Spring Street Bridge (Marsh Rainbow Arch Bridge)
Spanning Duncan Creek
Chippewa Falls
Chippewa County
Wisconsin

HAER No. WI-37

HAER
WIS,
9-CHIFA,
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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
U. S. Department of the Interior
P. O. Box 37127
Washington, D. C. 20013-7127

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HISTORIC AMERICAN ENGINEERING RECORD

Spring Street Bridge
(Marsh Rainbow Arch Bridge)

HAER No. WI-37

Location:	Spanning Duncan Creek, carrying traffic from East Spring Street. City of Chippewa Falls, Chippewa County, Wisconsin UTM: 15.627000.4976920 Quad: Chippewa Falls
Date of Construction:	1916
Designer:	James Barney Marsh
Present Owner:	City of Chippewa Falls
Present Use:	Vehicular and pedestrian traffic
Significance:	The Spring Street Bridge is Wisconsin's only remaining example of the patented Marsh Rainbow Arch bridge design. James Barney Marsh, a native of North Lake, Wisconsin, developed designs for the concrete and steel structure and patented his innovations in 1912. The bridge remains completely intact, including the original ornamental lamp standards and globes.
Historian:	Edwin Cordes Wisconsin Historic Bridges Recording Project Summer 1987

HISTORICAL DOCUMENTATION

The Spring Street Rainbow Arch Bridge is Wisconsin's only remaining example of the J. B. Marsh patented design.[1] The concrete and steel structure spans a small creek in the residential area of Chippewa Falls. Built in 1916, the bridge replaces an earlier span which collapsed only six months after its construction. The graceful bowstring arch with its massive concrete exterior is a landmark for the area and remains in excellent condition.

DESCRIPTION

The Spring Street Bridge crosses Duncan Creek with a total clear span of 93 feet. Total width of the bridge is 29 feet, 3 inches. A 20-foot roadway crosses the structure and contains one 8-foot sidewalk. The massive arch forms are composed of steel truss work encased in concrete. The bridge design received its nickname "rainbow arch" because of the characteristic enlargement of the arch forms as they approach the abutments. The arch, which has a total rise of 20 feet, expands from 3 feet radially at the crown to over 52 inches at the springing points. The floor deck is hung from the arches, using eight steel hangers per side also enclosed in concrete. Steel I-beams attached to the hangers support the roadway.[2]

All of the original ornamental and aesthetic components of the bridge remain. A cast cement railing integrated into the arch and vertical members encloses the structure. Original cast steel lamp standards with ionic capitols and glass globes stand at all four corners of the bridge. The interior railing contains a cast plaque identifying the Iowa Bridge Company of Des Moines as the contractor and crediting the Board of Public Works and other key politicians as instrumental in the bridge's construction.

The bridge plate reads:[3]

Marsh Rainbow Arch Bridge
Patented August 6, 1912
Built By

Iowa Bridge Company
Des Moines
1916

Board of Public Works
Geo. E. Dee Mayor, W.M. Bowe City Atty., J.T. Hurd City Eng.

SITE DEVELOPMENT

The history of the Spring Street crossing is filled with much superstition snd many calamities, including at least two desths and many reported losses of personal property. Reports labeling the crossing a 'hoodoo' reach as far bsck as the early 1880s.[4] The earlieet victim of the Spring Street crossing was a highway workman named Jeff Murphy who died when a dump cart he was operating while filling the east abutment broke away and fell down the embankmsnt. In 1880, an iron bridge collspsed while Louis Blum, who was driving a wagon loaded with Leinenkugel beer, was crossing. The mishap killed one of the horses and destroyed a complete shipment of beer, causing many of the city residents to "die of thirst."[5] Paul Felix, s local contractor was killed in 1911 while working on the underside of the bridge. While Felix removed a scaffold, a large timber struck him in the head.[6]

On July 20, 1915, the previous steel truse bridge across Duncan Creek at Spring Street was deemed unsafe. The City Board of Public Works proceeded to advertise for bids on a new concrete etructure at this site. The contract was awarded on August 27th to the lowest bidder, Thomas E. Wooley of La Crosse, Wieconsin, for a price of $7,947. The concrete span was completed by December 7, 1915, and accepted by the city.[7]

On Sunday, April 1, 1916, the concrete bridge collapsed under the pressure of the annual spring floods. Public outrage at the failure of the new structure led the Common Council to adopt a resolution to conduct sn investigstion and sue the person reeponsible for ite collapse. The investigation concluded that Wooley wss not at fault. The bridge's collapse resulted from severe flooding, the hasty completion before the winter freeze, snd the improper design of the center pier footings.[8] The rubble from the bridge was bulldozed by a crew of expert stone wreckers from Camp Guthrie and the abutments made ready for a new span for a total cost of $1,120.[9]

