Girders; and that the following is a full, clear, and exact specification thereof, which will enable others skilled in the art to make and use the said invention.

My invention consists in the construction of a wrought-iron girder composed of a T-bar, upper head made with ribs on its under edges, and of a plate or lattice-web with lower head of T-bar, angles, or angles and plate, as is hereinafter more fully shown.

In the accompanying drawing, Figure 1 is a view of girder made with lattice web and T-bar, upper and lower heads; and Fig. 2 is a view of girder made with T-bar, upper head, plate, web, and angle, and plate lower head.

The head A consists of a T-bar made with leg B, and having its head flat on top, and provided with ribs *a a* on its under edges. The leg B can be placed at one side of the center of the head, to secure a symmetrical appearance, if desired. The head, being made flat on top, allows the addition of cover-plates when desired, for additional section at the center or along the whole length of the head. The web C of plate or lattice-bar is riveted to the leg B of the upper head A, and the lower head of the girder can be made of a second T-bar, A′, or of two angles, D D, with a plate, E, if desired, for extra section, as shown.

The advantages of this construction will be evident on considering that the upper head of the girder acts under compression, and when the girder is loaded this head has a tendency to give way by bending sidewise. Consequently, by making such head wide and in one solid piece, and then concentrating the metal in the ribs on the edges of the head, where it has the greatest effect to prevent crushing or cockling the head, the same amount of head-section will make a much stronger girder than when used in the ordinary I-beam or angle-bar form of head.

What I claim as new, and desire to secure by Letters Patent, is—

A wrought-iron girder having an upper T-head made with flat top and ribs on its under edges, in combination with a plate or lattice-web and T or angle lower head, substantially as and for the purpose specified.

As evidence of the foregoing witness my hand this 7th day of August, A. D. 1876.

DAVID HAMMOND.

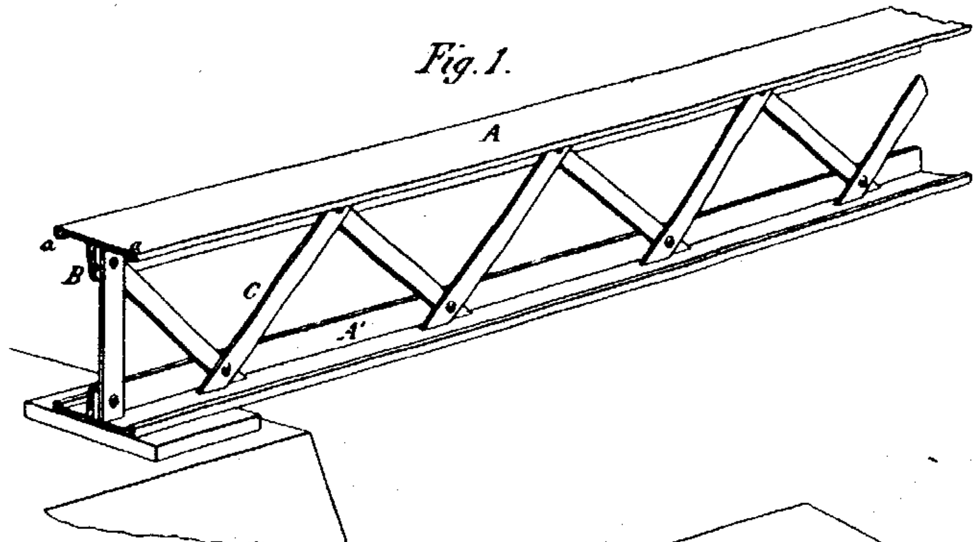
Witnesses:
WM. BRITTON,
JOB ABBOTT.

D. HAMMOND.

WROUGHT-IRON GIRDER.

No. 184,522. Patented Nov. 21, 1876.

Fig. 1.



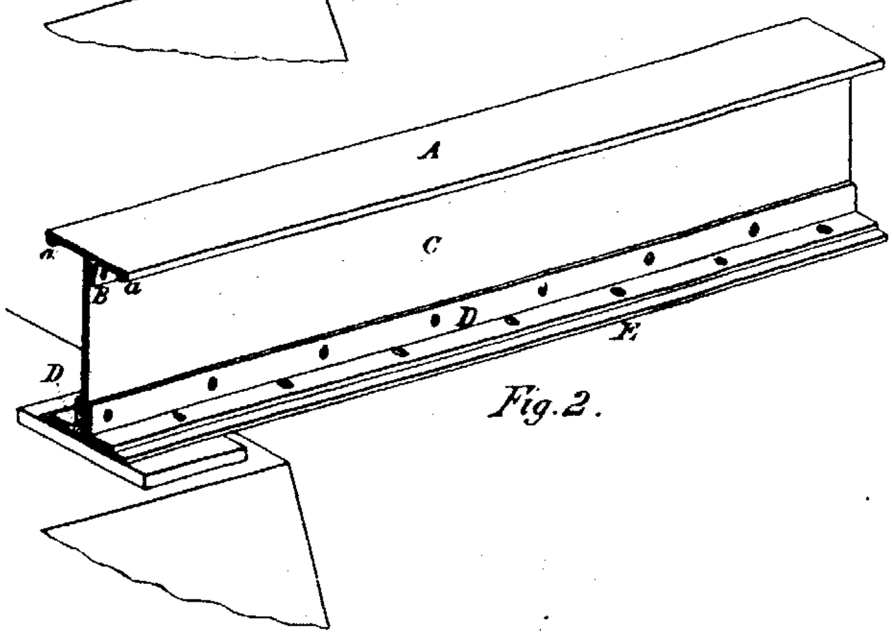


Fig. 2.

Ruth H. Abbott
Andrew Schoffin } Witnesses

David Hammond Inventor.
by Job Abbott, Attorney.