In June 1916, the City Common Council requested that the city engineer prepare plans and eetimatee for a new bridge at Spring Street. The city engineer, J. T. Hurd, recommended a concrete reinforced concrete etructure, since a steel structure would be of no savings, due to the war's inflation of metsl prices. Hurd's plans cslled for a simple three-centered arch span with neo-classical styling. On June 21, a request for bids on the project was announced in the locsl papers. The notice also etated that alternative deeigne by the contractors would also be considered.[10]

Bids were received from three companiee by the July 18 deadline. The Iowa Bridge Compsny of Minneapolis, Minnesota, received the contract for construction of a concrete arch etructure according to the plane of the Marsh Engineering Company of Des Moines, Iowa. Other companies bidding for the contract were the Illinois Bridge Company of Chicago and the Illinois Bridge Company of Jacksonville, Illinois. The Iowa Bridge Company's Marsh deeign estimate was substantially lower than their bid on the city engineer-designed structure. The company's total bid was $13,950. The City Council estimated that a considerable amount of money could be saved by employing the present abutments and reusing additional reinforcing steel the city had on hand. The total estimate was eventually reduced by $1,300.[11]

The Iowa Bridge Company's bidding was supervised by company executive Grant Montgomery. While this was the first bridge of its kind in Wisconsin, Montgomery assured the council of the design's strength and widespread use in Europe. The company had recently completed a number of these type of bridges for the Federal Government in Yellowstone Park. Montgomery personally supervised completion of the span, and the bridge opened to pedestrian traffic on October 15, 1916.[12]

CONSTRUCTION

The Marsh Arch design eliminated many of the time consuming tasks involved in traditional concrete construction. Complete steel trusses were employed for reinforcement in the arches. The steel trusswork was assembled on the ground and then lifted in place. Angle irons placed in sets of four, eight to a side, were attached to the arch and served as the hangers for the deck. Steel truss members were also used for the bottom chords. The steel trusses were used to support their own formwork, thus eliminating the need for costly and time consuming falsework construction beneath the structure. Large steel I-beams were welded to the hangers across the width of the bridge. After formwork was attached to these beams, the contractor poured the concrete decking. Once the deck had cured, concrete casting began on the arches and hangers.[13]

The Spring Street design is of the fixed type, meaning that both ends of the massive arches are set securely into the concrete embankments. Variations of the basic patented design allowed for arches set on cast steel rockers, allowing a minimal amount of movement. In the Chippewa Falls example, the entire amount of force generated by the bridge is absorbed as horizontal thrust of the arches in the embankments.

J. B. MARSH

James Barney Marsh, the man whose name identifies these unusual bridges, received a patent for his innovations on August 6, 1912 (United States Patent number 1,035,026).[14] Born in North Lake, Wisconsin, in 1856, Marsh moved to Iowa, where he attended Iowa State University at the age of 18. The inventor received a degree in mechanical engineering in 1882. After graduation, Marsh accepted a position with the Des Moines office of the King Bridge Company of Cleveland, Ohio, and made patented improvements on the company's standard metal bowstring truss bridge. By 1896, the engineer's independent thinking and ambition led him to form the Marsh Bridge Company. Marsh began experimentation with concrete bridge construction. By 1909, the company had expanded numerous times and was now called the Marsh Engineering Company.[15]

Marsh's patented bridge design parallels the design of similar structures in Europe. M. A. Considere, a well-known French engineer, constructed a concrete arch structure in France in 1904. Marsh's patented design followed eight years later. The inventor's rainbow arch design, however, received limited acceptance throughout the United States. A number of bridges according to Marsh's design were built in the Midwest, especially in Ohio, but the design never became an industry standard. The chief advantages of the Marsh system included the ability to construct a concrete bridge with minimal weight and floor thickness, while still permitting maximum headroom below the deck. The span is also protected from the elements by its concrete outer shell. Horizontal web members were eliminated, since all tension was exerted on the vertical hangers.[16] The resulting structure was also more aesthetically pleasing than standard plate girder concrete construction.

UNITED STATES PATENT OFFICE.

JAMES B. MARSH, OF DES MOINES, IOWA.

REINFORCED ARCH-BRIDGE.

1,035,026. Specification of Letters Patent. Patented Aug. 6, 1912.
Application filed November 1, 1911. Serial No. 658,060.

To all whom it may concern:

Be it known that I, JAMES B. MARSH, a citizen of the United States, residing at Des Moines, in the county of Polk and State of Iowa, have invented certain new and useful Improvements in Reinforced Arch-Bridges, and I do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to bridges, and more especially to those employing arches; and the object of the same is primarily to construct the bridge of reinforced concrete and in such a manner that the latter may expand and contract under varying conditions of temperature and moisture. This and other objects are carried out by the construction hereinafter more fully described and claimed and as shown in the drawings wherein—

Figure 1 is a side elevation of this bridge complete, with the arch partly in section; Fig. 2 is a central longitudinal sectional view thereof; Fig. 3 is a cross section on the line 3—3 of Fig. 1 showing but one half of the bridge as the other is like this; Figs. 4 and 5 are sectional views on the lines 4—4 and 5—5 respectively of Fig. 3; Fig. 6 is a section on the line 6—6 of Fig. 2, the same being taken on a smaller scale than Figs. 3, 4 and 5; Fig. 7 is a section on the line 7—7 of Fig. 1, and Fig. 8 is a section on the line 8—8 of Fig. 7; Fig. 9 is a section on the line 9—9 of Fig. 1, this view being taken on a smaller scale than Figs. 7 and 8; Figs. 10 and 11 are a side elevation and cross section (on the line 11—11 of Fig. 10) respectively of one of the wear plates; and Figs. 12 and 13 are perspective details thereof which will be referred to hereinafter; Fig. 14 is a plan view showing the lapping of the parapet on the bridge with that on the abutment; Fig. 15 is a side elevation of one of the abutments partly broken away to show it in section, and Fig. 16 is a plan view thereof; Fig. 17 is a longitudinal vertical section on an enlarged scale taken on the line 17—17 of Fig. 15.

Broadly speaking the object of the present invention is, to construct an arch bridge of reinforced concrete in such manner as to permit of a limited amount of expansion and contraction both of the arches and of the floor which are, of course, the longest members of the bridge. Broadly speaking, the parts of this structure as shown in the drawings are two abutments (which could be piers) P, a pair of arches A disposed between and springing from said abutments, the floor F carried by and between said arches and reaching from one abutment to the other where it abuts with the approaches, and the parapets or rails R along opposite sides of the floor line. These several parts will now be described.

The abutments P might well be piers between spans of a longer bridge than shown as above suggested, but in the present instance they are illustrated as composed of two side walls 1 which are of concrete surrounding a metallic reinforce composed of horizontal rods *a* and upright rods *b* formed into any suitable type of skeleton framework; braces 2 connecting these walls at suitable points and also of reinforced concrete structure; front or inner cross walls 3 connecting the inner edges of the side walls and rising to about the same height, these front walls also being of reinforced concrete structure and their skeleton frameworks *c* interlocking with those in the side walls; and footings 4 under all these walls, in which footings may be embedded piles 5 as best seen in Fig. 2.

The arches A are by preference two in number, and as they are duplicates of each other I will describe but one. These spring from points 6 within the bases 4 of the abutments P, pass through the front walls 3 and arch or curve over the stream being spanned, their curvature being such as to carry their crowns above the line of the floor F for quite some distance at the center of the bridge, and their distance apart being such as to permit the interposition of a floor F of sufficient width. It is quite possible to build a broader bridge than one with a single drive-way as illustrated in Fig. 9, by utilizing three or perhaps four of such arches, all disposed side by side and in strict parallelism; but the present specification will describe the simplest type of bridge, the understanding being that amplifications could be made without departing from the principle of my invention.

Structural details of the arch itself are shown at the top of Figs. 3 and 4. By preference it comprises two angle irons 8, beneath them two other angle irons 9 which are parallel with the angle irons 8 as to width but which by preference diverge slightly from them in their upright planes toward the extremities of the arch as seen in Fig. 1, and oblique braces or lattice-work 10 connecting four angle irons at frequent intervals: the rectangular skeleton framework thus produced being embedded in a concrete body 11 of proper consistency, size, configuration and color, and molded therein and thereon by any approved means forming no part of the present invention. Riveted to the angle irons 8 and 9 at proper points are plates 12, to which in turn are riveted angle irons 13 and 14 standing in parallelism with each other and connected at intervals by suitable braces 15, and all forming an upright skeleton structure depending from the arch A and constituting with its surrounding and inclosing body 16 of concrete a hanger by means of which the floor F is supported from the arch A. As seen in Fig. 1, for a bridge of the size and shape illustrated there would be about five of such hangers, and the section line of Fig. 3 is taken through the longest which is at the center of the arch. By preference the metallic framework of each hanger consists of two angle irons 13 and two others numbered 14—four in all—and near their lower ends there are plates 17 and 18 riveted outside of the outer irons 14 and inside the inner irons 13, and other plates 19 and 20 at lower points as shown in Fig. 3; and the lower ends of the several irons are firmly connected by oblique braces 21, everything being of course surrounded by the concrete body 16. The upper plates 17 and 18 of each hanger are connected with the similar plates of the hanger opposite by means of cross rods 22, preferably having depressed centers 23 as seen in Fig. 3, and the lower plates 19 and 20 are similarly connected with the corresponding plates on the opposite hanger by lower cross rods 24. At intervals these four cross rods 23 and 24 are caught in the bend of a U-shaped yoke 25 as seen in Fig. 5, the upper extremities of the side arms of said yoke being bent outward as shown at 26 so as to pass over transverse rods 27 which in turn rest upon longitudinal rods 28 that extend throughout the length of the floor. In addition, if desired, other pieces 29 may be disposed as indicated in dotted lines in Fig. 3, and these may be taken as typical of amplifications of the metallic framework which is embedded in and surrounded by a concrete body 30 molded thereupon and therearound in any suitable way as above suggested. In this manner is built up what might be called "ties" crossing the bridge structure and connecting the lower ends of the hangers in pairs. Where the arches cross the floor line occur what might be called "beams" best illustrated in Figs. 7 and 8. Here are side plates 31 connected by cross rods 32 having depressed centers 33, their lower portions connected by a number of cross rods 34 interposed between said depressed centers and passing through the lower portions of the plates 31, and several upper cross rods 35—all making up a skeleton framework which is surrounded by a concrete body 36 molded thereon in the manner above suggested so that the beams integrally connect the arches at these two points.

The railing or parapet R may, of course, have any fanciful design but essentially comprises a hand rail 40 and preferably includes another or mid-rail 41, both in the present instance formed of a concrete body surrounding one or more metallic reinforces, and extending the full length of the bridge. Where these rails pass the hangers, the latter support them as seen in Fig. 6; where they pass the beams (at points where the arches cross the floor line as above described) these rails are supported on upright posts 42 as best seen in Figs. 7 and 9; and at both ends of the arch these rails are connected integrally with end posts 43 which stand above the cross walls 3 of the abutments P, so that that portion of the parapet numbered 44 and built upon the abutment has its own post 45 outside said end post 43 and is entirely separate from that portion which is carried by the bridge proper.

The floor F of this improved bridge comprises a concrete slab or body 50 molded upon and surrounding transverse rods 58 at intervals crossing the series of longitudinal wires 28 which were described above as extending throughout the length of the bridge and which form the skeleton reinforce for this slab, and at both edges of the same are curbs 51 also by preference reinforced by rods 52, the surface of the floor being a filling of earth or any suitable material, 53, lying upon said slab and disposed between the curbs. The latter where they pass the hanger are extended outward and integrally united therewith, or in other words the hanger is shouldered as seen at 54 in Fig. 6 so that it is united integrally with the curb 51; but where the curbs pass the arches above the beams already described, they are free from said arches as indicated in Fig. 7, and in fact the entire slab 50 is free from the beams at these points on the bridge whereas it is molded integral with the ties where it crosses them and the transverse reinforce rods of said ties are connected with the longitudinal rods 28 by means of the yokes 25 as above described. This detail of construction accounts for the numerous cross rods 34 in the beams instead of the two cross rods 24 in the ties, and also for the presence of the upper cross rods 35 in the beams; as the latter must be self-sustaining between their points of integral connection with the arches A, whereas the ties are integrally connected with and supported by the hangers but are also integrally connected with the floor F and are therefore not necessarily self-sustaining. It will be seen, therefore, that in the type of bridge illustrated the floor F, the ties, the hangers supporting them, and those portions of the arches to which said hangers are connected, all constitute one unitary reinforced concrete structure; the extremities of the floor beyond the endmost hangers project over the beams and between the two arches and rest upon the end walls 3 of the two abutments P, while the arches are disconnected from the floor at these points; and the parapets are integral with the hangers where they pass them, supported on their own posts above the beams, and supported at their extremities on individual posts 43 flush with and rising from the two extremities of the floor F. Hence the arches may expand and contract to allow for changes in temperature and other climatic conditions and the extremities of the floor will slide upon the walls 3 in a manner which will be clear.

Wear plates 60 carried by headed pins 61 are supported beneath the slab 50 of the floor at points over said beam by having said pins molded into the slab as shown in Fig. 7: and these plates rest upon other plates 62, preferably having side flanges 63, and which are supported by the beam in any suitable manner as by rivets or studs 64 molded thereinto. Details of these plates are shown on sheet 3 of the drawings, and Figs. 7 and 8 illustrate their use. During the expansion or contraction of the members of this improved bridge on account of climatic changes or the stress of weight upon it, the rise and fall of the arches due to their longitudinal expansion and contraction may cause the beams to move slightly beneath the ends of the floor, and this is accommodated by the disconnection of the beam structure and the slab and the interposition of the wear plates just described. On the other hand, the expansion and contraction of the floor F may cause its ends to move over said beams, and this is accommodated in the same manner.

What is claimed as new is:

1. In a bridge, the combination with the abutments, parapets along the side walls thereof, a pair of arches springing from points in the abutments below the upper edges of their walls, and beams integrally connecting said arches at two points between the abutments; of a floor of reinforced concrete whose extremities rest slidably on the front walls of said abutments and whose body overlies said beams, flat wear plates secured respectively to the beams and floor and in slidable contact with each other, posts rising from the edges of said floor, the endmost posts standing inside those on the parapets, and rails connecting the posts on the floor.

2. In a reinforced concrete bridge, the combination with the abutments, a pair of arches integral with and springing from points low in the inner walls of said abutments, and two beams integrally connecting said arches at points adjacent the abutments; of hangers depending from the arches in pairs between said beams, cross ties integrally connecting the lower ends of said hangers in pairs, a floor consisting of a depressed body and raised curbs along its edges, the body formed integral with said ties and slidably mounted on said beams and parapets and the curbs formed integral with said hangers but separate from said arches, flat wear plates secured respectively to said beams and to the floor where it crosses them, and a filling upon the body of the floor between its curbs.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

JAMES B. MARSH.

Witnesses:
H. H. FLANAGAN,
N. E. MARSH.

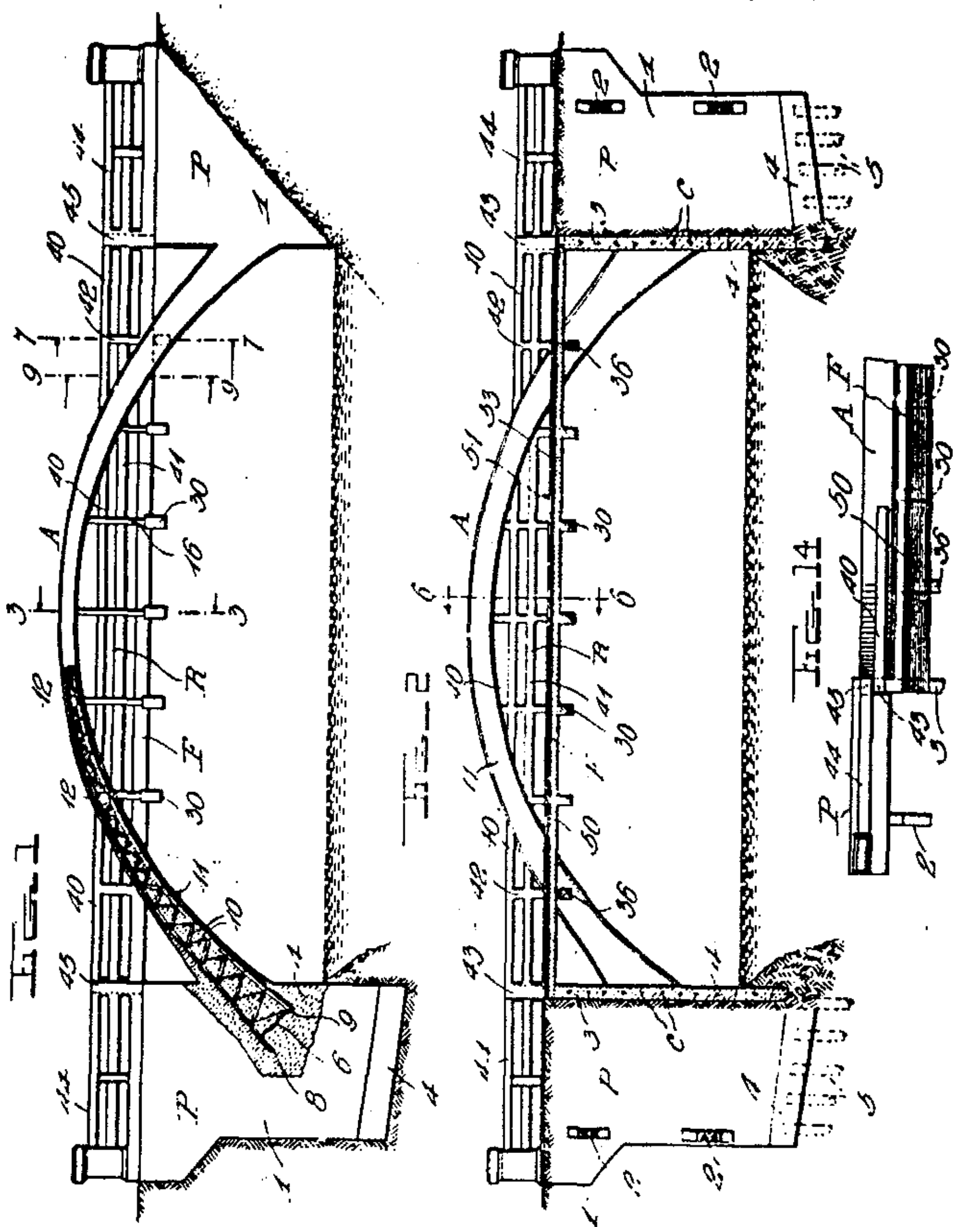
J. B. MARSH.

REINFORCED ARCH BRIDGE.

APPLICATION FILED NOV. 1, 1911.

1,035,026. **Patented Aug. 6, 1912.**

4 SHEETS—SHEET 1.



Witnesses

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N. L. Collamer

Inventor

J. B. Marsh

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Attorneys

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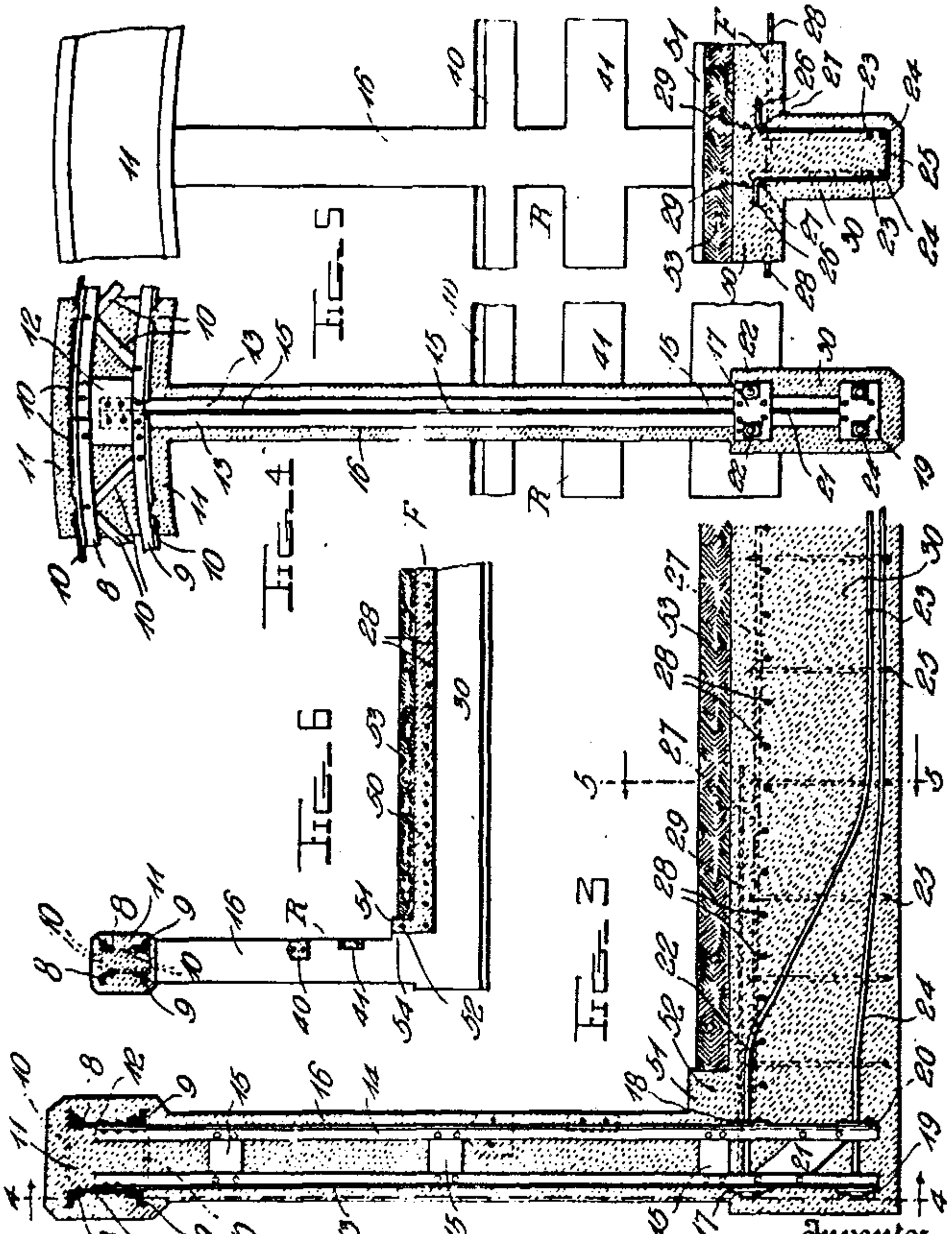
4 SHEETS-SHEET 2.



Witnesses

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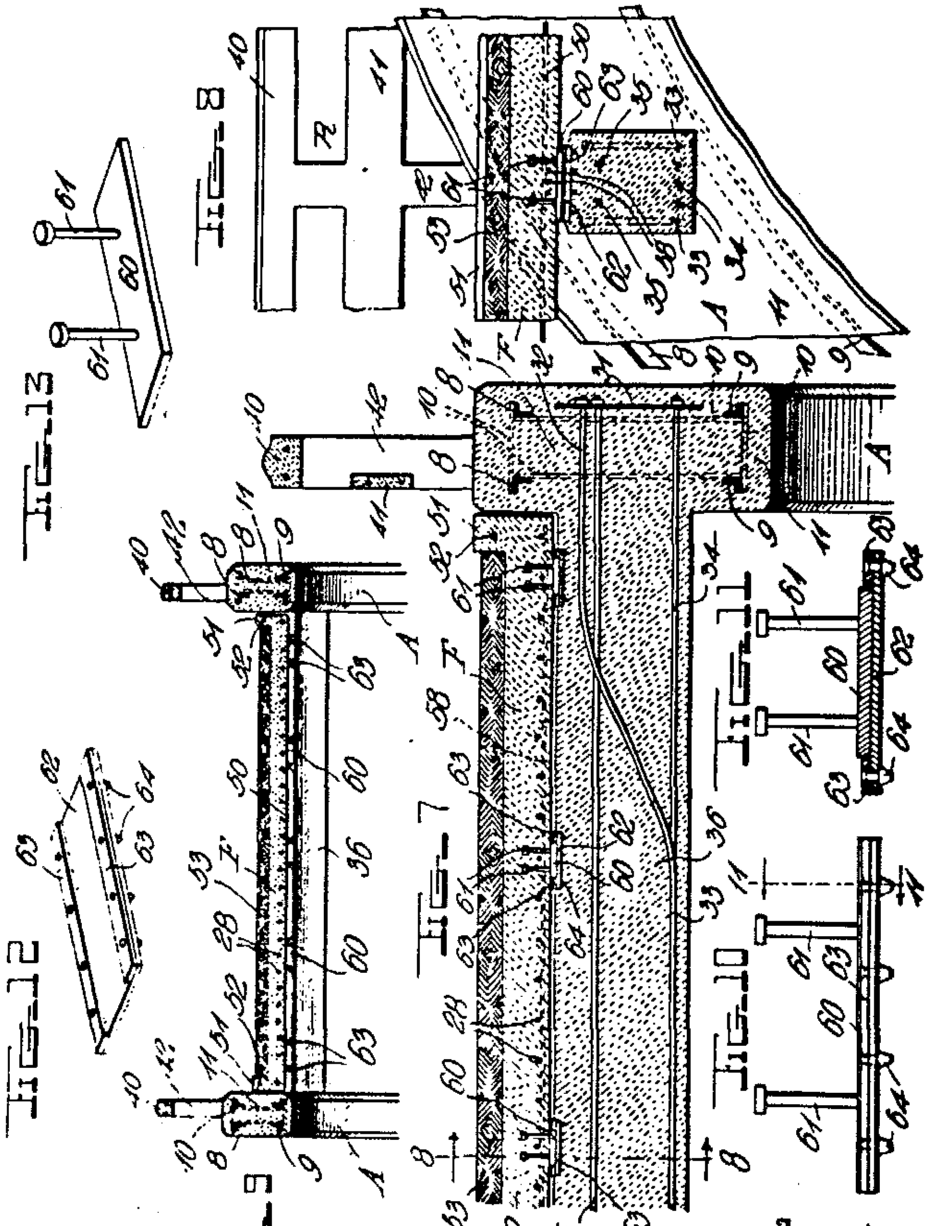
4 SHEETS-SHEET 3.



Witnesses

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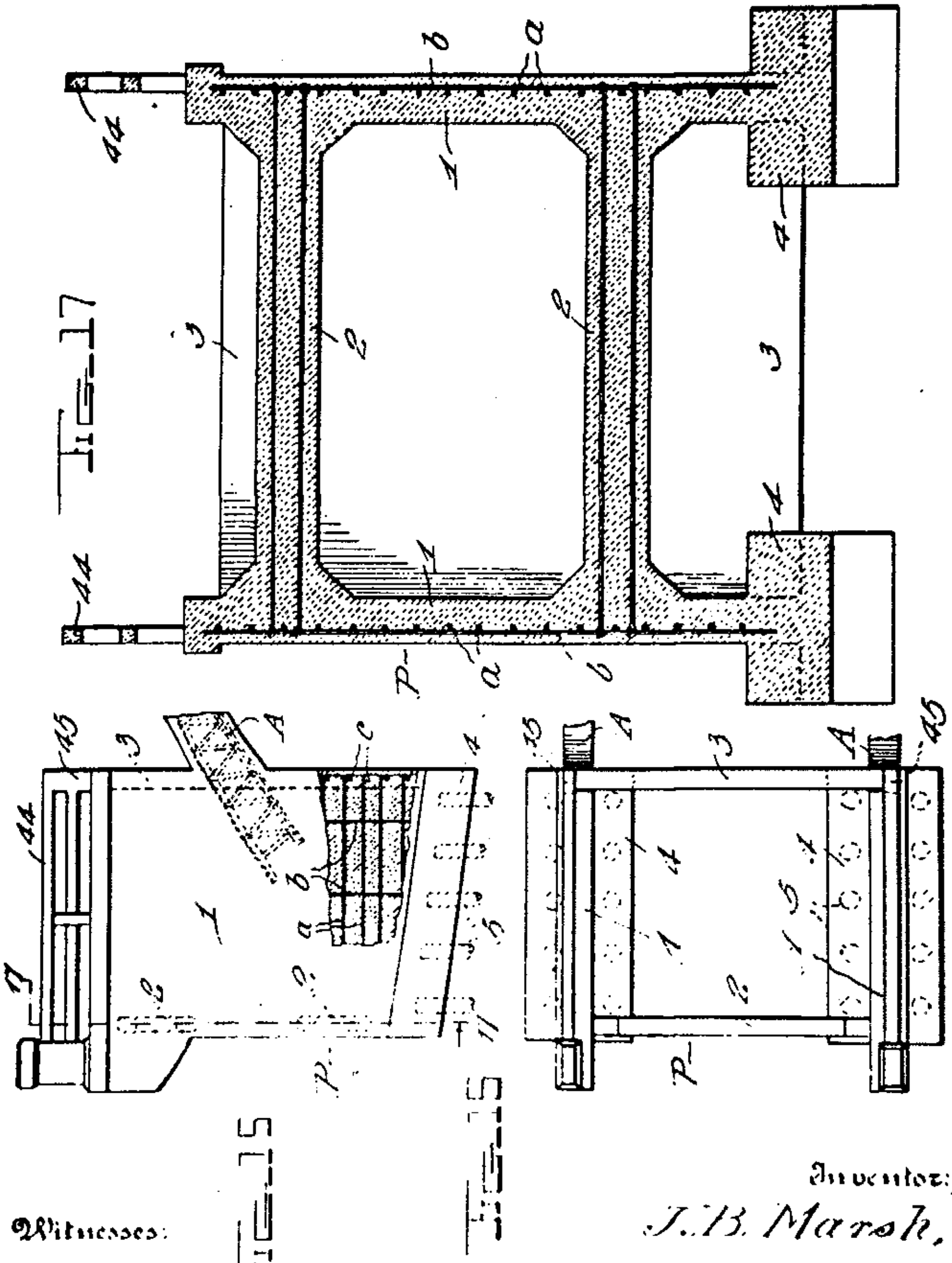
4 SHEETS—SHEET 4.



Witnesses:

N. L. Collamer

Inventor:
J. B. Marsh,
by H. B. Willson & Co.
Attorneys.

FOOTNOTES

1 Jeffrey A. Hess & Robert Frame, Historic Highway Bridges in Wisconsin: Stone and Concrete Arch Bridges. Wisconsin Department of Transportation Publications, 1986. Volumes 1 & 2, p. 261.

2 Design for Marsh Rainbow Arch Bridge over Duncan Creek at Spring Street, Chippewa Falls, Wisconsin, June 1916. Original plans for the bridge's construction can be found in the city engineer's office in Chippewa Falls.

3 Bridge Plate, found on southeast interior of abutment.

4 The Chippewa Falls Evening Independent, April 26, 1916.

5 Ibid., April 20, 1916.

6 Ibid.

7 "Procesdings" of ths Chippewa Falls City Council, August 27, 1915, December 7, 1915. A copy can be found in the City Clerk's office, Chippewa Falls City Hall.

8 The Evening Independent, June 21, 1916.

9 Ibid., April 4, 1916.

10 Proceedings, July 1, 1916.

11 Ibid, October 17, 1916.

12 The Evening Independent, September 24, 1916.

13 "Rock Island Builds Two Rainbow Arch Bridges," Railway Age, Vol. 65, No. 23, December 6, 1918, pp. 1003-1004.

14 United States Patent #1,035,026. James B. Marsh of Des Moines, Iowa, for a reinforced arch bridge. Patented August 6, 1912.

15 Larry Jochims, "Rainbow Arch Bridges Add Variety To Kansas Highways." Kansas Preservation, Sept-Oct. 1980, p. 2.

16 "Rock Island," p. 1004.

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Gast, E. A. "A Through Reinforced-Concrete Arch Bridge." Engineering News. February 16, 1911, pp. 196-198.

Hess, Jeffrey A. and Frame, Robert. Historic Highway Bridges in Wisconsin-Stone and Concrete Arch Bridges. Wisconsin Department of Transportation Publications, 1986. Volumes 1 & 2.

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"Proposal Instruction to Bidders Specifications and Contract for Reinforced Concrete Arch Bridge." A copy of the original specifications and contract can be found at the city records office, Chippewa Falls.

The Chippewa Falls Evening Independent. April 20, 1916, to June 21, 1916.

The National Register of Historic Places Inventory-Nomination Form for the Spring Street Marsh Rainbow Arch Bridge in Chippewa falls, Wisconsin, compiled by Diane H. Filipowicz, January 1982.

United States Patent #1,035,026. James B. Marsh of Des Moines, Iowa, for a reinforced arch bridge. Patented August 6, 1912.